NRDC

January 12, 2024

Via email to:
Masum A Patwary, Environmental Scientist C
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703 B Street, Marysville, CA 95901
Yolo80Corridor@dot.ca.gov

Re: Comments on the Draft Environmental Impact Report for Yolo 80 Corridor Improvements Project

Dear Masum Patwary:

On behalf of the Natural Resources Defense Council (NRDC), we submit these comments on the Draft Environmental Impact Report (DEIR) for the Yolo 80 Corridor Improvements Project (Project).

For decades, the California Department of Transportation (Caltrans) has built out a massive network of roads and highways that crisscross our landscapes and communities. These projects have come at significant cost to the families displaced by highway projects, communities that breathe the nation's dirtiest air, and ecosystems harmed by vehicle pollution and habitat destruction.

Most recently, Caltrans has proposed widening the I-80 corridor between Kidwell Road in Solano County and West El Camino Avenue in Sacramento County. The proposal has raised myriad concerns, including allegations by a senior Caltrans official that the agency illegally "piecemealed" the Project's environmental review by splitting it into two parts. *See, e.g.*, Debra Kahn, *Caltrans official says she was demoted for objecting to highway expansion*, Politico, Oct. 3, 2023 [attached as Ex. A].

To add to the Project's issues, the Project's DEIR has glaring deficiencies that obscure its significant environmental impacts. Caltrans must address the flaws in the DEIR to ensure that the public and decision-makers can sufficiently consider the Project. Our letter details these deficiencies as follows: 1) Caltrans improperly piecemealed the Project; 2) the DEIR's alternatives analysis is flawed; 3) the DEIR does not fully disclose or adequately consider the Project's significant impacts on the environment; and 4) even when it recognizes the Project's significant impacts, the DEIR fails to adequately mitigate these impacts as required by CEQA.

1. Caltrans improperly piecemealed the Project

In the fall of 2023, Jeanie Ward-Waller, Caltrans's deputy director of planning and modal programs, was demoted after filing a whistleblower complaint claiming that Caltrans had piecemealed this Project. *See* Ex. A. Before this DEIR, under the guise of "pavement rehabilitation," Caltrans approved preparatory road-widening construction under a CEQA exemption. This road-widening will help accommodate the new lanes the Project proposes. *See* Ex. A.

Under CEQA, a "project" is "the whole of an action" that may result in a change to the environment. Cal. Code Regs., tit. 14, § 15378. "There is no dispute that CEQA forbids 'piecemeal' review of the significant environmental impacts of a project." *Berkeley Keep Jets Over the Bay Committee v. Board of Port Com'rs*, 91 Cal. App. 4th 1344, 1358 (Cal. Ct. App. 2001), *as modified on denial of reh'g* (Sept. 26, 2001). Rather, "CEQA mandates that environmental considerations do not become submerged by chopping a large project into many little ones, each with a potential impact on the environment, which cumulatively may have disastrous consequences." *Burbank–Glendale–Pasadena Airport Authority v. Hensler*, 233 Cal. App. 3d 577, 592 (Cal. Ct. App. 1991).

Here, Caltrans may not split the Project into smaller pieces to hide its environmental consequences. This earlier construction should have been properly reviewed under CEQA at the time of its approval, as part of this Project. And although evaluation of the prior construction in this DEIR does not cure those prior CEQA violations, Caltrans must nonetheless fully consider any cumulative impacts of the prior construction in this DEIR. The DEIR's passing reference to the prior construction (DEIR 2-355) fails in this regard.

2. Caltrans' consideration of alternatives is misleading and incomplete

A. The DEIR's analysis of whether the Build Alternatives fulfill the Project's purpose is faulty

The DEIR lists the Project's purpose as follows:

1. Ease congestion and improve overall person throughput
2. Improve freeway operation on the mainline, ramps, and at system interchanges

3. Support reliable transport of goods and services throughout the region
4. Improve modality and travel time reliability
5. Provide expedited traveler information and monitoring systems

DEIR 1-5. Due to the DEIR's modeling errors, it is impossible to evaluate whether any of the alternatives will achieve this purpose.

In the DEIR, Caltrans essentially considered thirteen alternatives: one No Build Alternative and six pairs of Build Alternatives. Each Build Alternative includes a variation where an I-80 managed lane direct connector is added and one where it is not. The No Build Alternative leaves the Project area as it is and was used as the baseline for comparison to the other alternatives. Build Alternatives 2a, 2b, 3a, 3b, 4a, 4b, 5a, and 5b (Added Lane Alternatives) all add one lane in each direction to I-80 and U.S. 50. They differ only in what kind of lane is added (i.e., high-occupancy vehicle lane, high-occupancy toll lane, express lane). Build Alternatives 6a and 6b add a transit-only lane in each direction. Build Alternatives 7a and 7b do not build lanes and instead convert one of the current lanes to a high-occupancy vehicle lane.

Caltrans states that the No Build Alternative would result in "severe traffic congestion and impaired mobility," DEIR 1-22, and therefore would not meet the Project's purpose. Meanwhile, Caltrans assumes that the Build Alternatives will meet the Project's purpose. *See* DEIR 1-7 to 1-8. These conclusions are based on faulty traffic modeling, as addressed in detail in Section 3.A, *infra*. In short, the erroneous modeling overstates the congestion in the No Build Alternative and therefore makes the Build Alternatives look much better in comparison.

Because of this faulty modeling, the DEIR does not provide enough accurate information to ascertain whether the Build Alternatives would fulfill the Project's purpose. Due to the No Build Alternative's overinflated traffic estimates, the public and decision-makers cannot accurately determine whether the Build Alternatives ease congestion, support transport reliability, or fulfill any of the Project's other goals.

B. Caltrans omitted alternatives that better achieve the Project's purpose with fewer environmental impacts

There are several reasonable alternatives that would achieve the above purpose with fewer environmental impacts and better implementation of relevant state and regional plans and targets. Caltrans omitted these alternatives from the DEIR. As a result, the DEIR does not paint an adequate picture of the range of options available to decision-makers.

First, Caltrans should have considered more alternatives that do not add any vehicle miles travelled (VMT). Pursuant to the California Climate Crisis Act (AB 1279), the state adopted the 2022 Scoping Plan for Achieving Carbon Neutrality, which includes VMT reduction of 25% per capita by 2035 and 30% by 2045. California Air Resources Board, *2022 Scoping Plan for Achieving Carbon Neutrality* 72 (2022) [attached as Ex. B]. Caltrans could better comply with these targets and achieve the Project's purpose by considering alternatives that have an established track record of reducing VMT. These alternatives could have included significantly improved rail service along the Capitol Corridor featuring faster, more frequent, and electrified rail service to meet the needs of travelers moving between cities and regions along the I-80 corridor. Another alternative would have entailed improved local public transit and active transportation infrastructure and service in the region's communities to replace more local-serving trips that use I-80. A final alternative focused on VMT reduction would have entailed investing in a robust regional travel demand management strategy that encourages use of transit, ridesharing, walking, biking, and telework options for communities along I-80, and other applicable strategies from Table 1 of the Caltrans VMT Mitigation Playbook. Caltrans, *SB 743 Program Mitigation Playbook* 7–8 (2022) [attached as Ex. C].

The DEIR also omits an alternative with more than one tolled lane in each direction. Having multiple tolled lanes in each direction would allow for greater congestion relief than just having one tolled lane, bring in more toll revenue to fund VMT-reducing strategies, and contribute to meeting statutory carbon-reduction goals like those in the Scoping Plan. The omission of this alternative is especially damning because it was expressly included in the 2020 Metropolitan Transportation Plan/Sustainable Communities Strategy (MTP/SCS) prepared by the Sacramento Area Council of Governments (SACOG) pursuant to SB 375. When it approved the SACOG MTP/SCS, the California Air Resources Board (CARB) assumed that this project would have multiple tolled lanes in each direction. California Air Resources Board, *Evaluation of the Sacramento Area Council of Governments' SB 375 2020 Sustainable Communities Strategy* 26 (2020) [attached as Ex. D]. Without more than one tolled lane in each direction, the Project will lead to higher greenhouse gas (GHG) emissions than the MTP/SCS allows for.

Finally, the DEIR omits an all-lane tolling alternative. This option would allow Caltrans to manage lanes with pricing, achieving permanent congestion reduction without adding VMT-inducing capacity. This alternative could also generate revenue to permanently fund VMT-reducing programs and alternatives to driving along the corridor, including enhanced rail capital and service improvements, local, regional, and long-distance bus service, and improved active transportation corridors, trails, and networks. *See, e.g.*, U.S. Dep't of Transp., Fed. Highway Admin., *Congestion Pricing*, https://ops.fhwa.dot.gov/congestionpricing/cp_benefits.htm [attached as Ex. E]. Such an all-lane tolling program could be designed with a procedural and outcomes focus on improving transportation equity. *See, e.g.*, TransForm, *Pricing Roads, Advancing Equity* (2019) [attached as Ex. F].

3. Caltrans did not fully disclose and adequately analyze the Project's impacts

The DEIR fails to fully disclose and adequately consider several of the Project's impacts. As a result, the public and the relevant decision-makers will be unable to accurately ascertain the Project's effects on the environment.

A. The DEIR's flawed modeling leads to erroneous conclusions about traffic impacts, greenhouse gas emissions, air quality, and energy impacts

There are several errors in the DEIR's modeling and assessment of the Project's expected impacts on travel patterns. These failures lead to the erroneous conclusion that the Project would not lead to significant traffic impacts. The traffic-related errors have knock-on effects on the DEIR's analysis of greenhouse gas emissions (GHG), air quality, and energy. These issues are also addressed in the expert report prepared for NRDC by Norm Marshall, President of Smart Mobility, Inc. [hereafter, "Marshall Report"] [attached as Ex. G.].

The first of the traffic-related errors was Caltrans's choice to use SACSIM, a static trip assignment model. This type of model assumes that drivers' departure time will remain static in the face of congestion, leading to unrealistic predictions about the No Build Alternative. *See, e.g.*, Fehr & Peers, *I-80/US-50 Managed Lanes Transportation Analysis Report* 76 (2023). For example, SACSIM cannot account for the fact that drivers will naturally shift their departure times to avoid congested peak periods. Therefore, it predicts that in order to avoid the congestion, drivers will take an unrealistically long detour, increasing the predicted VMT of the No Build Alternative. This leads Caltrans to the flawed conclusion that the Build Alternatives will reduce VMT because drivers will take a more direct route. This contributes to the DEIR's conclusion that widening the roadway will lead to lower VMT, contradicting the established literature which shows that widening congested roadways increases VMT. *See, e.g.*, Jamey M. B. Volker and Susan L. Handy, *The Induced Travel Calculator and Its Applications* 5 (Feb. 2021) [attached as Ex. H].

Rather than using a static trip assignment model, Caltrans should have used a dynamic trip assignment model. A dynamic trip assignment model hews closer to reality by assuming that when faced with extreme congestion, instead of taking long detours, drivers will simply adjust their departure time to avoid traffic. Such a model would correctly estimate lower VMT for the No Build Alternative, and therefore comparatively higher VMT for the Build Alternatives. By relying on an inappropriate model that produces implausible results, Caltrans has not informed the public and the relevant decision-makers about the project's environmental impacts.

Another issue with Caltrans' traffic analysis is that SACSIM cannot account for induced travel. The DEIR acknowledges this by using the National Center for Sustainable Transportation (NCST) Induced Travel Calculator for the induced VMT analysis. *See, e.g.*, DEIR 2-117, 3-41. However, instead of using the NCST figures for the traffic analysis, Caltrans stuck with SACSIM, despite admitting that it cannot properly account for induced travel. This leads to further underestimation of traffic impacts. *See* Marshall Report, Ex. G, at 4.

Caltrans's third traffic-related error is the improper use of the Build Alternatives' land use and traffic growth effects as the baseline for all traffic analyses, including for the No Build Alternative. Highway expansion often leads to increases in car-centric development in the area, which in turn leads to more VMT. Because of this, Caltrans's Transportation Analysis Framework requires that traffic models be sensitive to land use changes in response to network changes. Caltrans, *Transportation Analysis Framework* 21 (1st ed., 2020) [attached as Ex. I]. However, the DEIR's traffic analysis uses the same land use inputs across all the alternatives, including the No Build Alternative. Fehr & Peers at 26 ("Caltrans district staff directed that the model land uses be maintained without changes from the MTP/SCS versions for all alternatives, including the no build alternative."); *see also* Marshall Report, Ex. G, at 7. This means that the traffic estimates for the No Build Alternative will be inflated by the land use and traffic growth inputs of the Build Alternatives. As a result, the comparative traffic caused by the Build Alternatives is further underestimated. These flaws in the traffic modeling allow Caltrans to understate the Project's effects on VMT.

The shortcomings in the traffic analysis detailed above cause errors in the DEIR's connected analysis of GHG emissions, criteria pollutant emissions, and energy consumption. As detailed above, the DEIR's flawed traffic modeling undercounts the Project's impacts on VMT and overestimate the congestion in the No Build scenario. The DEIR's analysis of GHG emissions, air pollution, and energy consumption relies on these measurements, meaning that the DEIR also undercounts how much GHG emissions, air pollution, and energy consumption will result from the Project. *See* Marshall Report, Ex. G, at 9–10. As a result, the DEIR reaches the erroneous conclusion that the Build Alternatives will lead to reduced GHG emissions, air pollutant emissions, and energy consumption, contradicting the literature establishing that widening roadways will cause more VMT, and therefore greater GHG emissions, air pollution impacts (more exhaust from combustion; more brake and tire wear; more suspended road particles), and more energy consumption (more vehicle fuel consumed).

Furthermore, the DEIR's claims that the Build Alternatives will lead to decreased GHG emissions, air pollutant emissions, and energy consumption in the future are reliant on newer vehicles' efficiency improvements and future fuel economy standards. These changes would occur with or without the Project. By including them in the DEIR, Caltrans obfuscates the true measure of the Project's impact: a comparison of the GHG emissions, air pollution, and energy consumption with and without the Project. Thus, the inclusion of this irrelevant information can only serve to confuse the public and decision-makers into thinking that the Project's impacts will be less severe than the reality.

Therefore, Caltrans has failed to fully disclose and accurately analyze GHG emissions, air pollution, and energy impacts. This analysis should be redone and grounded in realistic estimates of the VMT caused by the project without reference to extraneous variables.

B. Even as to the induced VMT that Caltrans admits is significant, Caltrans still vastly underestimates the impact

The only impact that Caltrans admits would be significant is the Project's induced VMT. According to the DEIR, the VMT caused by the Build Alternatives would top out at 133 million annual auto VMT. DEIR 3-41.

However, as shown in the Marshall Report, when properly used, the NCST Induced Travel Calculator (the same calculator used by the DEIR to estimate induced VMT), actually produces a much larger figure. The Marshall Report shows that Caltrans underestimated induced VMT by up to 44.4%. Marshall Report, Ex. G, at 3–4. Such a large discrepancy means that even though the DEIR admits that the VMT induced by the Build Alternatives will be significant, the public and decision-makers are not getting an accurate picture of just how significant the induced VMT will be. Caltrans should explain how it reached its figure in this analysis and why it differs from the result in the Marshall Report.

C. The DEIR fails to adequately measure the growth induced by the Project

The DEIR admits that the Build Alternatives will "change development patterns surrounding the project area." DEIR 2-53. Given that the I-80 corridor connects the Sacramento area to the Bay Area and that Sacramento is typically more affordable than the Bay Area, it stands to reason that increasing the number of vehicle lanes through the corridor will encourage Bay Area commuters to move further east, leading to more development in the areas surrounding the Project. *Id.* Despite admitting all of this, Caltrans concludes that there would be "no adverse effects associated with growth" because other factors like "other impediments to growth. . . , market conditions, and local land use policies are a greater influence on land use change than roadway capacity." *Id.*

The DEIR is meant to measure the Project's impacts, including on development; it is entirely irrelevant whether other factors may influence growth more than the Project. The operative question is how much the Project will influence growth and development. The DEIR should be redone to squarely address this matter.

D. The DEIR fails to adequately analyze the Project's marginal impacts on species and habitats

Several times throughout the DEIR, Caltrans simply describes current conditions, then baldly asserts that the Project will not have significant impacts. These conclusions do not even try to measure the Project's added impacts on certain species and habitats that will be harmed by the construction of the Project.

For example, the DEIR acknowledges that the western yellow-billed cuckoo, a threatened species, and the least Bell's vireo, an endangered species, could use the project area as migratory stopover habitat. Still, to conclude that "there will be no impact on western yellow-billed cuckoo or least Bell's vireo," the DEIR simply states that area is already subject to "frequent anthropogenic disturbances" and that "the activities proposed in the staging areas would be similar to those already occurring in the area." DEIR 3-14. The DEIR makes no effort to define the marginal impacts added by the Project or to analyze their effects on these species.

The DEIR similarly brushes off the Project's impacts on native resident or migratory fish or wildlife species, established native resident or migratory wildlife corridors, and native wildlife nursery sites because "[t]he project is located in areas with high levels of anthropogenic disturbances within and near the Caltrans right-of-way." DEIR 3-16. Again, such bare assertions do not provide any information on the Project's impacts.

4. The DEIR fails to adequately mitigate induced VMT, even though there are feasible mitigation measures

If an EIR concludes that a project will have a significant impact, CEQA requires the lead agency to adopt feasible mitigation measures or alternatives that reduce that impact to a level of insignificance. Cal. Pub. Res. Code §§ 21081, 21002. If the agency believes that there are no feasible mitigation measures or alternatives that reduce the project's impacts to less than significant, it must explain why and adopt a statement of overriding considerations before approving the project. Cal. Pub. Res. Code § 21081(b), 21002; Cal. Code Regs., tit. 14, §§ 15043, 15093.

Even though its faulty modeling underestimates the annual VMT induced by the Project, the DEIR still predicts that the Added Lane Alternatives will result in at least 128 million additional annual auto VMT. DEIR 3-41. However, the DEIR proposes to mitigate only 57.1 million annual auto VMT, less than half of the Project's added VMT. This is contrary to Caltrans' own guidance, which states that "[t]he level of induced travel projected generally represents the level of VMT to be mitigated." Caltrans, *Transportation Analysis under CEQA* 22 (1st ed., 2020) [attached as Ex. J].

The Project's sizable unmitigated induced VMT remains a significant impact. If further mitigation measures are not feasible, then Caltrans must explain why and support its conclusion with substantial evidence. And if Caltrans tries to argue that the remaining induced VMT is not significant, "[a]n agency's choice of a significance threshold [must be] founded on substantial evidence." *Mission Bay All. v. Off. of Cmty. Inv. & Infrastructure*, 6 Cal. App. 5th 160, 206 (Cal. Ct. App. 2016). Here, Caltrans makes no attempt to do either. The closest that the DEIR gets to an explanation is buried in an appendix, wherein Caltrans states that the mitigation budget is "14-15% of [the Project's] $350 million [budget]." Caltrans, *Yolo 80 Managed Lanes Project Draft VMT Mitigation Plan* 8 (Oct. 20, 2023). Caltrans implies this as justification for choosing its limited mitigation measures. However, there is no explanation why a project with a budget this massive has such a paltry mitigation fund or why Caltrans cannot contribute more to mitigation. Due to these oversights, the Project's mitigation measures cannot pass muster.

Furthermore, several of the proposed mitigation measures cannot credibly achieve the amount claimed. The Marshall Report finds that the measures related to transit pass subsidies and commuter incentives are duplicative and lead to double-counting of VMT reductions. The Marshall Report also finds that several mitigation measures assume rates of utilization and VMT impact that are unrealistically high, leading to overstated VMT reduction benefits. Marshall Report, Ex. G, at 11–19.

There are also several feasible measures that could further mitigate induced VMT, as required by CEQA. For example, as addressed above, Caltrans could consider an alternative with more than one tolled lane in each direction. *See* Sec. 2.B, *supra*. Without such measures, the DEIR fails to comply with CEQA requirements.

5. Delays in providing requested technical studies

The CEQA Guidelines requires that technical information in appendices "shall be readily available for public examination and shall be submitted to all clearinghouses which assist in public review." Cal. Code Regs., tit. 14, § 15147. NRDC attempted to obtain copies of the technical studies by emailing yolo80corridor@dot.ca.gov and the District 3 Chief Public Information Officer on November 16 and November 27 to request copies of the technical studies listed in Appendix H, but did not receive a response. After a third request directed to Caltrans and California State Transportation Agency leadership, we finally received the technical studies on December 13, 2023, with further information provided on January 11, 2024. While the deadline for comments was extended until January 12, Caltrans ultimately provided NRDC with less than the minimum time required to review and comment on the DEIR and its technical information. *See* Cal. Code Regs., tit. 14, § 15105.

6. Conclusion

The DEIR has numerous shortcomings. It left out alternatives that it should have studied while sandbagging the No Build Alternative with unrealistic assumptions. It also failed to adequately disclose, analyze, and mitigate the Project's impacts. These fatal flaws must be corrected—and the DEIR recirculated for public comment—before the Project may lawfully be approved.

Sincerely,

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Exhibit A

CALIFORNIA

Caltrans official says she was demoted for objecting to highway expansion

Jeanie Ward-Waller was removed last month from her position overseeing California's transportation planning.

Jeanie Ward-Waller filed whistleblower complaint about Sacramento-area road construction projects allegedly circumventing environmental rules. | Rich Pedroncelli/AP Photo

By DEBRA KAHN
10/03/2023 06:06 PM EDT

A top California transportation official who was reassigned last month told POLITICO she was demoted for objecting to highway expansions that will increase driving.

Jeanie Ward-Waller, Caltrans' deputy director of planning and modal programs, was taken off the job in September. Her reassignment came three weeks after she said she notified agency officials that she would file a whistleblower complaint about Sacramento-area road construction projects allegedly circumventing environmental rules.

Caltrans' chief deputy director, Michael Keever, notified Ward-Waller on Sept. 14 that she would be terminated from her role Oct. 4 and placed on administrative leave until then. In a letter seen by POLITICO, he offered her the option of returning to her previous role at the agency or one administrative level above that.

Ward-Waller's attorney, Christian Schreiber, said she was still weighing her next steps. "We plan to press her employment-related claims and her whistleblower retaliation claims and litigation, if that's what's necessary," he said in an interview.

Caltrans officials declined to comment on specific claims. "Caltrans will cooperate with any independent investigation into these claims," agency spokesperson Edward Barrera said in a statement. "In addition, Caltrans does not comment on personnel matters."

Ward-Waller had served in the position since January 2020 and was an appointee of former Caltrans Director Toks Omishakin, whom Gov. Gavin Newsom (D) promoted last year to Secretary of Transportation. She started at Caltrans in 2017 as sustainability program manager and before that was the policy director for the California Bicycle Coalition.

As deputy director of planning, she oversaw Caltrans' long-range planning and research and helped set the agency's policy direction. The agency has authority over all state highways and oversees all state and federal transportation spending, including on rail, bike lanes and pedestrian routes as well as roads.

Ward-Waller said in an interview — her first since her termination — that she had objected to two construction projects on Highway 80 because, she said, Caltrans' state and federal permits improperly understated their environmental impacts.

"My job at Caltrans headquarters was really to help move us in a direction where we're not widening highways so much anymore," she said. "We care about climate, we care about equity, so we're trying to move towards more multimodal options and do less widening. My involvement in projects like this is from that kind of a perspective, of trying to challenge the districts to think differently about how they're approaching projects like this."

The projects are both located on the Yolo Causeway, an elevated highway between Davis and Sacramento that crosses the Yolo Bypass, a floodplain that serves as wildlife habitat. The first project began construction in August and the second is expected to begin construction by October 2024.

Ward-Waller alleged that Caltrans improperly described the first project as "pavement rehabilitation" when it will actually widen the road to accommodate new lanes. Because of that, she said, it's illegally using state funds that are intended only for road maintenance, not widening.

She also said the projects should have been considered as one and that by "piecemealing" them into two, Caltrans was able to streamline permitting for the first project, avoiding a full evaluation of alternatives under the California Environmental Quality Act and the National Environmental Policy Act.

Ward-Waller said she had been raising concerns about the project since July. She said she elevated the concerns in a text message to Keever on Aug. 16 and detailed them in a meeting with him on Aug. 17 before going on vacation for two weeks.

“That was the time I basically said, ‘We need to call an external audit here,’” she said.

After being demoted Sept. 14, Ward-Waller said, she submitted a formal whistleblower complaint to Caltrans on Sept. 16.

She also identified in the complaint two other projects underway in the Sacramento region that she said are improperly using maintenance funding while actually widening the roads and said the Caltrans district that oversees the region is known for trying to use road-maintenance funding to widen highways. “This was somewhat their way of doing business,” she said.

Caltrans declined further comment.

FILED UNDER: CALIFORNIA, CLIMATE

Exhibit B

CALIFORNIA
AIR RESOURCES BOARD

December 2022

2022 Scoping Plan for Achieving Carbon Neutrality

CARB's mission is to promote and protect public health, welfare, and ecological resources through effective reduction of air pollutants while recognizing and considering effects on the economy. CARB is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards.

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Abbreviations

°F	Fahrenheit
°C	Celsius
AB	Assembly Bill
AQMD	Air Quality Management District
AR5	IPCC Fifth Assessment Report
BECCS	bioenergy with carbon capture and storage
CAISO	California Independent System Operator
CalEPA	California Environmental Protection Agency
CalGEM	California Geologic Energy Management Division
CalSTA	California State Transportation Agency
CAP	climate action plan
CARB	California Air Resources Board
CCR	California Code of Regulations
CCS	carbon capture and sequestration
CCUS	carbon capture, utilization, and storage
CDFA	California Department of Food and Agriculture
CDPH	California Department of Public Health
CDR	carbon dioxide removal
CE	common era
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CES	CalEnviroScreen
CH_4	methane
CMAQ	Community Multiscale Air Quality
CNRA	California Natural Resources Agency
CO_2	carbon dioxide
COPD	chronic obstructive pulmonary disease

CORE	Clean Off-Road Equipment
CPUC	California Public Utilities Commission
CVM	Climate Vulnerability Metric
DAC	direct air capture
DPR	Department of Pesticide Regulation
Draft EA	Draft Environmental Analysis for this Scoping Plan
EA	Environmental Analysis
ED	emergency department
EIA	U.S. Energy Information Administration
EJ	environmental justice
EJ Advisory Committee	Environmental Justice Advisory Committee
EO	executive order
EV	electric vehicle
F-gas	fluorinated gas
FCEV	fuel cell electric vehicle
GCF	Governors' Climate and Forests Task Force
GDP	gross domestic product
GHG	greenhouse gas
GSP	gross state product
GW	gigawatt
GWh	gigawatt-hour
GWP	global warming potential
HDV	heavy-duty vehicle
HD ZEV	heavy-duty zero-emission vehicle
HFC	hydrofluorocarbon
IBank	Infrastructure and Economic Development Bank
ICE	internal combustion engine
IPCC	Intergovernmental Panel on Climate Change

IPT	incidence-per-ton
IWG	Interagency Working Group
LCFS	low-carbon fuel standard
LDV	light-duty vehicle
MDV	medium-duty vehicle
MMT	million metric tons
$MMTCO_2e$	million metric tons of carbon dioxide equivalent
MOU	memorandum of understanding
MRR	Mandatory Reporting of GHG Emissions
$MTCO_2e$	metric tons of carbon dioxide equivalent
MW	megawatt
N_2O	nitrous oxide
NEMS	National Energy Systems Model
NF_3	nitrogen trifluoride
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NRDC	National Resources Defense Council
NWL	Natural and Working Lands
OEHHA	Office of Environmental Health Hazard Assessment
OGV	Ocean-Going Vessel
OPR	Governor’s Office of Planning and Research
OTC	once-through cooled
PFC	perfluorocarbon
PHMSA	Pipelines and Hazardous Materials Safety Administration
PM	particulate matter
$PM_{2.5}$	fine particulate matter
PPP	public-private partnership
RFS	renewable fuel standard

ROG	reactive organic gases
RPS	Renewables Portfolio Standard
SB	Senate Bill
SC-CH_4	social cost of methane
SC-CO_2	social cost of carbon
SC-GHG	social cost of greenhouse gases
SC-N_2O	social cost of nitrous oxide
SF_6	sulfur hexafluoride
SGIP	Self-Generation Incentive Program
SLCP	short-lived climate pollutant
TSD	Technical Support Document
UC	University of California
UCLA	University of California, Los Angeles
UNFCCC	United Nations Framework Convention on Climate Change
U.S. EPA	United States Environmental Protection Agency
VMT	vehicle miles traveled
WUI	wildland-urban interface
ZEV	zero-emission vehicle

Executive Summary

This Scoping Plan lays out the sector-by-sector roadmap for California, the world's fifth[1] largest economy, to achieve carbon neutrality by 2045 or earlier, outlining a technologically feasible, cost-effective, and equity-focused path to achieve the state's climate target. This is a challenging but necessary goal to minimize the impacts of climate change. There have been three previous Scoping Plans. Previous plans have focused on specific greenhouse gas (GHG) reduction targets for our industrial, energy, and transportation sectors—first to meet 1990 levels by 2020, then to meet the more aggressive target of 40 percent below 1990 levels by 2030. This plan, addressing recent legislation and direction from Governor Newsom, extends and expands upon these earlier plans with a target of reducing anthropogenic emissions to 85 percent below 1990 levels by 2045. This plan also takes the unprecedented step of adding carbon neutrality as a science-based guide and touchstone for California's climate work. The plan outlines how carbon neutrality can be achieved by taking bold steps to reduce GHGs to meet the anthropogenic emissions target and by expanding actions to capture and store carbon through the state's natural and working lands and using a variety of mechanical approaches.

Greenhouse gases	Air pollution	Petroleum demand
↓85%	↓71%	↓94%

What this means for California is an ambitious and aggressive approach to decarbonize every sector of the economy, setting us on course for a more equitable and sustainable future in the face of humanity's greatest existential threat, and ensuring that those who benefit from this transformation include communities hardest hit by climate impacts and the ongoing pollution from the use of fossil fuels. The combustion of fossil fuels has polluted our air—particularly in low-income communities and communities of color—for far too long and is the root cause of climate change. This Scoping Plan helps us chart the path to a future where race and class are no longer predictors of disproportionate burdens from harmful air pollution and climate impacts.

The major element of this unprecedented transformation is the aggressive reduction of fossil fuels wherever they are currently used in California, building on and accelerating carbon reduction programs that have been in place for a decade and a half. That means rapidly moving to zero-emission transportation; electrifying the cars, buses, trains, and trucks that now constitute California's single largest source of planet-warming pollution. It also means phasing out the use of fossil gas used for heating our homes and buildings. It means clamping down on chemicals and refrigerants that are thousands of times more powerful at trapping heat than carbon dioxide (CO_2). It means providing our communities with sustainable options for walking, biking, and public transit to reduce reliance on cars and their associated expenses. It means continuing to build out the solar arrays, wind turbine capacity, and other resources that provide clean, renewable energy to displace fossil-fuel fired electrical generation. It also means scaling up new options such as renewable hydrogen for hard-to-electrify end uses and biomethane where needed. Successfully achieving the outcomes called for in this Scoping Plan would reduce demand for liquid petroleum by 94 percent

1 In October 2022, California was poised to become the world's fourth largest economy.

and total fossil fuel by 86 percent in 2045 relative to 2022.[2] Despite these world-leading efforts, some amount of residual emissions will remain from hard-to-abate industries such as cement, internal combustion vehicles still on the road, and other sources of GHGs, including high global warming chemicals used as refrigerants.

The plan addresses these remaining emissions by re-envisioning our natural and working lands—forests, shrublands/chaparral, croplands, wetlands, and other lands—to ensure they play as robust a role as possible in incorporating and storing more carbon in the trees, plants, soil, and wetlands that cover 90 percent of the state's 105 million acres while also thriving as a healthy ecosystem. Modeling indicates that natural and working lands will not, on their own, provide enough sequestration and storage to address the residual emissions. For that reason, it is necessary to research, develop, and deploy additional methods of capturing CO_2 that include pulling it from the smokestacks of facilities, or drawing it out of the atmosphere itself and then safely and permanently utilizing and storing it, as called for in recent legislation. Carbon removal also will be necessary to achieve net negative emissions to address historical GHGs already in the atmosphere.

This is a plan that aims to shatter the carbon status quo and take action to achieve a vision of California with a cleaner, more sustainable environment and thriving economy for our children. This ambitious plan will serve as a model for other partners around the world as they consider how to make their transition. As we have so often in the past, California can continue to serve as a leader in innovation that has produced not only the fifth largest economy on the planet, but ultimately one of the most energy-efficient economies, with a track record of demonstrating the ability to decouple economic growth from carbon pollution. This plan also builds upon current and previous environmental justice efforts to integrate environmental justice directly into the plan, to ensure that all communities can reap the benefits of this transformational plan. Specifically, this plan identifies a path to keep California on track to meet its SB 32 GHG reduction target of at least 40 percent below 1990 emissions by 2030.

2 See *CARB's energy demand reductions*.

- Identifies a technologically feasible, cost-effective path to achieve carbon neutrality by 2045 and a reduction in anthropogenic emissions by 85 percent below 1990 levels.
- Focuses on strategies for reducing California's dependency on petroleum to provide consumers with clean energy options that address climate change, improve air quality, and support economic growth and clean sector jobs.
- Integrates equity and protecting California's most impacted communities as driving principles throughout the document.
- Incorporates the contribution of natural and working lands (NWL) to the state's GHG emissions, as well as their role in achieving carbon neutrality.
- Relies on the most up-to-date science, including the need to deploy all viable tools to address the existential threat that climate change presents, including carbon capture and sequestration, as well as direct air capture.
- Evaluates the substantial health and economic benefits of taking action.
- Identifies key implementation actions to ensure success.

The path forward is informed by robust science. The recent Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) summarizes the latest scientific consensus on climate change. It finds that atmospheric concentrations of CO_2 have increased by 50 percent since the industrial revolution and continue to increase at a rate of two parts per million each year.[3] By the 2030s, and no later than 2040, the world will exceed 1.5°C warming unless there is drastic action. While every tenth of a degree matters—every incremental increase in warming brings additional negative impacts—climate-related risks to human health, livelihoods, and biodiversity are projected to increase further under 2°C warming, compared to 1.5°C.[4] For example, at 1.5°C of global warming, we would experience increasing heat waves, longer warm seasons, and shorter cold seasons, but at 2°C of global warming, heat extremes would more often reach critical tolerance thresholds for human health and agriculture.[5] We are already seeing unprecedented climate change impacts, such as continued sea level rise, that are "irreversible" for centuries to millennia, and we are dangerously close to hitting 1.5°C in the near term.[6] To avoid climate catastrophe and remain below 1.5°C with limited or no overshoot of that threshold, global net anthropogenic CO_2 emissions need to reach net zero by 2050.

3 *IPCC. 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.*

4 *IPCC. 2018. Global Warming of 1.5°C. World Meteorological Organization. Geneva, Switzerland. 32 pp.*

5 *IPCC. 2021. Climate change widespread, rapid, and intensifying – IPCC. August.*

6 *United Nations. 2021. IPCC report: 'Code red' for human driven global heating, warns UN chief. August 9.*

It has been 16 years since the Global Warming Solutions Act of 2006 was passed and signed into law. In 2017, the second update to the Assembly Bill (AB) 32 Climate Change Scoping Plan[7] (2017 Scoping Plan) laid out a cost-effective and technologically feasible path to achieve the 2030 GHG reduction target. At the time, many characterized the plan and the AB 32 target as unachievable, citing that it would lead to massive business and job loss, and excessive costs. Those predictions proved to be incorrect as California achieved its AB 32 target years ahead of schedule, all the while growing our economy, with the state distinguishing itself as a hub for green technology investment. This Scoping Plan draws on a decade and a half of proven successes and additional new approaches to provide a balanced and aggressive course of effective actions to achieve carbon neutrality in 2045, if not before, in addition to the 2030 goal.

California's economy is projected to grow vigorously in the coming years and decades. In 2045, under a Reference Scenario, the gross state product would be $5.1 trillion, nearly $2 trillion more than in 2021, and allow growth that would add hundreds of thousands of jobs. Under the Scoping Plan scenario, impacts to economic and job growth would be negligible in both 2035 and 2045, while delivering $199 billion of benefits in the form of reduced hospitalizations, asthma cases, and lost work and school days due to the cleaner air supported by this plan. This should come as no surprise given the tremendous growth of California's economy since the Great Recession of 2007–2009, even as the state has taken drastic measures to lower emissions. As noted, the savings associated with ambitious climate action are extensive, both in terms of avoided climate impacts and health costs. As described in Chapter 1, the health costs of climate and air pollution in the U.S. are well over $800 billion today and will continue to grow in the coming years[8] without robust action. Similarly, the costs of delayed or insufficient climate action could cost the U.S. upwards of $14.5 trillion over the next 50 years.[9] We can either take action now or pay the cost of inaction, both now and later.

We cannot take on this unprecedented challenge alone. Collaboration with the federal government, other U.S. states, and other jurisdictions around the world will continue to be fundamental for California to succeed in achieving its climate targets, especially as the pace of our efforts increases in the coming years. We believe this collaboration and coordination also creates a race to the top, encouraging and enabling other jurisdictions to achieve climate and air quality goals as well, and often providing lessons for national action.

One example of fruitful collaboration is California's longstanding vehicle emissions standards programs, which have repeatedly been freely adopted by other states, consistent with the federal Clean Air Act. California's programs frequently pioneer more rigorous standards or new technologies—such as the now-standard catalytic converter and the rules that led directly to the nation-leading numbers of zero-emission vehicles on our roads today. From initial standards for cars

7 *CARB. 2017. California's 2017 Climate Change Scoping Plan.*

8 *Alwis, D. D., and V. S. Limaye. No date. The Costs of Inaction: The Economic Burden of Fossil Fuels and Climate Change on Health in the United States. NRDC, The Medical Society Consortium on Climate and Health, and WHPCA.*

9 *Deloitte. 2022. The Turning Point: A New Economic Climate in the United States.*

and trucks decades ago to the world-leading Advanced Clean Trucks program currently helping to electrify heavy-duty vehicles, this partnership continues to offer regulatory options and spread innovative technologies. A major example of future work is the Advanced Clean Cars II program, which lays out California's legally binding path to achieving 100 percent zero emission vehicle (ZEV) sales in 2035.[10] The California Air Resources Board (CARB) continues to work closely with many other states that also see zero-emission vehicles as critical to their climate and public health goals and expects many states to choose to adopt this regulation as well. This partnership with other states also creates market certainty for automakers, which in turn helps to ensure that California consumers have access to a variety of ZEVs at multiple price points.

The Scoping Plan Process

Four scenarios were extensively modeled to develop this Scoping Plan, with the objective of informing the most viable path to remain on track to achieve our 2030 GHG reduction target: a reduction in anthropogenic emissions by 85% below 1990 levels and carbon neutrality by 2045. All four have their merits and are informed by stakeholder input. The scenario ultimately chosen as the basis of this Scoping Plan is the alternative that most closely aligns with existing statute and Executive Orders. It was selected because it best achieves the balance of cost-effectiveness, health benefits, and technological feasibility.

For the first time, this Scoping Plan includes modeling and quantification of GHG emissions and carbon sequestration in natural and working lands (NWL). To date, the focus has been only on reducing the emissions of GHGs from our transportation, energy, and industrial sectors. The state's 2020 and 2030 GHG reductions targets only include these sources, as they are the primary drivers of climate change and disproportionate harmful air pollution in our vulnerable communities. This Scoping Plan, through the lens of carbon neutrality, expands the scope to more meaningfully consider how our NWL contribute to our long-term climate goals. For the first time, new and cutting-edge modeling tools allow us to estimate the quantitative ability of our forests and other landscapes to remove and store carbon under different scenarios. These cutting-edge tools were developed through a stakeholder process and in coordination with other agencies for the purpose of this update and will continue to be refined over time and made available to others seeking to do similar work.

10 *Executive Department. State of California. Executive Order N-79-20.*

As recent data and Scoping Plan modeling shows, our NWL also can act as a source of emissions, principally in the form of wildfires. California's forests are experiencing a deadly combination of drought and heat combined with a century of misguided fire suppression management. Scoping Plan modeling shows that, at this time and until our forests reach a balance through appropriate treatments, California's NWL will act as a net source of emissions, not a sink. As such, the Scoping Plan includes policy direction and actions intended to quickly move the sector toward being a net sink and a more natural state, where wildfires will continue to be an important part of the healthy forest cycle but not at the intensity and frequency observed in recent years.

Development of this Scoping Plan also includes careful consideration of, and coordination with, other state agencies, consistent with Governor Gavin Newsom's whole-of-government approach to tackling climate change. State agency plans and regulations, including the SB 100 Joint Agency Report,[11] State Implementation Plan, Climate Action Plan for Transportation Infrastructure,[12] AB 74 Studies on Vehicle Emissions and Fuel Demand and Supply,[13,14,15] Short-Lived Climate Pollutant Strategy (SLCP Strategy),[16] CARB's Achieving Carbon Neutrality Report,[17] Climate Smart Lands Strategy,[18] Natural Working Land Implementation Plan,[19] and the California Climate Insurance Report: Protecting Communities, Preserving Nature, and Building Resiliency,[20] among others, provided critical inputs and data points for this plan. This Scoping Plan is the product of work by multiple agencies across the Administration, including dozens of public workshops and years of rigorous analysis and economic modeling by California's leading institutions. This cooperation on planning lays the foundation for even closer coordination among and between state agencies to put the plan into effect.

The plan is also the product of tireless efforts of, and recommendations from, the AB 32 Environmental Justice Advisory Committee (EJ Advisory Committee). The EJ Advisory Committee, created by statute, plays a critical role to inform the development of each Scoping Plan and helps to ensure environmental justice is integrated throughout the plan. CARB reconvened the EJ Advisory Committee in early 2021 to advise on the development of this Scoping Plan. In their advisory role, the EJ Advisory Committee has worked together to provide inputs to CARB to inform the development of scenarios and the associated modeling. And in April 2022, the EJ Advisory Committee provided draft preliminary recommendations in advance of the Draft 2022 Scoping Plan to help ensure the draft plan meaningfully addresses environmental justice. The CARB Board and EJ Advisory Committee held a joint board hearing on September 1, 2022, where the EJ Advisory Committee presented their final recommendations on the Scoping Plan. Over five dozen of the recommendations are reflected in the Scoping Plan. Going forward, as this plan is ultimately acted on by the Board, ongoing input from the EJ Advisory Committee will be essential to address environmental justice and achieve the ambitious vision outlined in the plan throughout its implementation in the coming years.

11 *California Public Utilities Commission (CPUC), California Energy Commission (CEC), and CARB. 2021. SB 100 Joint Agency Report.*

12 *California State Transportation Agency (CalSTA). 2021. Climate Action Plan for Transportation Infrastructure.*

13 *California Environmental Protection Agency (CalEPA). 2021. Carbon Neutrality Studies.*

14 *Brown, A. L., et. al. 2021. Driving California's Transportation Emissions to Zero. University of California Institute of Transportation Studies.*

15 *Deschenes, O. 2021. Enhancing equity while eliminating emissions in California's supply of transportation fuels. University of California Santa Barbara.*

16 *CARB. Short-Lived Climate Pollutants.*

17 *Energy and Environmental Economics, Inc. 2020. Achieving Carbon Neutrality in California: PATHWAYS Scenarios Developed for the California Air Resources Board. October.*

18 *California Natural Resources Agency (CNRA). 2021. Draft Climate Smart Lands Strategy.*

19 *CARB. 2019. Draft California 2030 Natural and Working Lands Climate Change Implementation Plan.*

20 *California Department of Insurance. 2021. Protecting Communities, Preserving Nature, and Building Resiliency.*

Importantly, per legislative direction, the Scoping Plan development includes modeling and analyses of emissions, economics, air quality, health, jobs, and public health. This work is important to inform the discussion around trade-offs and how to balance the various legislative direction in identifying a path to achieve the state's climate goals. The technical work serves as a backdrop to what this means to Californian's daily lives—to how they will work, play, and live as we act to eliminate fossil fuel combustion and achieve the many public health and environmental benefits that will result from that action.

Ensuring Equity and Affordability

The state has a long history of public health and environmental protection. However racist and discriminatory practices such as redlining have resulted in low-income communities and communities of color being disproportionately exposed to health hazards and pollution burdens.[21] These communities are often located adjacent to major roadways and large stationary sources that not only emit GHGs, but also harmful localized air pollution. The plan delivers on the promise to transform the way we move, live, and work by nearly eliminating our dependence on fossil fuels. It includes effective actions to move with all possible speed to clean energy, zero-emission cars and trucks, energy-efficient homes, sustainable agriculture, and resilient NWL. And it prioritizes working with the communities most impacted to ensure that these strategies address their needs.

An important part of our equity consideration is ensuring the transition to a zero-emission economy is affordable and accessible, and that it uplifts disadvantaged, low-income communities and communities of color. Some aspects of the transition will have associated costs (e.g., escalating efforts to retrofit existing homes and businesses to support electric appliances and vehicles and increased costs of insurance). The state must ensure that these costs do not disproportionately burden consumers. In addition, the state has an important role to play in providing financial incentives, especially to low-income consumers, to allow for uptake of clean technologies. The Department of Community Services and Development's Low Income Weatherization Program is a prime example of this approach, enabling low-income Californians to be part of the zero-emission transition, all while lowering energy bills. The program provides low-income households with solar

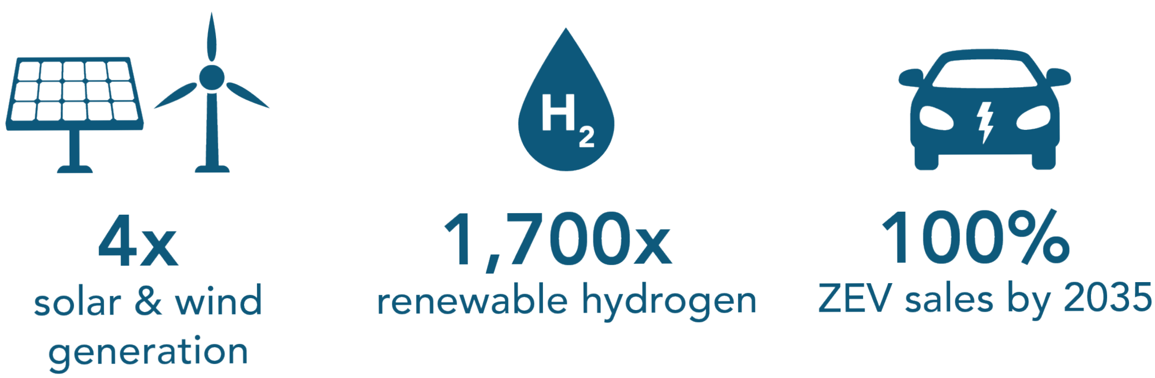
21 *CalEPA. 2021. Pollution and Prejudice: Redlining and Environmental Injustice in California. August 16.*

photovoltaic systems and energy efficiency upgrades at no cost to residents, helping cushion the impact of climate change on vulnerable communities.

With this Scoping Plan, the state also adds another tool to help identify and close climate change impact gaps that will emerge over time. As California invests in climate mitigation and adaptation, it is essential to understand the relative impact of climate change across the state's diverse communities. We know not all communities are equally resilient in the face of climate impacts due to persisting health and opportunity gaps. We also know that a global metric such as the Social Cost of Carbon cannot adequately capture the incremental additional impact faced by overly burdened communities. The Climate Vulnerability Metric (CVM) is specifically focused on quantifying the community-level impacts of a warming climate on human welfare.

Energy and Technology Transitions

To support the transformation needed, we must build the clean energy production and distribution infrastructure for a carbon-neutral future. The solution will have to include transitioning existing energy production and transmission infrastructure to produce zero-carbon electricity and hydrogen, and utilizing biogas resulting from wildfire management or landfill and dairy operations, among other substitutes. In almost all sectors, electrification will play an important role. That means that the grid will need to grow at unprecedented rates and ensure reliability, affordability, and resiliency through the next two decades and beyond. It also means we need to keep all options on the table, as it will take time to fully grow the electricity grid to be the backbone for a decarbonized economy. We also know that electrification is not possible in all situations. As such, this plan systematically evaluates and identifies feasible clean energy and technology options that will bring both near-term air quality benefits and deliver on longer-term climate goals.



This transition will not happen overnight. It will take time and planning to ensure a smooth transition of existing energy infrastructure and deployment of new clean technology. And while this Scoping Plan has the longest planning horizon of any Scoping Plan to date, this 25-year horizon is still relatively short in terms of transforming California's economy. We must avoid making choices that will lead to stranded assets and incorporate new technologies that emerge over time. Importantly, given the pace at which we must transition away from fossil fuels, we absolutely must identify and address market and implementation barriers to be successful. The scale of transition includes adding four times the solar and wind capacity by 2045 and about 1,700 times the amount of current hydrogen supply.

As we transition our energy systems, we must also rapidly deploy the clean technologies that rely on a decarbonized grid. As called for in Executive Order N-79-20, all new passenger vehicles sold in California will be zero-emission by 2035, and all other fleets will have transitioned to zero-emission as fully possible by 2045. This means the percentage of fossil fuel combustion vehicles will continue to rapidly decrease, becoming a fading vision of the past. Successful implementation of this Executive

Order (EO) and other zero-emission priorities will have to be attractive to consumers. As an example, electric and hydrogen transportation refueling must be readily accessible, and active transportation and clean transit options must be cheaper and more convenient than driving.

Cost-Effective Solutions Available Today

Ultimately, to achieve our climate goals, urgent efforts are needed to slash GHG emissions. Fortunately, cost-effective solutions are available to do so in many cases. In short, this plan relies on existing technologies—it does not require major technological breakthroughs that are highly uncertain.

For example, targeted action to reduce methane emissions can be achieved at low or negative cost, and with significant near-term climate and public health benefits. In many cases, renewable energy and energy storage are cheaper than polluting alternatives, and are already firmly part of our business-as-usual approach; modeling related to the most recent integrated resource planning process at the California Public Utilities Commission (CPUC) has shown that scenarios associated with the best emissions outcomes had the lowest average rates. As another example, research from Energy Innovation shows that the U.S. can achieve 100 percent zero-carbon power by 2035 without increasing customer costs.[22]

The same is either already true, or soon to be true, for zero-emission vehicles as well. Myriad studies show cost parity for light-duty and heavy-duty ZEVs being achieved by mid-decade or shortly thereafter. A carbon neutrality study conducted by the University of California (UC) Institute of Transportation Studies and funded by the California Environmental Protection Agency (CalEPA) shows that achieving carbon neutrality in the transportation sector will save Californians $167 billion through 2045.[23] Similar research from the Goldman School of Public Policy at UC Berkeley finds that achieving 100 percent light-duty ZEV sales nationwide would save consumers $2.7 trillion through 2050; equivalent to $1,000 per household, per year, for 30 years.[24]

22 *Phadke, A. et al. 2020. "Illustrative Pathways to 100 Percent Zero Carbon Power by 2035 Without Increasing Customer Costs, Energy Innovation." September.*

23 *Brown, A. L., et al. 2021. Driving California's Transportation Emissions.*

24 *Goldman School of Public Policy. 2021. 2035: The Report: Transportation. UC Berkeley. April.*

Many of these outcomes are a direct result of California's vision and policy development to advance clean energy and climate solutions, including through the Renewables Portfolio Standard, Advanced Clean Cars II regulations, SLCP Reduction Strategy, and others. While the world collectively has not yet fully deployed clean energy and climate solutions at the scale needed to adequately address climate change, California has made tremendous progress—even since the last Scoping Plan update in 2017. Continued ambition, leadership, and climate policy development from California will help the state achieve the scale of emissions reductions needed from technologies and strategies that are already cost-effective or close to it today, and will move additional technologies and strategies to that point in the near future. Achieving those outcomes and reducing costs for the entire array of climate solutions needed to achieve carbon neutrality and then maintain net-negative emissions will prove the true measure of California's success. This will enable California to not just meet our own climate targets, but to ultimately develop the replicable solutions that can scale globally to address global warming.

Continue with a Portfolio Approach

Over the past decade and a half, the state has undertaken a successful three-pronged approach to reducing GHGs: incentives, regulations, and carbon pricing. The 2017 Scoping Plan leveraged existing programs such as the Renewables Portfolio Standard, Advanced Clean Cars, Low Carbon Fuel Standard, Short-lived Climate Pollutant Strategy, mobile source measures to achieve federal air quality targets, and a Cap-and-Trade Program, among others, to lay out a technologically feasible and cost-effective path to achieve the 2030 GHG reduction target. When looking toward the 2045 climate goals and the deeper GHG reductions needed across the AB 32 GHG Inventory sectors, all of the existing programs must be evaluated and, as necessary, strengthened to support the rapid production and deployment of clean technology and energy, as well as the increased pace and scale of actions on our natural and working lands.

The challenge before us requires us to keep all tools on the table. Given the climate mitigation co-benefits, critical actions to deliver near-term air quality benefits, such as those included in the State Implementation Plan to achieve the federal air quality standards, are incorporated into this Scoping Plan, as are new legislative mandates to decarbonize the electricity and cement sectors. And, if additional gaps are identified, new programs and policies must be developed and implemented to ensure all sectors are on track to reduce emissions. Opportunities to leverage these programs to address ongoing air quality disparities must also be considered, along with targeted environmental justice policies such as the AB 617 Community Air Protection Program and the investments made possible through the California Climate Investments Program.

Conclusion

California has never undertaken such a comprehensive, far-reaching, and transformative approach to fighting climate change as that called for in this plan. Once implemented, it will place every aspect of how we live, work, play, and travel in California on a more sustainable footing, with a focus on directly benefitting those communities already most burdened by pollution. This comprehensive approach reflects how climate change is already changing life in California. We have all experienced the impacts of devastating wildfires, extreme heat, and drought. Despite much progress, California still has some of the worst air pollution in the nation, especially in the San Joaquin Valley and the Los Angeles Basin, which is driven by the continued use of fossil fuel-powered trucks and cars.

This Scoping Plan provides a solution; a way forward and a vision of a California where we can and will address those impacts. This plan is fundamentally based on hope. It is a hope grounded in experience and science that we can fundamentally improve the California we leave to future generations. The plan is built on the legacy of effective actions and on the conviction that we can effectively marshal the combined capabilities of California—from state, regional, tribal, and local governments to industry to our research institutions, and most importantly, to the nearly 40 million Californians who will benefit from the actions laid out in the plan. It addresses the challenge of our generation by laying out a pathway and guideposts for action across three decades. But the Scoping Plan is only that: a plan. The hard work—and hopeful work—is putting its recommendations into action. And there is no time to waste.

Post-adoption of the Scoping Plan

As with previous Scoping Plans, CARB Board approval is the beginning of the next phase of climate action. Specifically, approval of this plan catalyzes a number of efforts, including the development of new regulations as well as amendments to strengthen regulations and programs already in place, not just at CARB but across state agencies. The unprecedented rate of transition will also require the identification and removal of market and implementation barriers to the production and deployment of clean technology and energy. All of these actions and more will be needed if we are to achieve our climate goals.

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Chapter 1: Introduction

"The debate is over around climate change. Just come to the state of California. Observe it with your own eyes."

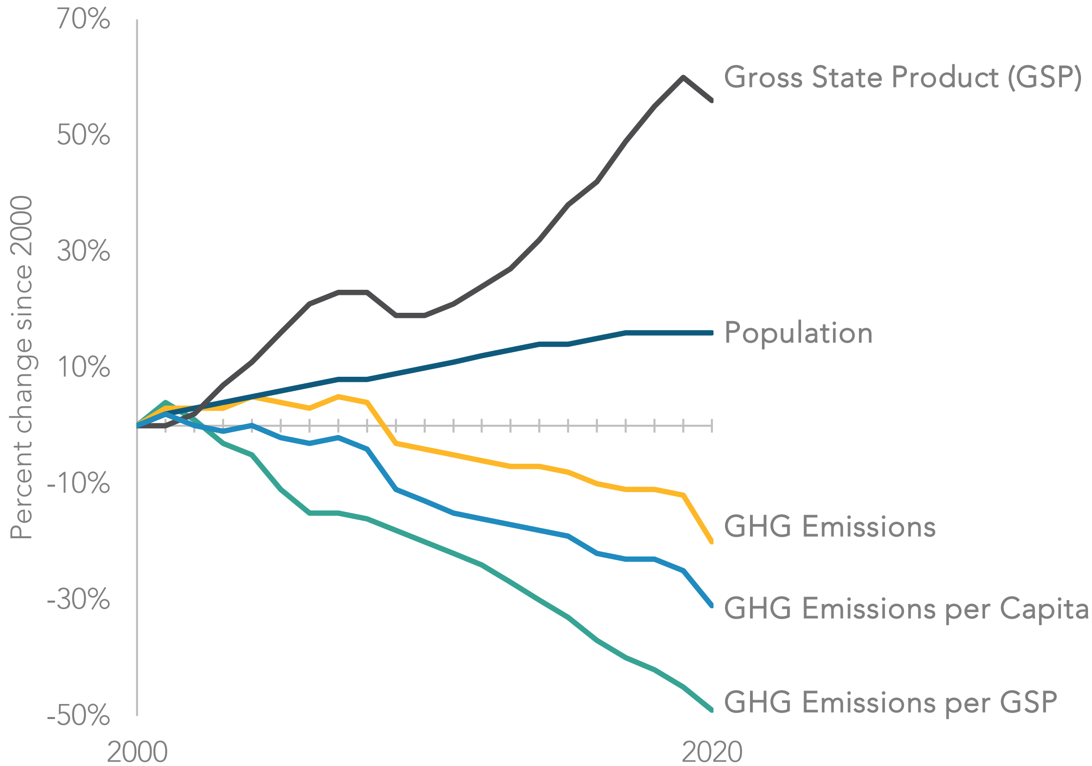
- California Governor Gavin Newsom in September 2020 after surveying the devastation caused by catastrophic wildfires

The impacts of climate change are no longer a distant threat on the horizon—they are right here, right now, with a growing intensity that is adversely affecting our communities and our environment, here in California and across the globe. The science that, decades ago, predicted the impacts we are currently experiencing is even stronger today and unambiguously tells us what we must do to limit irreversible damage: we must act with renewed commitment and focus to do more and do it sooner. That science is indisputable. Unless we increase ambition, we will be faced with more fire, more drought, more temperature extremes, and deadly, choking air pollution. The future of our state—our communities, economy, and ecosystems—is inextricably tied to the way we respond in this decade and the partnerships we forge along the way.

The impacts of climate change fall most heavily on frontline communities that bear the brunt of extreme heat, drought, wildfires, and other effects. Low-income communities and communities of color are also disproportionately impacted by fossil fuel combustion-related air pollution and related health problems. The continued phaseout of fossil fuel combustion will advance both climate and air quality goals and will deliver the greatest health benefits to the most impacted communities.

As it has responded to this climate crisis, California has established itself as a global leader in science-based, public health-focused climate change mitigation and air quality control. The California Legislature has worked with both Republican and Democratic governors to advance action on public health and environmental protections—and California has made progress on addressing climate change during periods of both Republican and Democratic federal administrations. Since the passage of Assembly Bill 32 (AB 32) (Núñez and Pavley, Chapter 488, Statutes of 2006), California has developed bold, creative, and durable policy solutions to protect our environment and public health, all while growing our economy. In fact, California met the target established in AB 32—a return of greenhouse gas (GHG) emissions to 1990 levels by 2020—years ahead of schedule, even as the state established itself as the one of the largest economies in the world. As Figure 1-1 below shows, California's emissions and economic growth have continued to decouple, and California is now the fifth largest economy in the world.

Figure 1-1: California total and per capita GHG emissions[25]



Recognizing both California's early successes in achieving GHG emissions reductions while growing the economy, as well as the worsening impacts of climate change, our governors and legislators have continued to enact ambitious goals. California's unwavering commitment to address climate change is based on indisputable science and data. This commitment is also informed by our collective efforts to address environmental justice and advance racial equity, such that race will no longer be a predictor for disproportionate environmental burdens faced by low-income communities and communities of color. As the Office of Environmental Health Hazard Assessment's

[25] Due to the global pandemic, 2020 is an outlier year and should not be considered indicative of a trend; emissions are likely to increase as economies recover from the impacts of the pandemic.

(OEHHA's) recent analysis of race/ethnicity and air pollution vulnerability and CalEnviroScreen 4.0 scores demonstrate, much work remains to be done.[26]

Many of California's environmental policies have served as models for similar policies in other U.S. states, and at national and international levels. Moving forward, California will continue its pursuit of collaborations and advocacy for action to address climate change at all levels of government. While California is responsible for just one percent of global GHG emissions, and we must do our part, we also play an important role in exporting both political will and technical solutions to address the climate crisis globally.

Today, we have a chance to re-envision California's future and set the state on a path to be carbon neutral no later than 2045 while advancing equity, addressing environmental justice, and continuing to grow our economy. This Scoping Plan provides a roadmap outlining key policies we can implement to achieve our climate goals while improving the health and welfare of Californians and addressing disparities in health outcomes to create a more equitable future. It will enable us to turn the corner in our efforts to protect and preserve our critical natural and public resources, all while providing unparalleled opportunities for clean, pollution-free economic growth.

Severity of Climate Change Impacts

With the increasing severity and frequency of drought, wildfire, extreme heat, and other impacts, Californians just have to look out their windows to know that climate change is real and rapidly getting worse. The impacts we thought we would see in the decades to come are happening now. We must act decisively to both reduce our GHG emissions and build resilience to these impacts for ourselves, future generations, and our iconic landscapes.

Wildfires

Of the twenty largest wildfires ever recorded in California, nine occurred in 2020 and 2021. The worst wildfire season in California's recorded history was in 2018, with over 24,226 structures damaged or destroyed and over 100 lives lost. The largest wildfire season ever recorded in state history was in 2020, where more than 4.3 million acres burned, albeit at different intensity and with varying ecological impacts, and over 112 million metric tons of

[26] OEHHA and CalEPA. 2021. Analysis of Race/Ethnicity and CalEnviroScreen 4.0 Scores. https://oehha.ca.gov/media/downloads/calenviroscreen/document/calenviroscreen40raceanalysisf2021.pdf.

carbon dioxide (CO_2) emitted into the atmosphere.[27] The economic damage of these fires was estimated to be over $10 billion in property damage and over $2 billion in fire suppression costs.[28] The Camp Fire, which destroyed much of Paradise, California, was the world's costliest natural disaster in 2018, with overall damages of $16.5 billion.[29] It was also the deadliest fire in California history, with 85 civilian fatalities. Wildfires have always been part of California's natural ecology and will continue to be. However, changes to the state's climate and precipitation expands the footprint of wildfire threat, severity, and intensity, with one quarter of California—more than 25 million acres—now classified as being under very high or extreme fire threat.[30]

The impacts of wildfire smoke have been linked to respiratory infections, cardiac arrests, low birth weight, mental health conditions, and exacerbated asthma and chronic obstructive pulmonary disease.[31] In 2020, with all of California covered by wildfire smoke for over 45 days—and 36 counties for at least 90 days—maximum fine particulate ($PM_{2.5}$) levels persisted in the "hazardous" range of the Air Quality Index for weeks in several areas of the state.[32,33]

Catastrophic wildfire damages extend beyond human health and the economy. The Castle Fire in 2020 and the KNP Complex and Windy Fires in 2021 led to the loss of an unprecedented number of giant sequoias: an estimated 13 to 19 percent of the giant

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[27] CARB. 2020. Public Comment Draft Greenhouse Gas Emissions of Contemporary Wildfire, Prescribed Fire, and Forest Management Activities. https://ww3.arb.ca.gov/cc/inventory/pubs/ca_ghg_wildfire_forestmanagement.pdf.

[28] News18. 2021. San Francisco Bay Area Receives its First Wildfire Warning of 2021, After California Concludes its Driest Year. https://www.news18.com/news/buzz/san-francisco-bay-area-receives-its-first-wildfire-warning-of-2021-after-california-concludes-its-driest-year-3722897.html.

[29] Munich RE. 2019. Extreme Storms, Wildfires and Droughts Cause Heavy Nat Cat Losses In 2018. https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2019/2019-01-08-extreme-storms-wildfires-and-droughts-cause-heavy-nat-cat-losses-in-2018.html#-1808457171.

[30] CARB. No date. Wildfires. https://ww2.arb.ca.gov/our-work/programs/wildfires/about.

[31] Reid, C. E., M. Brauer, F. H. Johnston, M. Jerrett, J. R. Balmes, and C. T. Elliott. 2016. "Critical Review of Health Impacts of Wildfire Smoke Exposure." *Environmental Health Perspectives* http://dx.doi.org/10.1289/ehp.1409277.

[32] Vargo J. A. 2020 (updated in 2021 using the NOAA Hazard Mapping System). "Time Series of Potential US Wildland Fire Smoke Exposures." *Frontiers in Public Health* https://doi.org/10.3389/fpubh.2020.00126.

[33] CalFire. 2020 *Fire Siege Report.* https://www.fire.ca.gov/media/hsviuuv3/cal-fire-2020-fire-siege.pdf.

sequoia population in the Sierra Nevada. An iconic species, giant sequoias are the largest trees on earth, with exceptional longevity outside of climate extremes.[34,35]

It is clear that we must take drastic measures to prepare for future wildfires, which is why California invested $2.7 billion in wildfire resilience from fiscal years 2020 to 2023. The exponential increase in funding launched more than 552 wildfire resilience projects in less than a year, and CAL FIRE met its 2025 goal of treating 100,000 acres a full three years ahead of schedule. Since Fiscal Year 2019–20, treatment work has significantly increased, and CAL FIRE has averaged 100,000 acres treated each fiscal year.

Although we are making progress, we have a lot more work to do in order to achieve our goal of treating one million acres annually by 2025. The Governor's Wildfire and Forest Resilience Strategy details 99 actions needed to address the key drivers of catastrophic wildfires, ramp up the pace and scale of forest management, and make threatened communities more resilient to catastrophic fires. It is also important to note that natural wildfire cycles are a part of a sustainable forest ecosystem and will continue to play a role in a healthy forests' future. We should not expect wildfires to cease, but we must manage our lands to address catastrophic wildfires that result from buildup of carbon stocks due to our interventions to suppress wildfires and from climate change resulting from fossil fuel combustion.

Drought

Drought is a recurring feature of the California climate that has been intensified by increasingly warmer average temperatures. Anthropogenic climate trends have exacerbated drought conditions; human-caused climate change accounts for 19 percent of drought severity and 42 percent of the soil moisture deficit in this region since 2000. The governor declared a drought state of emergency in October 2021, and as of September 2022, 94 percent of California was in severe drought, and 99.8 percent[36] of the state was in at least moderate drought. The first three months of 2022 were the driest January, February, and March on record in California.[37] The harsh drought conditions affecting California are part of a larger megadrought—a drought lasting more than two

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[34] Shive, K., C. Brigham, T. Caprio, and P. Hardwick. 2021. 2021 Fire Season Impacts to Giant Sequoias. The Nature Conservancy and National Park Service. https://www.nps.gov/articles/000/2021-fire-season-impacts-to-giant-sequoias.htm.

[35] Shive, K. L., A. Wuenschel, L. J. Hardlund, S. Morris, M. D. Meyer, and S. M. Hood. 2022. "Ancient Trees and Modern Wildfires: Declining Resilience to Wildfire in the Highly Fire-adapted Giant Sequoia." *Forest Ecology and Management* 511, 120110. https://doi.org/10.1016/j.foreco.2022.120110.

[36] Drought.gov. California. National Oceanic and Atmospheric Administration (NOAA) and the National Integrated Drought Information System. https://www.drought.gov/states/california.

[37] Drought.ca.gov. September 26, 2022. California Drought Update. https://drought.ca.gov/media/2022/09/Weekly-CA-Drought-Update-09262022-FINAL.pdf.

decades—that has been ongoing in the Southwestern region of North America since 2000. The past 22 years have been the region's driest period since at least 800 CE.[38]

While large urban water districts with diversified sources of water supply have maintained water deliveries to customers through the drought, hundreds of individual well owners and some small water systems have suffered disruption. The state is providing funding for water system consolidation and modernization projects in small communities, emergency repairs and replacements for dry wells, and bottled and hauled water deliveries. A 2021 law requires small suppliers to create drought contingency plans. During the drought of the last three years the state has delivered emergency drinking water assistance to nearly 10,000 households and 150 water systems.

California agriculture is responsible for more than half of all U.S. domestic fruit and vegetable production, and in 2021 drought resulted in the fallowing of nearly 400,000 acres of fields.[39] Direct crop revenue losses were approximately $962 million, and total economic impacts were more than $1.7 billion, with over 14,000 full- and part-time job losses.[40] During the 2011–2017 drought, California's agricultural industry suffered at least $5 billion in losses.[41] The 2022–23 budget includes $100 million to support agricultural water conservation practices, provide on-farm technical assistance, and provide direct relief to small farm operators.

Though native California species are adapted to drought, human engineering has altered most streams and wetlands in the state, making drought increasingly stressful to fish and wildlife. The state has conducted hundreds of fish and amphibian rescues in this drought to move creatures from diminished habitat, upgraded hatcheries, and boosted hatchery production, and has hauled millions of young hatchery salmon to San Francisco Bay to avoid adverse river conditions. State biologists monitor dozens of streams statewide and have negotiated voluntary agreements with landowners and water users to improve stream flows and temperatures.

California has started to implement major policies to build resilience to combat drought—such as the Sustainable Groundwater Management Act of 2014, the governor's Water Resilience Portfolio (2020), the governor's Water and Supply Strategy (August 2022), and

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[38] Williams, A. P., B. I. Cook, and J. E. Smerdon. 2022. "Rapid Intensification of The Emerging Southwestern North American Megadrought in 2020–2021." *Nature Climate Change* https://doi.org/10.1038/s41558-022-01290-z.

[39] Medellín-Azuara, J. 2022. *Economic Impacts of the 2021 Drought on California Agriculture.* University of California Merced. https://wsm.ucmerced.edu/wp-content/uploads/2022/02/2021-Drought-Impact-Assessment_20210224.pdf.

[40] Medellín-Azuara. *Economic Impacts of the 2021 Drought*.

[41] National Resources Defense Council (NRDC). 2019. Climate Change and Health in California. Issue Brief. https://www.nrdc.org/sites/default/files/climate-change-health-impacts-california-ib.pdf.

new standards for indoor, outdoor, and industrial water use. However, it is crucial that we take further actions to minimize the impacts of drought in the years to come.

Extreme Heat

California's hottest summer on record was 2021.[42] Death Valley recorded the world's highest reliably measured temperature (130°F) in July 2021, breaking its own record (129°F) from summer 2020.[43] Meanwhile, Fresno also broke one of its own records, with 64 days over 100°F in 2021.[44] This is part of a trend: the daily maximum average temperature, an indicator of extreme temperature shifts, is expected to rise 4.4°F–5.8°F by 2050 and 5.6°F–8.8°F by 2100.[45] Heat waves that result in public health impacts are also projected to worsen throughout the state. By 2050, these heat-related health events are projected to last two weeks longer in the Central Valley and occur four to ten times more often in the Northern Sierra region.[46]

Heat ranks among the deadliest of all climate hazards in California, and heat waves in cities are projected to cause two to three times more heat-related deaths by mid-century.[47] Climate vulnerable communities[48] will experience the worst of these effects, as heat risk is associated and correlated with physical, social, political, and economic factors. Aging populations, infants and children, pregnant people, and people with chronic illness are especially sensitive to heat exposure.[49,50] Combining these characteristics and existing health inequities with additional factors such as poverty, linguistic isolation,

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[42] NOAA. 2022. Climate at a Glance. https://www.ncdc.noaa.gov/cag/statewide/time-series/4/tavg/3/8/1895-2021?base_prd=true&firstbaseyear=1901&lastbaseyear=2000.

[43] Masters, J. 2021. Death Valley, California, breaks the all-time world heat record for the second year in a row. Yale Climate Connections. https://yaleclimateconnections.org/2021/07/death-valley-california-breaks-the-all-time-world-heat-record-for-the-second-year-in-a-row/.

[44] NOAA. Climate Data Online Search. Accessed on 16 March 2022. https://www.ncdc.noaa.gov/cdo-web/search.

[45] Governor's Office of Planning and Research (OPR), CEC, and CNRA. 2018. *California's Fourth Climate Change Assessment*. Page 23. https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf.

[46] OPR, CEC, and CNRA. *California's Fourth Climate Change Assessment - Statewide Summary Report.* https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf.

[47] Ostro, B., S. Rauch, and S. Green. 2011. "Quantifying the health impacts of future changes in temperature in California." National Library of Medicine. https://pubmed.ncbi.nlm.nih.gov/21975126/.

[48] CARB. Priority Populations. California Climate Investments. https://www.caclimateinvestments.ca.gov/priority-populations.

[49] Basu, R. 2009. "High Ambient Temperature and Mortality: A Review of Epidemiologic Studies from 2001 to 2008." National Library of Medicine. https://pubmed.ncbi.nlm.nih.gov/19758453/.

[50] Basu, R., and B. Malig. 2011. "High Ambient Temperature and Mortality in California: Exploring the Roles of Age, Disease, and Mortality Displacement." National Library of Medicine. https://pubmed.ncbi.nlm.nih.gov/21981982/.

housing insecurity, and the legacy of racist redlining practices, can put individuals at a disproportionately high risk of heat-related illness and death.[51,52] Rising temperatures will also speed up smog-forming chemical reactions, leading to worse asthma, reduced lung function, cardiac arrest, and cognitive decline. African American, American Indian/Alaskan Native, and Puerto Rican Californians are particularly sensitive to smog, as they are between 28.6 and 132.5 percent more likely to be diagnosed with asthma than white Californians.[53]

In addition to the dangers to public health, California's September 2022 heat wave is particularly illustrative of how more frequent extreme heat strains the state's infrastructure we depend on to adapt to a changing climate. For example, as all-time high temperature records were broken in Sacramento, San Jose, Santa Rosa and Fairfield, electricity demand for air conditioning threatened to overwhelm the state power supply.[54]

California has taken major steps to protect communities from the impacts of extreme heat. Our recent budgets invest $800 million to cool our schools and neighborhoods, including projects to reduce urban overheating. The Extreme Heat Action Plan, released in April 2022, outlines the all-of-government approach California is taking to reduce urgent risks and build long-term resilience to the impacts of extreme heat. In September 2022, Governor Newsom signed multiple bills addressing extreme heat, including AB 2238 (Rivas, Chapter 264, Statutes of 2022), which will create the nation's first extreme heat advance warning and ranking system to better prepare communities ahead of heat waves. The Administration is committed to addressing extreme heat, but we still have a lot of work to do.

Wildfires, drought, and extreme heat are some of the most pronounced climate impacts California is experiencing, but they are not the only ones. Sea level rise, rising ocean temperatures, ocean acidification, and inland flooding are also already having devastating impacts on our communities, ecosystems, and economy, and will continue to do so in the years and decades to come. The decisions and actions that we take today will determine how strongly we will feel the impacts of climate change in the future.

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[51] Hoffman, J. S., V. Shandas, and N. Pendleton. 2020. "The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas." MDPI. https://www.mdpi.com/2225-1154/8/1/12/htm.

[52] U.S. Climate Resilience Toolkit. No date. Heat and Social Inequity in the United States. https://toolkit.climate.gov/tool/heat-and-social-inequity-united-states.

[53] NRDC. 2019. Climate Change and Health. Issue Brief. https://www.nrdc.org/sites/default/files/climate-change-health-impacts-california-ib.pdf.

[54] Samenow, Jason. 2022. No September on record in the West has seen a heat wave like this. *The Washington Post.* September 9. https://www.washingtonpost.com/climate-environment/2022/09/08/western-heatwave-records-california-climate/.

Imperative To Act

Consequences of Further Warming

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) found that it will not be possible to keep global warming within the threshold of 1.5°C to avoid the most severe impacts of climate change unless we make immediate and large-scale reductions in GHG emissions. It finds that atmospheric concentrations of CO_2 have increased by 50 percent since the industrial revolution, and that they continue to increase at a rate of two parts per million each year.[55] Without immediate action, the world will exceed 1.5°C (or 2.7°F) warming by the 2030s, and no later than 2040.

While every tenth of a degree matters—every incremental increase in warming brings additional negative impacts—climate-related risks to human health, livelihoods, and biodiversity are projected to increase further under 2°C (or 3.6°F) warming, compared to 1.5°C.[56] To remain below 1.5°C with limited or no overshoot of that threshold, global net anthropogenic CO_2 emissions need to be cut by about half by 2030 and reach net-zero by 2050.

If we fail to make rapid changes, we may not be able to limit global warming to 2°C,[57] and the consequences of inaction would be catastrophic. Our planet is already 1.2°C warmer than pre-industrial times due to human-induced warming, and many impacts we are already experiencing, such as sea level rise, are "irreversible" for centuries to millennia.[58] Californians with the fewest resources, who are disproportionately low-income communities and communities of color, are the most vulnerable to the impacts of climate change. While the human costs associated with health impacts can never be fully monetized, a recent report finds that the health costs of climate and air pollution in the U.S. are well over $800 billion today and will continue to grow in the coming years.[59]

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[55] IPCC. 2021. *Climate Change 2021: The Physical Science Basis.* https://www.ipcc.ch/report/ar6/wg1/.

[56] IPCC. 2018. *Special Report: Global Warming of 1.5°C.* World Meteorological Organization. https://www.ipcc.ch/sr15/.

[57] IPCC. 2021. Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. In Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.

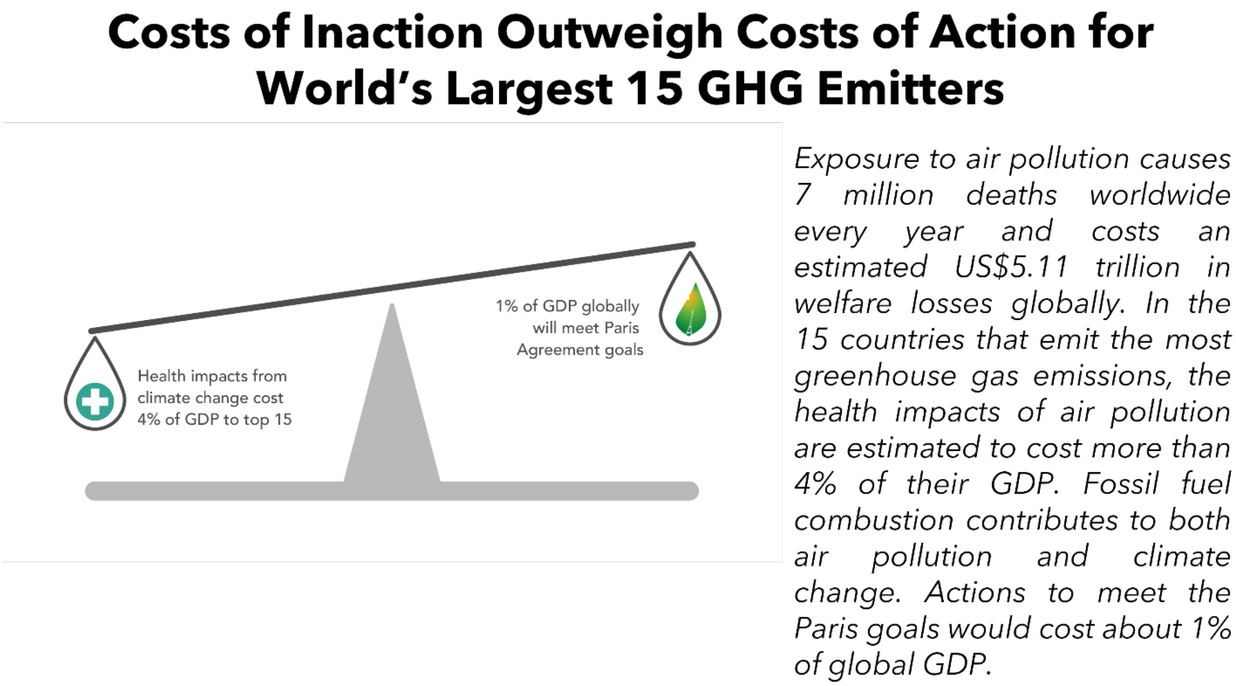
[58] United Nations. 2021. IPCC report: 'Code red.' https://news.un.org/en/story/2021/08/1097362#:~:text=%27Code%20red%20for%20humanity%27&text=We%20are%20at%20imminent%20risk,%2C%20to%20keep%201.5%20alive.%22.

[59] Alwis, D. D., and V. S. Limaye. No date. *The Costs of Inaction.* https://www.nrdc.org/sites/default/files/costs-inaction-burden-health-report.pdf.

Any delays in action or insufficient action are a threat to public health and the environment. The impacts to our economy would be devastating as well. While not specific to California, a 2022 report from Deloitte Economics Institute finds that failing to take sufficient action to reduce emissions could result in economic losses to the U.S. of more than $14.5 trillion over the next 50 years.[60] On a hopeful note, however, the report finds that if the country invests now and in the coming years in a net-zero economy, $3 trillion could be added to the economy over the next 50 years. The U.S. annual gross domestic product (GDP) would be 2.5 percent higher in 2070 in this fast-action scenario than in the delayed action scenario. The lessons for California from these analyses are clear: invest now or pay the price later. As shown in Figure 1-2, inaction can lead to negative consequences for individuals, communities, the economy, and society as a whole. As discussed later, Governor Newsom and the Legislature have accepted this imperative and made significant investments in climate action. This Scoping Plan combined with the historic investments and policy direction from the governor and Legislature, will result in unprecedented action to address the climate crisis.

[60] Deloitte. 2022. *The Turning Point.* https://www2.deloitte.com/content/dam/Deloitte/us/Documents/about-deloitte/us-the-turning-point-a-new-economic-climate-in-the-united-states-january-2022.pdf?id=us:2el:3dp:wsjspon:awa:WSJSBJ:2021:WSJFY22.

Figure 1-2: The real costs of inaction[61]



Scoping Plan Overview

Previous Scoping Plans

The Scoping Plan is a strategy the California Air Resources Board (CARB) develops and updates at least one every five years, as required by AB 32. It lays out the transformations needed across our society and economy to reduce emissions and reach our climate targets. This Scoping Plan is the third update to the original plan that was adopted in 2008. The initial Scoping Plan laid out a path to achieve the AB 32 2020 limit of returning to 1990 levels of GHG emissions, a reduction of approximately 15 percent below business as usual.[62] The 2008 Scoping Plan included a mix of incentives, regulations, and carbon pricing, laying out the portfolio approach to addressing climate change and clearly making the case for using multiple tools to meet California's GHG targets. The 2013 Scoping Plan assessed progress toward achieving the 2020 limit and made the case for addressing

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[61] Katowice, P. 2018. *Health benefits far outweigh the costs of meeting climate change goals.* WHO. https://www.who.int/news/item/05-12-2018-health-benefits-far-outweigh-the-costs-of-meeting-climate-change-goals.
[62] CARB. 2008. *Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/document/adopted_scoping_plan.pdf.

short-lived climate pollutants (SLCPs).[63] The most recent update, the 2017 Scoping Plan,[64] also assessed the progress toward achieving the 2020 limit and provided a technologically feasible and cost-effective path to achieving the Senate Bill 32 (SB 32, Pavley, Chapter 249, Statutes of 2016) target of reducing GHGs by at least 40 percent below 1990 levels by 2030.

Overview of this Scoping Plan

It is paramount that we continue to build on California's success by taking effective actions and doubling down on implementation of the strategies outlined here. As such, this Scoping Plan builds on and integrates efforts already underway to reduce the state's GHG, criteria pollutant, and toxic air contaminant emissions by identifying the clean technologies and fuels that should be phased in as the state transitions away from combustion of fossil fuels. By selecting and pursuing a sustainable and clean economic path, the state will continue to successfully execute existing programs, work to eliminate air pollution inequities, demonstrate the coupling of economic growth and environmental progress, and enhance new opportunities for engagement within the state to address and prepare for climate change.

The 2022 Scoping Plan for Achieving Carbon Neutrality (Scoping Plan) is the most comprehensive and far-reaching Scoping Plan developed to date. It identifies a technologically feasible and cost-effective path to achieve carbon neutrality by 2045 while also assessing the progress California is making toward reducing its GHG emissions by at least 40 percent below 1990 levels by 2030, as called for in SB 32 and laid out in the 2017 Scoping Plan.[65] The 2030 target is an interim but important stepping stone along the critical path to the broader goal of deep decarbonization by 2045. Modeling for this Scoping Plan shows that this decade must be one of transformation on a scale never seen before to set us up for success in 2045.

The relatively longer path assessed in this Scoping Plan incorporates, coordinates, and leverages many existing and ongoing efforts to reduce GHGs and air pollution, while identifying new clean technologies and energy. Given the focus on carbon neutrality, this Scoping Plan also includes discussion for the first time of the Natural and Working Lands (NWL) sectors as both sources of emissions and carbon sinks. Chapter 2 of this document

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[63] CARB. 2014. *First Update to the Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.
[64] CARB. 2017. *California's 2017 Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf.
[65] CARB. 2017. *California's 2017 Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf.

includes a description of a suite of specific actions to drastically reduce GHGs across all sectors. Chapter 3 provides the air quality and economic evaluations of the actions. Chapter 4 provides a broader description of the many actions needed across all sectors to achieve carbon neutrality. Chapter 5 provides an overview of the next steps and partnerships needed to implement this Scoping Plan. Guided by legislative direction, the actions identified in this Scoping Plan reduce overall GHG emissions in California and deliver policy signals that will continue to drive investment and certainty in a low carbon economy. This Scoping Plan builds upon the successful framework established by the Initial Scoping Plan and subsequent updates while identifying new, technologically feasible, and cost-effective strategies.

Principles That Inform Our Approach to Addressing the Climate Challenge

California has decades of experience addressing the climate challenge. Through this experience, and based on extensive engagement with stakeholders through our regulatory and program development processes, we have developed a set of principles to inform our approach.

Unprecedented Investments in a Sustainable Future

The scale of transformation needed over this decade to avoid the worst impacts of climate change and meet our ambitious climate goals is extraordinary. This is why Governor Newsom and the Legislature invested over $15 billion in climate action through the 2021–2022 California Comeback Plan, and why the 2022–2023 budget marks the beginning of the California Climate Commitment—the governor's multi-year plan to invest $54 billion in climate action. The enacted budgets (Figure 1-3) and the California Climate Commitment represent investments of a historic scale and will advance precisely the type of all-of-government approaches necessary to create the whole-of-society changes described in this Scoping Plan that will enable us to avert the worst impacts of climate change.

Figure 1-3: Comprehensive California climate change investments

The *California Climate Commitment* includes the following game-changing elements:

- $10 billion for zero-emission vehicles (ZEVs), including $1.5 billion for electric school buses to protect students' health and $3 billion to build an accessible charging network. ZEV investments will particularly focus on programs such as heavy-duty vehicle and port electrification that will reduce emissions and protect public health in low-income communities.
- $2.1 billion for clean energy investments, such as long duration storage, offshore wind, green hydrogen,[66] and industrial decarbonization.
- $13.8 billion for programs that reduce emissions from the transportation sector, such as improving public transportation while also funding walking, biking, and adaptation projects.
- Over $720 million for California's higher education institutions and research that will support the next generation of climate innovations.

[66] For the purposes of this Scoping Plan, "renewable hydrogen" and "green hydrogen" are interchangeable and are not limited to only electrolytic hydrogen produced from renewables.

- Nearly $1 billion to build sustainable, affordable housing and over $1 billion to help low-income Californians realize energy cost savings through building decarbonization.
- Nearly $9 billion for wildfire risk reduction, drought mitigation, extreme heat resilience, and nature-based solutions.

These investments are incredibly important in the context of this Scoping Plan in that they accompany and help support implementation of the many policies and regulations that will continue to be necessary to achieve our 2030 and carbon neutrality targets. In addition, these incentive programs jump-start emission reduction strategies for priority sectors, sources, and technologies, leveraging private-sector investment and building sustainable, growing markets for clean and efficient technologies. Many of California's incentive programs work in concert with federal and other state programs to drive emission reductions. As an example, as California pushes to move to 100% sales of new zero emission-vehicles, including plug-in hybrid vehicles, the Newsom Administration continues to invest heavily in incentive programs that allow families, communities, and businesses to choose zero-emission vehicles. This is done while simultaneously working with the federal government, other states, and jurisdictions around the world to align policies, regulations, and incentives, creating market certainty for the automakers that serve our markets.

Centering Equity

Prioritizing equity is just as important as the magnitude of the climate investments California is making. Addressing climate change and advancing our equity and economic opportunity goals cannot be decoupled. In line with the governor's Executive Order[67] to take additional actions to embed equity analysis and considerations, this plan works to center equity by addressing disparities for historically underserved and marginalized communities. California strives to ensure that our climate and air research, regulations, investments, and plans include provisions that specifically address and advance equity. This includes reducing and eliminating air pollution disparities, removing barriers that can prevent frontline communities from accessing benefits, lowering costs for low-income Californians, and promoting high-quality jobs. CARB's incentive programs regularly surpass their mandated equity targets, and CARB has incorporated equity-focused provisions in our research, planning, and regulatory efforts. For instance, statute requires that a minimum of 35 percent of California Climate Investments benefit low-income households along with disadvantaged and low-income communities (referred to as *priority*

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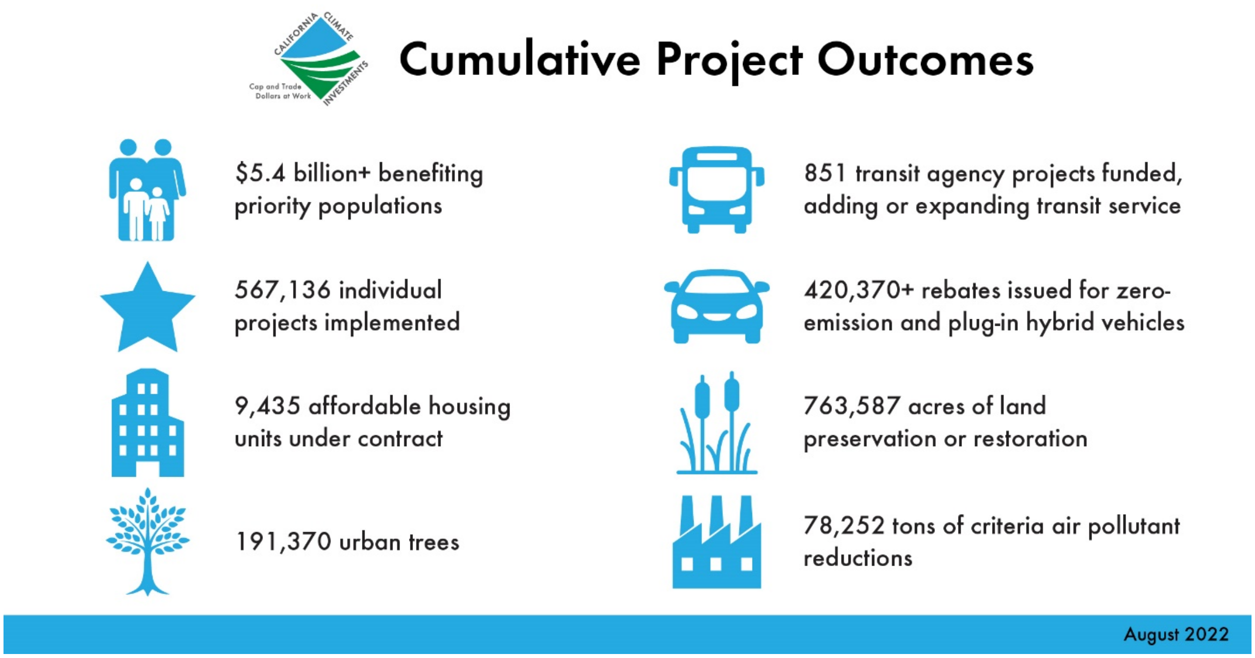
[67] Executive Department. State of California. 2022. Executive Order N-16-22. GSS_9320_2-20220912152941 (ca.gov).

populations). However, 48 percent—over $5.4 billion—of implemented California Climate Investments project funding is benefiting priority populations, greatly exceeding the statutory minimums (see Figure 1-4). Senate Bill 535 (De León, Chapter 830, Statutes of 2012) and AB 1550 (Gomez, Chapter 369, Statutes of 2016) direct state and local agencies to make significant investments using auction proceeds to assist California's most vulnerable communities. Under these laws, a minimum of 25 percent of the total investments are required to be located within and provide benefits to disadvantaged communities, and at least 10 percent of the total investments must benefit low-income communities and households. Moving forward, the state will continue to devote a greater share of incentive funding to priority populations, with the light-duty vehicle incentive program as just one example. We can simultaneously confront the climate crisis and build a more resilient, just, and equitable future for all communities.

Figure 1-4: California climate investments cumulative outcomes[68,69]



Role of the Environmental Justice Advisory Committee

To inform the development of the Scoping Plan, AB 32 calls for the convening of an Environmental Justice Advisory Committee (EJ Advisory Committee) to advise CARB in developing the Scoping Plan, and any other pertinent matter in implementing AB 32. It requires that the Committee be comprised of representatives from communities with the most significant exposure to air pollution, including communities with minority populations and/or low-income populations. On January 25, 2007, CARB appointed the first

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[68] CARB. 2022. California Climate Investments program implements $10.5 billion in greenhouse gas-reducing programs, expected to reduce 76 million metric tons of emissions. April 11. https://ww2.arb.ca.gov/news/california-climate-investments-program-implements-105-billion-greenhouse-gas-reducing-projects.

[69] SB 535 and AB 1550 require investments located in and benefiting low-income communities and households, which are termed *priority populations. Disadvantaged communities* are currently defined by CalEPA as the top 25 percent of communities experiencing disproportionate amounts of pollution, environmental degradation, and socioeconomic and public health conditions according to the Office of Environmental Health Hazard Assessment's *CalEnviroScreen tool,* plus certain additional communities including federally recognized Tribal Lands. Low-income communities and households are defined by statute as those with incomes either at or below 80 percent of the statewide median or below a threshold designated as low-income by the Department of Housing and Community Development.

Environmental Justice Advisory Committee to advise it on the Initial Scoping Plan and other climate change programs.

For this Scoping Plan, CARB reconvened the EJ Advisory Committee in May 2021. The committee is currently comprised of 14 environmental justice and disadvantaged community representatives, including the EJ Advisory Committee's first tribal representative, who was appointed in February 2022. In October 2021, the EJ Advisory Committee formally created eight workgroups. These workgroups are a space for EJ Advisory Committee members to better understand specific sectors of the Scoping Plan and to assist the EJ Advisory Committee in the development of recommendations on this Scoping Plan. In December 2021, the EJ Advisory Committee provided scenario input responses to help shape the modeling for this Scoping Plan. In February 2022, San Joaquin Valley EJ Advisory Committee members hosted their first community workshop, with over 100 attendees. In March 2022, the CARB Board held a joint public meeting with the EJ Advisory Committee to discuss their draft preliminary recommendations for this Scoping Plan. In June 2022, over 165 attendees participated in a statewide community workshop held by EJ Advisory Committee members. The full schedule of EJ Advisory Committee Meetings and meeting materials are available on CARB's website.[70] This Scoping Plan includes references where EJ Advisory Committee Final Recommendations[71] are included in the document. The final recommendations were discussed at a joint CARB and EJ Advisory Committee Hearing on September 1, 2022.

The integration of environmental justice is critical to ensure that certain communities are not left behind. The AB 32 EJ Advisory Committee provided recommendations on September 30 in advance of the final Scoping Plan. There are footnotes to indicate where there is alignment between the AB 32 EJ Advisory Committee's recommendations and this Scoping Plan. While the language in the text may not fully incorporate the specific EJ Advisory Committee's recommendation, the footnotes do acknowledge the places in the text where there is general alignment with the spirit of the EJ Advisory Committee's recommendation.

Partnering with Tribes

[70] CARB. Environmental Justice Advisory Committee Meetings and Events. https://ww2.arb.ca.gov/environmental-justice-advisory-committee-meetings-and-events.
[71] Environmental Justice Advisory Committee. September 30, 2022. 2022 Scoping Plan Recommendations. https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/090122/finalejacrecs.pdf.

There are 109 federally recognized tribes and over 60 non-federally recognized tribes in California.[72] In 2011, Governor Brown issued Executive Order B-10-11, recognizing and reaffirming the inherent right of tribes to exercise sovereign authority over their members and territory and directing state agencies to engage in government-to-government consultation with tribe and to work to develop partnerships and consensus.[73] In 2019, Governor Newsom issued Executive Order N-15-19, which acknowledges and apologizes on behalf of the state for the historical "violence, exploitation, dispossession and the attempted destruction of tribal communities."[74] Establishing partnerships with tribal leaders to incorporate their priorities, traditional expertise, and knowledge will be important to achieving California's climate goals. The Scoping Plan includes actions that tribal partners can voluntarily implement for sources under their jurisdiction (e.g., transitioning to zero emission fleets, installing infrastructure and control technologies, conducting climate smart land management). The Scoping Plan also uplifts the importance of having our tribal partners help guide actions that may impact tribal cultural resources and of benefitting from tribal input.

We also need alignment between state and local partners and tribes on actions related to land-use decisions. This means respecting and reinforcing tribal sovereignty and self-determination. As tribes do not always draw clear lines between the "natural" and "cultural" resources of a place, taking a holistic perspective will result in positive impacts in ability to address the complex issues of land management and regulatory undertakings.

Tribes have an intimate and historical knowledge of places and should be engaged early on to inform planning and future management related to activities that may impact tribal resources and areas including potential funding opportunities, technical assistance, and capacity building, where appropriate. Additionally, tribes should be involved in the identification of their own significant resources and areas of use. As decisions are made related to Scoping Plan undertakings, agencies should recognize and appropriately consider cultural resources and management from the beginning, not as an afterthought; and consider how the project could impact tribes.

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[72] These numbers are subject to change depending on determinations made by the Bureau of Indian Affairs (BIA) and the Native American Heritage Commission (NAHC). Please consult the most current Federal Register for a list of federally recognized tribes and the NAHC for a list of non-federally recognized tribes in California. As of the date of the Scoping Plan, the current list for federally recognized tribes is located at 87 Fed. Reg. 4636 (Jan. 28, 2022).

[73] Executive Order B-10-11. https://www.ca.gov/archive/gov39/2011/09/19/news17223/index.html#:~:text=EXECUTIVE%20ORDER%20B-10-11%20Published%3A%20Sep%2019%2C%202011%20WHEREAS,and%20affirmed%20in%20state%20and%20federal%20law%3B%20and.

[74] Executive Order N-15-19. https://tribalaffairs.ca.gov/wp-content/uploads/sites/10/2020/02/Executive-Order-N-15-19.pdf.

Finally, to the extent allowed by law, traditional ecological knowledge and culturally sensitive information should be protected, as this is information that may not be common knowledge and may not be known outside the tribe, as each tribe is unique and influenced by its local environment and cultural practices. Protection of this information will help foster productive relationships with tribes and should be included as part of the process. CARB and other agencies should continue to foster relationships with tribal partners.

Maximizing Air Quality and Health Benefits

The state has over 50 years of experience successfully cleaning the air in California by addressing criteria pollutants and toxic air contaminants from mobile and stationary sources. CARB has been a leader in measuring, evaluating, and reducing sources of air pollution that impact public health. Its air pollution programs have been adapted for national programs and emulated in other countries. Significant progress has been made in reducing diesel particulate matter (PM), which is a designated toxic air contaminant, and many other hazardous air pollutants. CARB partners with local air districts to address stationary source emissions and adopts and implements state-level regulations to address sources of criteria and toxic air pollution, including mobile sources. CARB also collaborates with federal agencies to address air pollution from sources primarily under federal jurisdiction. In many instances, actions to reduce fossil fuel combustion and achieve federal air quality standards also help to reduce GHG emissions.

However, air pollution disparities still exist, and more must be done to ensure the most vulnerable populations have safe air to breathe. California must continue to evaluate opportunities to harmonize our climate and air quality programs through innovative policymaking and by building on existing programs like the Low Carbon Fuel Standard (LCFS) and Community Air Protection Program. The LCFS includes a provision that allows electric utilities to opt-in and generate residential electric vehicle (EV) charging credits, where some of the revenues are invested back into rebate programs that address air quality and climate pollution.[75] The Community Air Protection Program[76] is the first of its kind in the country and brings together diverse stakeholders, including CARB, local air districts, and residents of environmental justice communities to increase local air monitoring and develop community-led plans to improve air quality in the communities most impacted by air pollution.

This Scoping Plan identifies actions that will deliver near-term air quality benefits to communities with the highest exposures and provide long-term GHG benefits. Many of the actions in this Scoping Plan are key elements of the 2022 State Strategy for the State

[75] CARB. LCFS Utility Rebate Programs. https://ww2.arb.ca.gov/resources/documents/lcfs-utility-rebate-programs.

[76] CARB. Community Air Protection Program. https://ww2.arb.ca.gov/capp.

Implementation Plan to meet federal air quality standards,[77] which has a primary focus of reducing harmful air pollution and achieving federal air quality targets. California's approach of leveraging air quality and GHG policies together has yielded results. A 2022 report by the Office of Environmental Health and Hazard Assessment (OEHHA)[78] that evaluated GHG and harmful air pollution emissions from the heavy-duty vehicle (HDV) and large stationary source sectors found declines in emissions in both sectors, with the greatest declines in disadvantaged communities. Both sectors are subject to state GHG and air quality policies, in addition to federal and local rules on harmful air pollution. Because of historically racist and discriminatory practices such as redlining, both types of sources are disproportionately located adjacent to vulnerable communities, which are predominantly communities of color.[79] The key findings from the OEHHA report are as follows:

- Both HDVs and facilities subject to the Cap-and-Trade Program have reduced emissions of co-pollutants, with HDVs showing a clearer downward trend when compared to stationary sources. These emission reductions have major health benefits, including a reduction in premature pollution-related deaths.
- The greatest beneficiaries of reduced emissions from both HDVs and facilities subject to the Cap-and-Trade Program have been in communities of color and in disadvantaged communities in California, as identified by CalEnviroScreen (CES). This has reduced the emission gap between disadvantaged and non-disadvantaged communities, but a wide gap still remains.
- The transition to zero-emission HDVs will expedite further emissions reductions.
- While the progress observed is encouraging, inequities persist, and federal, state, and local climate and air quality programs must do more to reduce emissions of GHGs and co-pollutants to reduce the burden of emissions on disadvantaged communities and communities of color.

It will take all tools at all levels of government, with robust enforcement, to ensure that vulnerable communities continue to see improvements in air quality until no disparities exist in air pollution across the state.

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[77] CARB. 2022 State Strategy for the State Implementation Plan. https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy.

[78] OEHHA. 2022. *Impacts of Greenhouse Gas Emission Limits within Disadvantaged Communities: Progress Toward Reducing Inequities.* https://oehha.ca.gov/environmental-justice/report/ab32-benefits.

[79] CalEPA. 2021. Pollution and Prejudice. https://storymaps.arcgis.com/stories/f167b251809c43778a2f9f040f43d2f5.

Economic Resilience

The state's efforts to tackle the climate crisis will create economic and workforce development opportunities in the clean energy economy in communities across the state. Transitioning existing skills and expanding workforce training opportunities in climate-related fields are critical for reducing harmful emissions and supporting workers in transitioning to new, high-quality jobs. The Administration's recent budgets acknowledge the challenges facing workers in industries most affected by the state's response to climate change—especially those in the fossil fuel industry. It will invest $1 billion in regional partnerships and economic diversification to create new jobs and support a local tax base and workforce transition and development once opportunities are identified. It also will invest in safety nets to protect, and support impacted communities as part of the transition to a carbon neutral economy. Specifically, the Community Economic Resilience Fund Program[80] (CERF) supports communities and regional groups in producing regional roadmaps for economic recovery and transition that prioritize the creation of accessible, high-quality jobs in sustainable industries. The budget investments create the opportunity to future-proof and increase economic resilience in the face of more frequent climate impacts and shifting economic conditions. For these investments and implementation of the Scoping Plan to be successful in supporting the transition to a carbon neutral economy, workers and affected communities must be included in ongoing dialogue to ensure a high-road transition for regional economies.

That state also recognizes it can play a more direct role in supporting a sustainable work force through its incentive programs. In 2021, Assembly Bill 680 (AB 680) (Burke, Chapter 746, Statutes of 2021) was signed into law, requiring CARB to work with the California Labor and Workforce Development Agency to update the Funding Guidelines to include new workforce standards. CARB's Funding Guidelines currently include requirements for administering agencies to, wherever possible, foster job creation within California, provide employment opportunities or job training tied to employment, and target these opportunities to priority populations. The Funding Guidelines also recommend administering agencies prioritize investments in projects that directly support jobs or a job training and placement program, and that they report the estimated employment benefits and employment outcomes for projects that meet specified criteria. These new requirements apply to agencies administering certain California Climate Investments

[80] Office of Planning and Research. Community Economic Resilience Fund. https://opr.ca.gov/economic-development/cerf/.

programs that receive continuous appropriations from the Greenhouse Gas Reduction Fund and fall into the following six categories of standards:

- fair and responsible employer standards,
- inclusive procurement policies,
- prevailing wage for construction work,
- community workforce agreements for construction projects over one million dollars,
- preference for projects with educational institutions or training programs, and
- creation of high-quality jobs. CARB will be updating the Funding Guidelines through a public process over the next year to operationalize these new requirements.

Partnering Across Government

The Scoping Plan is an actionable plan to identify and align programs and policies to achieve California's climate targets. To realize the outcomes and deliver results in any Scoping Plan, action is critical. For this Scoping Plan, there are also actions that rely on our federal partners to take on sources primarily under their jurisdiction (such as aviation, and federally owned/managed lands) while they also continue to develop national programs for GHG reductions. The federal government is already taking major steps to advance these types of programs. The Inflation Reduction Act of 2022[81] includes $369 billion for domestic energy production and manufacturing and is expected to lead to U.S. GHG emission reductions of roughly 40 percent by 2030. Direct incentives will include those for clean vehicles and ENERGY STAR appliances, as well as improving transportation and clean energy in underserved communities.

We also need our local partners to align on actions related to land-use decisions that support sustainable, resilient, low-carbon communities and permitting for clean energy production facilities and infrastructure; diversion of organics from landfills; and other climate-related projects. State agencies also should use the Scoping Plan to review and update their own programs and policies to support the actions identified in this Scoping Plan. Importantly, the Scoping Plan also can serve as a resource as the Legislature considers new legislative direction and funding to support the state's path to carbon neutrality and continue action to address near-term air pollution disparities.

Partnering with the Private Sector

Government cannot achieve our climate targets alone. The scale of investment needed requires both private-sector investment and partnerships with philanthropies. Public

[81] Pub.L. No. 117-169 (August 16, 2022).

sector dollars, accompanied by strong and steady policy signals, must be a catalyst for deeper and broader investments by the private sector in both reducing emissions and building the resilience of our communities. Governor Newsom is committed to working collaboratively with businesses, including small businesses, to deploy the technologies, capital, and ingenuity that are hallmarks of the private sector.

California structures our climate policies and regulations to create market signals and certainty that spur private sector investment. For example, the Governor's Executive Order on Zero-Emission Vehicles[82] set 2035 as the target year for 100 percent zero-emission vehicle sales, creating a time horizon that allows automakers to scale up zero-emission fleets and sending a clear signal to the companies and utilities that would deploy charging infrastructure. The Executive Order has been followed by development and adoption of the Advanced Clean Cars II regulation. CARB convened auto manufacturers, environmental justice groups, labor organizations, and many other stakeholders to provide input into development of the regulation in a robust and transparent manner; again, with the aim of providing certainty for producers and consumers.

California also pursues public-private partnerships (PPP) as a mechanism to advance our collective climate goals. We know these vehicles can be effective at increasing the impact of public sector dollars and helpful in moving markets in a direction aligned with state policy. A new PPP the Administration is advancing is the Climate Catalyst Revolving Loan Fund, housed at the state's Infrastructure and Economic Development Bank (IBank). The fund offers a range of financial instruments—including flexible credit and credit support—to help bridge financing gaps currently preventing advanced climate solutions from scaling in the marketplace. The Catalyst Fund's initial areas of investment include forest biomass management and utilization (unlocking innovation to reduce wildfire threats), climate-smart agriculture, and clean energy transmission. The fund leverages public sector investments by mobilizing private finance for shovel-ready projects that are stuck in the deployment phase. As such, IBank is ideally positioned as the state's all-purpose "Green Bank," with increasing connection to federal financing programs such as US DOE's Loan Programs Office and the United States Environmental Protection Agency's (U.S. EPA) Greenhouse Gas Reduction Fund.

The Catalyst Fund builds from existing IBank financing programs that are themselves increasingly focused on the climate imperative. The IBank's Infrastructure State Revolving Fund provides supportive capital to climate-aligned projects promoted by local governments and certain nonprofit entities, and will be refining its criteria and market outreach strategies to increase its level of service. IBank's bonds program has supported

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[82] Executive Department. State of California. Executive Order N-79-20. *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf*.

multiple large environmental projects, including more than $2 billion in "green bonds," and is poised to help expand access to the state's deep and liquid bond capital market. Within IBank's Small Business Finance Center, the new Climate Tech Loan Guarantee program encourages commercial banks to back climate-focused small businesses, leveraging federal capital to insure a portion of the private bank's loan. And through IBank's Expanding Venture Capital Access Fund program, the state is promoting greater diversity in the venture capital community, including climate equity and climate justice.

All of these financing programs exist to leverage private capital in support of the state's climate goals, and to partner with state policy agencies driving the transition. IBank will also continue to collaborate closely with the State Treasurer's Office in its provision of capital support to climate solutions, ensuring that funding flows to programs best positioned to deliver success. This partnership of public and private capital, responsive to and in communication with the climate policy community, will ensure that California gets the maximum possible benefit from its allocation of scarce resources.

Supporting Innovation

Reaching our ambitious, deep decarbonization goals will require continued technological innovation. Investment in research, development, and deployment of clean technologies has never been more critical. Sending clear and sustained market and policy signals will encourage large and small companies alike to pursue innovation that can be scaled up and deployed here and beyond our borders. The full suite of AB 32 policies[83] has touched nearly every sector of California's economy and spurred technology innovation in the state, including the growth of technology developers, manufacturers, processors, and assemblers in many areas. Specifically, AB 32 policies and programs support both the supply side and the demand side to build new markets in California. On the supply side, AB 32 policies support businesses to demonstrate and refine technologies, and to help establish critical supply chains. On the demand side, AB 32 policies and programs provide outreach, education, and incentives—as well as disincentives—to motivate everyone from consumers to institutional purchasers to utility planners to adopt new, climate smart technologies. Innovations resulting directly from the state's climate policies include the following:

- In the past 10 years, a growing market for heavy-duty zero-emission vehicles (HD ZEVs) was established in California, and this market now represents the largest single share of North American supply and demand for HD ZEVs. Vehicle

[83] CARB. Climate Change Programs. *https://ww2.arb.ca.gov/our-work/topics/climate-change*.

and component manufacturers are making long-term investments to develop and produce HD ZEVs within California.

- Total consumption of renewable diesel in the California LCFS market has skyrocketed from approximately 1.8 million gallons in 2011 to nearly 589 million gallons in 2020. The LCFS is a key driver of market development for renewable diesel and its coproducts. While the federal renewable fuel standard (RFS) and blenders tax credit also benefit producers, an analysis of their respective contributions to market development, and interviews with industry representatives and independent experts, point to LCFS as a more important factor in market development, at least in recent years.
- In the past five years, a market for small-scale energy storage in California was created where none previously existed. As of 2020, 185 megawatts (MW) of small-scale energy storage projects have been interconnected to the grid. The significant increase in deployment in the last five years is a result of the Self-Generation Incentive Program (SGIP), which significantly reduces the upfront costs to purchase and install small-scale energy storage devices, and of growing customer interest in disaster resiliency in the face of increasing risk from wildfire and related utility outages. These systems have already provided disaster resiliency benefits for residential and non-residential customers.

We have seen how quickly market barriers can be overcome in response to strong policy signals, as occurred in the solar panel and electric vehicle battery space. Government-stated priorities have a significant role in guiding private and public research, development, and deployment. This Scoping Plan unequivocally puts the marker down on the need for innovation to continue in non-combustion technologies, clean energy, CO_2 removal options, and alternatives for SLCPs. The five-year update to the Scoping Plan allows for a periodic evaluation of new tools to add to the state's toolkit.

Engagement with Partners to Develop, Coordinate, and Export Policies

California works closely with other states, tribal governments, the federal government, and international jurisdictions to identify the most effective strategies and methods to reduce GHGs, manage GHG control programs, and facilitate the development of integrated and cost-effective regional, national, and international GHG reduction programs. For example, the state's Cap-and-Trade Program has been linked with Québec's since 2014, and CARB staff regularly engage with jurisdictions throughout the world on the design features of our Cap-and-Trade Program through memoranda of understanding (MOUs) and venues such as the International Climate Action

Partnership.[84] Low carbon fuel mandates similar to California's LCFS have been adopted by the U.S. EPA and by other jurisdictions, including Oregon, Washington, British Columbia, the European Union, and the United Kingdom. Many other jurisdictions from Japan to New Zealand, Australia, and the European Commission also continue to seek information and technical experience on our LCFS. California has and will continue to share information and encourage ambitious emissions reductions with interested jurisdictions, with a focus on China, India, Mexico, Canada, and the European Union. California's early action to reduce super-pollutants such as methane and other SLCPs was reaffirmed by the 2021 Global Methane Pledge signed by the U.S. and over 100 other countries at the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).[85]

In addition, under the Clean Air Act, the federal government is authorized to allow California to set more stringent vehicle emissions regulations than federal standards. California's goals and regulations to transition to 100 percent sales of new zero-emission passenger vehicles by 2035 (including plug-in hybrid vehicles), to drayage trucks by 2035, and other trucks and buses where feasible by 2045 are being emulated by partner states across the U.S. and in jurisdictions around the world. CARB's Advanced Clean Cars II regulation,[86] which codifies these targets, was approved in August 2022, and already at least four other states have announced their plans to adopt this regulation. Earlier in June 2020 CARB adopted the Advanced Clean Truck regulation, which requires truck manufacturers to meet increasing sale targets of zero-emission trucks in California through 2035. Since adoption, at least five other states—20 percent of the U.S. truck market—have adopted this regulation. These kinds of coordinated policies help signal to vehicle manufacturers a widespread and growing demand for zero-emissions technology, which in turn helps scale production and lower costs for consumers.

With the Mexican Secretariat for Environment and Natural Resources (SEMARNAT), California has engaged in a technical exchange on clean vehicle policies and helped to establish Mexico's Emissions Trading System (being piloted in 2022). A 2019 MOU signed between California and Environment and Climate Change Canada enables in-depth collaboration on policies and programs to decarbonize vehicles, engines, and fuels. This partnership has led to tangible emissions reductions, from aligning vehicle emissions targets and policies to collaborating on emissions testing and research critical to enforcing

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[84] International Carbon Action Partnership (ICAP). Homepage. https://icapcarbonaction.com/en?msclkid=dac30cb7b4f511ec94ccd0f1ae323e98.
[85] Global Methane Pledge. Homepage. https://www.globalmethanepledge.org/.
[86] Cal. Code Regs., tit. 13, §§ 1900,1961.2, 1961.3, 1962.2, 1962.3, 1962.4, 1962.5, 1962.6, 1962.7, 1962.8, 1965, 1968.2, 1969, 1976, 1978, 2037, 2038, 2112, 2139, 2140, 2147, and 2903; and Test Procedures located here: https://ww2.arb.ca.gov/rulemaking/2022/advanced-clean-cars-ii.

emissions limits for vehicle manufactures. At the national level, China has looked to California for cutting-edge requirements for car diagnostics and policies that promote zero-emissions vehicles. At a local level, Beijing has adopted California's vehicle emissions standards and several other progressive environmental regulations. California will continue and renew such efforts across China, including through a 2022 MOU signed with China's Ministry of Ecology and Environment.

Between 2021 and 2023, California also will serve as president of the Transport Decarbonisation Alliance, a global network of countries, regions, cities, and companies that come together to share experiences and technical expertise, and to increase the ambition and accelerate the deployment of targeted transportation decarbonization policies across freight, electric vehicle infrastructure, and active mobility. Throughout its presidency, California will focus its leadership on decarbonizing the cross-jurisdiction network of medium- and heavy-duty vehicles, both to ensure cleaner air in freight-adjacent communities and to stem the effects of climate change.

Over the years, California has also asserted the importance of and supported the ongoing efforts of state and local clean air and climate leadership. Through our participation in the Pacific Coast Collaborative alongside British Columbia, Washington, and Oregon,[87] the Under2 Coalition,[88] the U.S. Climate Alliance,[89] the International ZEV Alliance,[90] the Transportation Decarbonisation Alliance, and many more organizations, California has and will continue to build climate partnerships with state and local governments.

California also recognized the need to address the substantial emissions caused by the deforestation and degradation of tropical and other forests, and continues its work alongside other subnational governments as part of the Governors' Climate and Forests Task Force (GCF).[91] Founded in 2008, there are currently 39 GCF members, including states and provinces in Brazil, Colombia, Ecuador, Indonesia, Ivory Coast, Mexico, Nigeria, Peru, Spain, and the United States—all of whom are considering or operating programs to reduce emissions from deforestation, land-use, and rural development, and to benefit local and indigenous communities. CARB's California Tropical Forest Standard provides a rigorous methodology to assess jurisdiction-scale programs that reduce deforestation and to incentivize responsible action and investment.[92] The standard

[87] Pacific Coast Collaborative. Homepage. https://pacificcoastcollaborative.org/.
[88] Under2 Coalition. Homepage. https://www.theclimategroup.org/under2-coalition.
[89] United States Climate Alliance (USCA). Homepage. https://www.usclimatealliance.org/.
[90] ZEV Alliance. Homepage. Accelerating the Adoption of Zero-Emission Vehicles. https://zevalliance.org/.
[91] Governors' Climate and Forests Task Force. University of Colorado Boulder: Colorado Law. https://www.gcftf.org/.
[92] CARB. California Tropical Forest Standard. https://ww2.arb.ca.gov/our-work/programs/california-tropical-forest-standard.

provides a strong signal to value the preservation of tropical forests over continued destructive activities such as oil exploration and extraction and ensures rigorous social and environmental safeguards for indigenous peoples and local communities.

Working Toward Carbon Neutrality

To date, California and many other regions have focused on reducing GHG emissions from the industrial, energy, and transportation sectors. As defined in statute, the state's 2020 and 2030 targets include all in-state sources of GHG emissions—and those emissions associated with imported power that is consumed in the state. By moving to a framework of carbon neutrality, the scope for accounting is expanded to include all sources and sinks. As such, carbon neutrality is achieved when the GHG fluxes are at equilibrium—when sources equal sinks. Figure 1-5 depicts the sources included in the AB 32 GHG Inventory and the new sources and sinks added in this Scoping Plan under the framework of carbon neutrality. Natural and working lands are able to sequester carbon and therefore play an increasingly important role in this framework. However, modeling for this plan shows that carbon sequestration in our natural and working lands alone will be insufficient to achieve carbon neutrality no later than 2045. Therefore, this plan also considers the role of carbon capture and sequestration, as well as biological and mechanical carbon sequestration processes that are included in the IPCC Sixth Assessment Report,[93] as necessary tools for climate change mitigation.

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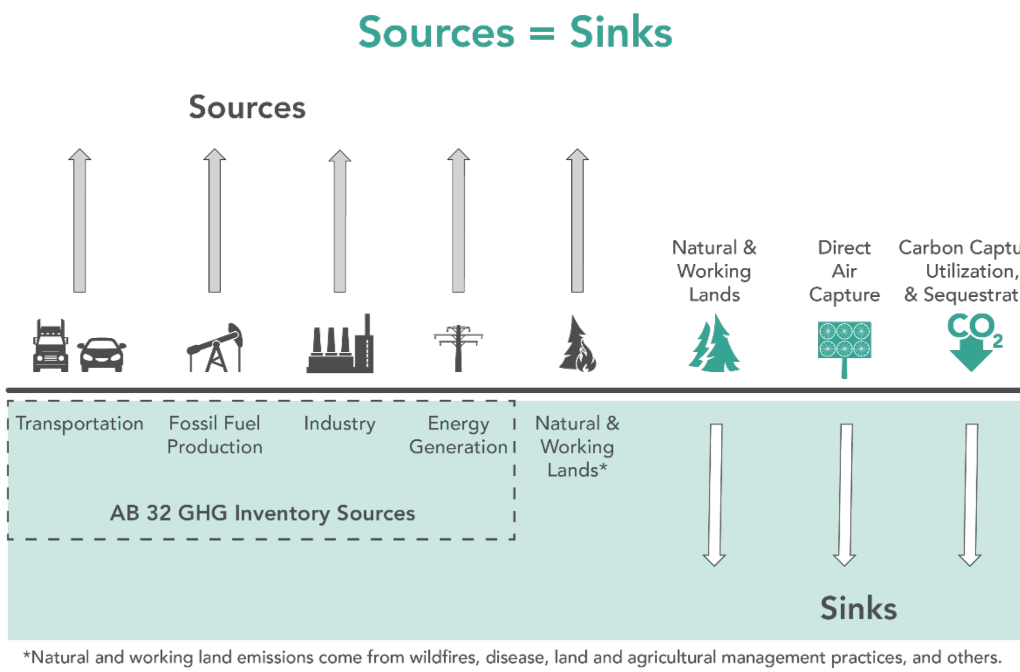
[93] IPCC. 2021. *Climate Change 2021: The Physical Science Basis.* https://www.ipcc.ch/report/ar6/wg1/.

Figure 1-5: Carbon neutrality: Balancing the net flux of GHG emissions from all sources and sinks



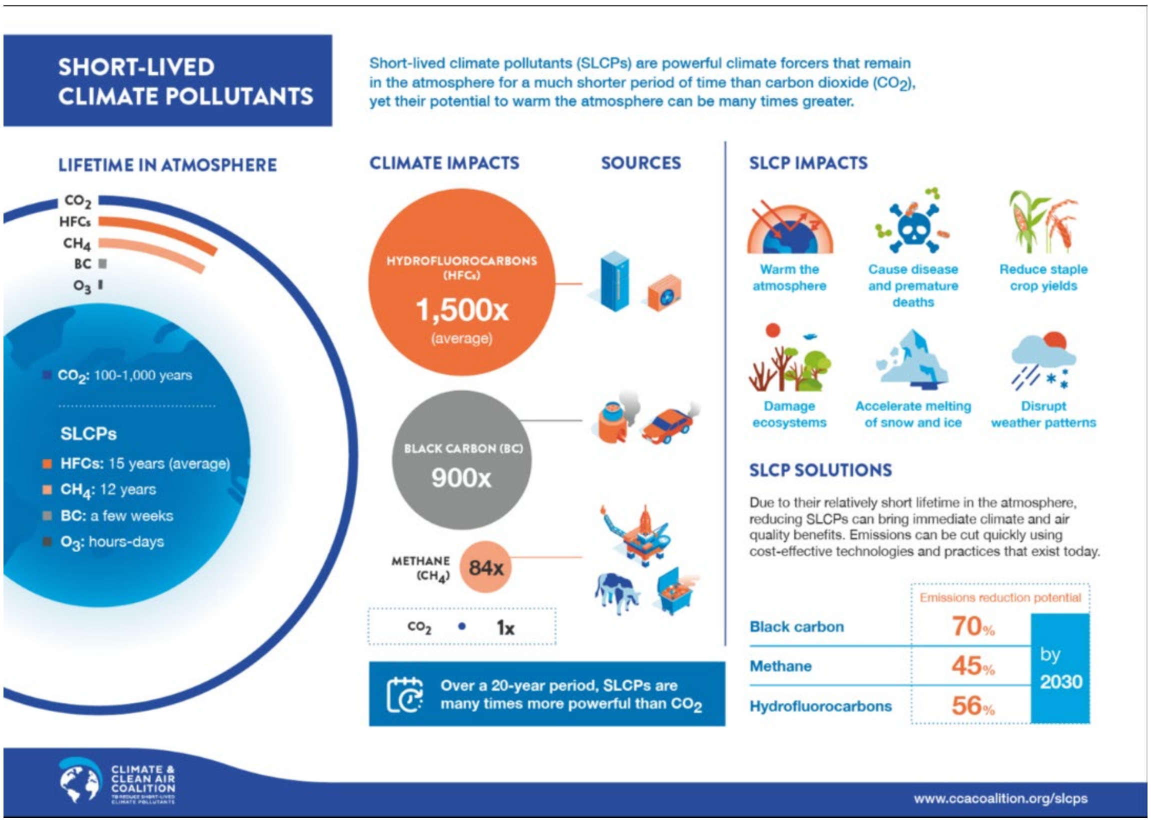
Supporting Healthy and Resilient Lands

Our natural and working lands are an important piece in California's fight to achieve carbon neutrality and build resilience to the impacts of climate change. Healthy land can sequester and store atmospheric carbon dioxide in forests, grasslands, soils, and wetlands. Healthy lands can also reduce emissions of powerful short-lived climate pollutants, limit the release of future GHG emissions, protect people and nature from the impacts of climate change, and build our resilience to future climate risks. Unhealthy lands have the opposite effect—they release more GHGs than they store and are more vulnerable to future climate change impacts. Through climate smart land management that focuses on supporting healthy living systems, we can support our carbon neutrality goals, reduce emissions, advance sequestration, and support healthy and more climate-resilient lands.

Maintaining the Focus on Methane and Short-Lived Climate Pollutants

Given the urgency of climate change, the often-disproportional impacts already being felt by underserved populations across California and the world, and the need to rapidly decarbonize and avoid climate tipping points as identified in the most recent IPCC assessment, efforts to reduce short-lived climate pollutants are especially important. SLCPs include methane (CH_4), black carbon (soot), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs), and they are among the most harmful pollutants to both human health and the global climate. SLCPs are more potent than CO_2 in terms of their impact on climate change (and subsequently, global warming) and have a much shorter lifetime in the atmosphere than CO_2 does. That means they have an outsized impact on climate change in the near term—they are responsible for up to 45 percent of current climate forcing. It also means that targeted efforts to reduce short-lived climate pollutant emissions can provide outsized climate and health benefits, within weeks to about a decade (see Figure 1-6).

Figure 1-6: Short-lived climate pollutant impacts[94]



California has been a leader in addressing SLCP emissions. As part of the 2014 Scoping Plan,[95] CARB committed to developing a dedicated strategy to reduce SLCP emissions.

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[94] Climate and Clean Air Coalition. Short-Lived Climate Pollutants (SLCPs). https://www.ccacoalition.org/en/content/short-lived-climate-pollutants-slcps.
[95] CARB. 2014. *First Update.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.

The resulting SLCP Reduction Strategy,[96] adopted by CARB in 2017, implements targets codified in SB 1383 (Lara, Chapter 395, Statutes of 2016) to reduce methane and HFC emissions by 40 percent by 2030 and anthropogenic black carbon emissions by 50 percent. California worked with several other states through the U.S. Climate Alliance to establish a similar goal to reduce SLCP emissions in line with the requirements of the Paris Agreement,[97] identifying the potential to reduce SCLPs by 40 to 50 percent by 2030 across the U.S. Climate Alliance.[98]

Process for Developing the Scoping Plan

This Scoping Plan was developed in coordination with the Governor's Office and state agencies, in accordance with direction from the Chair and Members of CARB, through engagement with the Legislature, with advice from the EJ Advisory Committee, in consultation with tribes, and with open and transparent opportunities for stakeholders and the public to engage in workshops and other meetings. Appendix A (Public Process) includes details of the public workshops, and Chapter 5 includes details of the EJ Advisory Committee's role in the Scoping Plan update process.

Guidance from the Administration and Legislature

This Scoping Plan reflects existing and recent direction in the Governor's Executive Orders and Statutes. Table 1-1 provides a summary of major climate legislation and executive orders issued since the adoption of the 2017 Scoping Plan.

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[96] CARB. 2017. *Short-Lived Climate Pollutant Reduction Strategy.* *https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf*.

[97] UNFCCC. 2015. Paris Agreement. *https://unfccc.int/sites/default/files/english_paris_agreement.pdf*.

[98] USCA. 2018. *From SLCP Challenge to Action: A Roadmap for Reducing Short-Lived Climate Pollutants to Meet the Goals of the Paris Agreement.* http://www.usclimatealliance.org/slcp-challenge-to-action.

Table 1-1: Major climate legislation and executive orders enacted since the 2017 Scoping Plan

Bill/Executive Order	Summary
Assembly Bill 1279 (AB 1279) (Muratsuchi, Chapter 337, Statutes of 2022) *The California Climate Crisis Act*	AB 1279 establishes the policy of the state to achieve carbon neutrality as soon as possible, but no later than 2045; to maintain net negative GHG emissions thereafter; and to ensure that by 2045 statewide anthropogenic GHG emissions are reduced at least 85 percent below 1990 levels. The bill requires CARB to ensure that Scoping Plan updates identify and recommend measures to achieve carbon neutrality, and to identify and implement policies and strategies that enable CO_2 removal solutions and carbon capture, utilization, and storage (CCUS) technologies. This bill is reflected directly in this Scoping Plan.
Senate Bill 905 (SB 905) (Caballero, Chapter 359, Statutes of 2022) *Carbon Capture, Removal, Utilization, and Storage Program*	SB 905 requires CARB to create the Carbon Capture, Removal, Utilization, and Storage Program to evaluate, demonstrate, and regulate CCUS and carbon dioxide removal (CDR) projects and technology. The bill requires CARB, on or before January 1, 2025, to adopt regulations creating a unified state permitting application for approval of CCUS and CDR projects. The bill also requires the Secretary of the Natural Resources Agency to publish a framework for governing agreements for two or more tracts of land overlying the same geologic storage reservoir for the purposes of a carbon sequestration project. The Scoping Plan modeling reflects both CCUS and CDR contributions to achieve carbon neutrality.
Senate Bill 846 (SB 846) (Dodd, Chapter 239, Statutes of 2022) *Diablo Canyon Powerplant: Extension of Operations*	SB 846 extends the Diablo Canyon Power Plant’s sunset date by up to five additional years for each of its two units and seeks to make the nuclear power plant eligible for federal loans. The bill requires that the California Public Utilities Commission (CPUC) not include and disallow a load-serving entity from including in their adopted resource plan, the energy, capacity, or any attribute from the Diablo Canyon power plant. The Scoping Plan explains the emissions impact of this legislation.
Senate Bill 1020 (SB 1020) (Laird,	SB 1020 adds interim renewable energy and zero carbon energy retail sales of electricity targets to California end-use customers set at 90 percent in 2035 and 95 percent in 2040.

Chapter 361, Statutes of 2022) *Clean Energy, Jobs, and Affordability Act of 2022*	It accelerates the timeline required to have 100 percent renewable energy and zero carbon energy procured to serve state agencies from the original target year of 2045 to 2035. This bill requires each state agency to individually achieve the 100 percent goal by 2035 with specified requirements. This bill requires the CPUC, California Energy Commission (CEC), and CARB, on or before December 1, 2023, and annually thereafter, to issue a joint reliability progress report that reviews system and local reliability. The bill also modifies the requirement for CARB to hold a portion of its Scoping Plan workshops in regions of the state with the most significant exposure to air pollutants by further specifying that this includes communities with minority populations or low-income communities in areas designated as being in extreme federal non-attainment. The Scoping Plan describes the implications of this legislation on emissions.
Senate Bill 1137 (SB 1137) (Gonzales, Chapter 365, Statutes of 2022) *Oil & Gas Operations: Location Restrictions: Notice of Intention: Health protection zone: Sensitive receptors*	SB 1137 prohibits the development of new oil and gas wells or infrastructure in health protection zones, as defined, except for purposes of public health and safety or other limited exceptions. The bill requires operators of existing oil and gas wells or infrastructure within health protection zones to undertake specified monitoring, public notice, and nuisance requirements. The bill requires CARB to consult and concur with the California Geologic Energy Management Division (CalGEM) on leak detection and repair plans for these facilities, adopt regulations as necessary to implement emission detection system standards, and collaborate with CalGEM on public access to emissions detection data.
Senate Bill 1075 (SB 1075) (Skinner, Chapter 363, Statutes of 2022) *Hydrogen: Green Hydrogen: Emissions of Greenhouse Gases*	SB 1075 requires CARB, by June 1, 2024, to prepare an evaluation that includes: policy recommendations regarding the use of hydrogen, and specifically the use of green hydrogen, in California; a description of strategies supporting hydrogen infrastructure, including identifying policies that promote the reduction of GHGs and short-lived climate pollutants; a description of other forms of hydrogen to achieve emission reductions; an analysis of curtailed electricity; an estimate of GHG and emission reductions that could be achieved through deployment of green hydrogen through a variety of scenarios; an analysis of the potential for opportunities to integrate hydrogen production and applications with drinking water supply treatment needs; policy recommendations for regulatory and permitting processes

	associated with transmitting and distributing hydrogen from production sites to end uses; an analysis of the life-cycle GHG emissions from various forms of hydrogen production; and an analysis of air pollution and other environmental impacts from hydrogen distribution and end uses. This bill would inform the production of hydrogen at the scale called for in this Scoping Plan.
Assembly Bill 1757 (AB 1757) (Garcia, Chapter 341, Statutes of 2022) *California Global Warming Solutions Act of 2006: Climate Goal: Natural and Working Lands*	AB 1757 requires the California Natural Resources Agency (CNRA), in collaboration with CARB, other state agencies, and an expert advisory committee, to determine a range of targets for natural carbon sequestration, and for nature-based climate solutions, that reduce GHG emissions in 2030, 2038, and 2045 by January 1, 2024. These targets must support state goals to achieve carbon neutrality and foster climate adaptation and resilience. This bill also requires CARB to develop standard methods for state agencies to consistently track GHG emissions and reductions, carbon sequestration, and additional benefits from natural and working lands over time. These methods will account for GHG emissions reductions of CO_2, methane, and nitrous oxide related to natural and working lands and the potential impacts of climate change on the ability to reduce GHG emissions and sequester carbon from natural and working lands, where feasible. This Scoping Plan describes the next steps and implications of this legislation for the natural and working lands sector.
Senate Bill 1206 (SB 1206) (Skinner, Chapter 884, Statutes of 2022) *Hydrofluorocarbon gases: sale or distribution*	SB 1206 mandates a stepped sales prohibition on newly produced high- global warming potential (GWP) HFCs to transition California's economy toward recycled and reclaimed HFCs for servicing existing HFC-based equipment. Additionally, SB 1206 also requires CARB to develop regulations to increase the adoption of very low-, i.e., GWP < 10, and no-GWP technologies in sectors that currently rely on higher-GWP HFCs.
Senate Bill 27 (SB 27) (Skinner, Chapter 237, Statutes of 2021)	SB 27 requires CNRA, in coordination with other state agencies, to establish the Natural and Working Lands Climate Smart Strategy by July 1, 2023. This bill also requires CARB to establish specified CO_2 removal targets for 2030 and beyond as part of its Scoping Plan. Under SB 27, CNRA is to establish and maintain a registry to identify projects in the state

Carbon Sequestration: State Goals: Natural and Working Lands: Registry of Projects	that drive climate action on natural and working lands and are seeking funding. CNRA also must track carbon removal and GHG emission reduction benefits derived from projects funded through the registry. This bill is reflected directly in this Scoping Plan as CO_2 removal targets for 2030 and 2045 in support of carbon neutrality.
Senate Bill 596 (SB 596) (Becker, Chapter 246, Statutes of 2021) *Greenhouse Gases: Cement Sector: Net-zero Emissions Strategy*	SB 596 requires CARB, by July 1, 2023, to develop a comprehensive strategy for the state's cement sector to achieve net-zero-emissions of GHGs associated with cement used within the state as soon as possible, but no later than December 31, 2045. The bill establishes an interim target of 40 percent below the 2019 average GHG intensity of cement by December 31, 2035. Under SB 596, CARB must: • Define a metric for GHG intensity and establish a baseline from which to measure GHG intensity reductions. • Evaluate the feasibility of the 2035 interim target (40 percent reduction in GHG intensity) by July 1, 2028. • Coordinate and consult with other state agencies. • Prioritize actions that leverage state and federal incentives. • Evaluate measures to support market demand and financial incentives to encourage the production and use of cement with low GHG intensity. The Scoping Plan modeling is designed to achieve these outcomes.
Executive Order N-82-20	Governor Newsom signed Executive Order N-82-20 in October 2020 to combat the climate and biodiversity crises by setting a statewide goal to conserve at least 30 percent of California's land and coastal waters by 2030. The Executive Order also instructed the CNRA, in consultation with other state agencies, to develop a Natural and Working Lands Climate Smart Strategy that serves as a framework to advance the state's carbon neutrality goal and build climate resilience. In addition to setting a statewide conservation goal, the Executive Order directed CARB to update the target for natural and working lands in support of carbon neutrality as part of this Scoping Plan, and to take into consideration the NWL Climate Smart Strategy.

	Executive Order N-82-20 also calls on the CNRA, in consultation with other state agencies, to establish the California Biodiversity Collaborative (Collaborative). The Collaborative shall be made up of governmental partners, California Native American tribes, experts, business and community leaders, and other stakeholders from across the state. State agencies will consult the Collaborative on efforts to: • Establish a baseline assessment of California's biodiversity that builds upon existing data and can be updated over time. • Analyze and project the impact of climate change and other stressors in California's biodiversity. • Inventory current biodiversity efforts across all sectors and highlight opportunities for additional action to preserve and enhance biodiversity. CNRA also is tasked with advancing efforts to conserve biodiversity through various actions, such as streamlining the state's process to approve and facilitate projects related to environmental restoration and land management. The California Department of Food and Agriculture (CDFA) is directed to advance efforts to conserve biodiversity through measures such as reinvigorating populations of pollinator insects, which restore biodiversity and improve agricultural production. The Natural and Working Lands Climate Smart Strategy informs this Scoping Plan.
Executive Order N-79-20	Governor Newsom signed Executive Order N-79-20 in September 2020 to establish targets for the transportation sector to support the state in its goal to achieve carbon neutrality by 2045. The targets established in this Executive Order are: • 100 percent of in-state sales of new passenger cars and trucks will be zero-emission by 2035. • 100 percent of medium- and heavy-duty vehicles will be zero-emission by 2045 for all operations where feasible, and by 2035 for drayage trucks. • 100 percent of off-road vehicles and equipment will be zero-emission by 2035 where feasible. The Executive Order also tasked CARB to develop and propose regulations that require increasing volumes of zero-electric passenger vehicles, medium- and heavy-duty

	vehicles, drayage trucks, and off-road vehicles toward their corresponding targets of 100 percent zero-emission by 2035 or 2045, as listed above. The Scoping Plan modeling reflects achieving these targets.
Executive Order N-19-19	Governor Newsom signed Executive Order N-19-19 in September 2019 to direct state government to redouble its efforts to reduce GHG emissions and mitigate the impacts of climate change while building a sustainable, inclusive economy. This Executive Order instructs the Department of Finance to create a Climate Investment Framework that: • Includes a proactive strategy for the state's pension funds that reflects the increased risks to the economy and physical environment due to climate change. • Provides a timeline and criteria to shift investments to companies and industry sectors with greater growth potential based on their focus of reducing carbon emissions and adapting to the impacts of climate change. • Aligns with the fiduciary responsibilities of the California Public Employees' Retirement System, California State Teachers' Retirement System, and the University of California Retirement Program. Executive Order N-19-19 directs the State Transportation Agency to leverage more than $5 billion in annual state transportation spending to help reverse the trend of increased fuel consumption and reduce GHG emissions associated with the transportation sector. It also calls on the Department of General Services to leverage its management and ownership of the state's 19 million square feet in managed buildings, 51,000 vehicles, and other physical assets and goods to minimize state government's carbon footprint. Finally, it tasks CARB with accelerating progress toward California's goal of five million ZEV sales by 2030 by: • Developing new criteria for clean vehicle incentive programs to encourage manufacturers to produce clean, affordable cars. • Proposing new strategies to increase demand in the primary and secondary markets for ZEVs. • Considering strengthening existing regulations or adopting new ones to achieve the necessary GHG reductions from within the transportation sector.

	The Scoping Plan modeling reflects efforts to accelerate ZEV deployment.
Senate Bill 576 (SB 576) (Umberg, Chapter 374, Statutes of 2019) *Coastal Resources: Climate Ready Program and Coastal Climate Change Adaptation, Infrastructure and Readiness Program*	Sea level rise, combined with storm-driven waves, poses a direct risk to the state's coastal resources, including public and private real property and infrastructure. Rising marine waters threaten sensitive coastal areas, habitats, the survival of threatened and endangered species, beaches, other recreation areas, and urban waterfronts. SB 576 mandates that the Ocean Protection Council develop and implement a coastal climate adaptation, infrastructure, and readiness program to improve the climate change resiliency of California's coastal communities, infrastructure, and habitat. This bill also instructs the State Coastal Conservancy to administer the Climate Ready Program, which addresses the impacts and potential impacts of climate change on resources within the conservancy's jurisdiction.
Assembly Bill 65 (AB 65) (Petrie-Norris, Chapter 347, Statutes of 2019) *Coastal Protection: Climate Adaption: Project Prioritization: Natural Infrastructure: Local General Plans*	This bill requires the State Coastal Conservancy, when it allocates any funding appropriated pursuant to the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access For All Act of 2018, to prioritize projects that use natural infrastructure in coastal communities to help adapt to climate change. The bill requires the conservancy to provide information to the Office of Planning and Research on any projects funded pursuant to the above provision to be considered for inclusion into the clearinghouse for climate adaption information. The bill authorizes the conservancy to provide technical assistance to coastal communities to better assist them with their projects that use natural infrastructure.
Executive Order B-55-18	Governor Brown signed Executive Order B-55-18 in September 2018 to establish a statewide goal to achieve carbon neutrality as soon as possible, and no later than 2045, and to achieve and maintain net negative emissions thereafter. Policies and programs undertaken to achieve this goal shall: • Seek to improve air quality and support the health and economic resiliency of urban and rural communities, particularly low-income and disadvantaged communities. • Be implemented in a manner that supports climate adaptation and biodiversity, including protection of the state's water supply, water quality, and native plants and animals.

	This Executive Order also calls for CARB to: • Develop a framework for implementation and accounting that tracks progress toward this goal. • Ensure future Scoping Plans identify and recommend measures to achieve the carbon neutrality goal. This Scoping Plan is designed to achieve carbon neutrality no later than 2045 and the modeling includes technology and fuel transitions to achieve that outcome.
Senate Bill 100 (SB 100) (De León, Chapter 312, Statutes of 2018) *California Renewables Portfolio Standard Program: emissions of greenhouse gases*	SB 100 mandates that the CPUC, CEC, and CARB plan for 100 percent of total retail sales of electricity in California to come from eligible renewable energy resources and zero-carbon resources by December 31, 2045. This bill also updates the state's Renewables Portfolio Standard (RPS) to include the following interim targets: • 44% of retail sales procured from eligible renewable sources by December 31, 2024. • 52% of retail sales procured from eligible renewable sources by December 31, 2027. • 60% of retail sales procured from eligible renewable sources by December 31, 2030. Under SB 100, the CPUC, CEC, and CARB shall use programs under existing laws to achieve 100 percent clean electricity. The statute requires these agencies to issue a joint policy report on SB 100 every four years. The first of these reports was issued in 2021. This Scoping Plan reflects the SB 100 Core Scenario resource mix with a few minor updates.
Assembly Bill 2127 (AB 2127) (Ting, Chapter 365, Statutes of 2018) *Electric Vehicle Charging Infrastructure: Assessment*	This bill requires the CEC, working with CARB and the CPUC, to prepare and biennially update a statewide assessment of the electric vehicle charging infrastructure needed to support the levels of electric vehicle adoption required for the state to meet its goals of putting at least 5 million zero-emission vehicles on California roads by 2030 and of reducing emissions of GHGs to 40% below 1990 levels by 2030. The bill requires the CEC to regularly seek data and input from stakeholders relating to electric vehicle charging infrastructure. This bill supports the deployment of ZEVs as modeled in this Scoping Plan.

Senate Bill 30 (SB 30) (Lara, Chapter 614, Statutes of 2018) *Insurance: Climate Change*	This bill requires the Insurance Commissioner to convene a working group to identify, assess, and recommend risk transfer market mechanisms that, among other things, promote investment in natural infrastructure to reduce the risks of climate change related to catastrophic events, create incentives for investment in natural infrastructure to reduce risks to communities, and provide mitigation incentives for private investment in natural lands to lessen exposure and reduce climate risks to public safety, property, utilities, and infrastructure. The bill requires the policies recommended to address specified questions.
Assembly Bill 2061 (AB 2061) (Frazier, Chapter 580, Statutes of 2018) *Near-zero-emission and Zero-emission Vehicles*	Existing state and federal law sets specified limits on the total gross weight imposed on the highway by a vehicle with any group of two or more consecutive axles. Under existing federal law, the maximum gross vehicle weight of that vehicle may not exceed 82,000 pounds. AB 2061 authorizes a near-zero-emission vehicle or a zero-emission vehicle to exceed the weight limits on the power unit by up to 2,000 pounds. This bill supports the deployment of cleaner trucks as modeled in this Scoping Plan.

Consideration of Relevant State Plans and Regulations

Development of this Scoping Plan also included careful consideration of, and coordination with, other state agency plans and regulations, including the SB 100 Joint Agency Report,[99] the 2022 State Strategy for the State Implementation Plan,[100] Climate Action Plan for Transportation Infrastructure,[101] AB 74 Studies on Vehicle Emissions and Fuel Demand and Supply,[102,103,104] Short-Lived Climate Pollutant Strategy (SLCP Strategy),[105]

[99] CPUC, CEC, and CARB. 2021. *SB 100 Joint Agency Report.* https://www.energy.ca.gov/sb100.
[100] CARB. January 31, 2022. Draft 2022 State Strategy for the State Implementation Plan. https://ww2.arb.ca.gov/sites/default/files/2022-01/Draft_2022_State_SIP_Strategy.pdf.
[101] CalSTA. 2021. *Climate Action Plan.* https://calsta.ca.gov/subject-areas/climate-action-plan.
[102] CalEPA. 2021. Carbon Neutrality Studies. https://calepa.ca.gov/climate/carbon-neutrality-studies/.
[103] Brown, A. L., et. al. 2021. *Driving California's Transportation Emissions.* https://escholarship.org/uc/item/3np3p2t0.
[104] Deschenes, O. 2021. *Enhancing equity*. https://zenodo.org/record/4707966#.YKPiaKhKi73.
[105] CARB. Short-Lived Climate Pollutants. https://ww2.arb.ca.gov/our-work/programs/slcp.

CARB's Achieving Carbon Neutrality Report,[106] Climate Smart Strategy,[107] and draft Natural and Working Lands Implementation Plan,[108] among others.

Input from Partners and Stakeholders

CARB also collaborated with other state agencies, held consultations with tribes, and solicited comments and feedback from affected stakeholders, including labor organizations and the public. The process to update the Scoping Plan began with kickoff workshops in early June 2021,[109] followed by over a dozen public workshops, including engagement with tribes,[110] and featured a series of EJ Advisory Committee and environmental justice community meetings.[111] The June 2021 workshop and several others were a joint agency effort, as there are many agencies with direct authority or jurisdiction over different sectors of the economy. Consultation with agencies also included bi-weekly, monthly, and weekly meetings.

During the summer of 2022 CARB held three community listening sessions, hosted by the CARB Chair and Board, in communities around the state, along with one virtual community listening session and one tribal listening session specifically for tribes. Many tribes provided written feedback, which was incorporated into this Scoping Plan. In addition, CARB respects tribal sovereignty and also engaged in a consultation campaign with tribes, which resulted in government-to-government consultations, and this Scoping Plan is reflective of this process.[112]

Emissions Data That Inform the Scoping Plan

Greenhouse Gas Emissions

AB 32 includes which GHGs are to be regulated, reduced, and included in the state's targets and goals. That list includes seven GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs),

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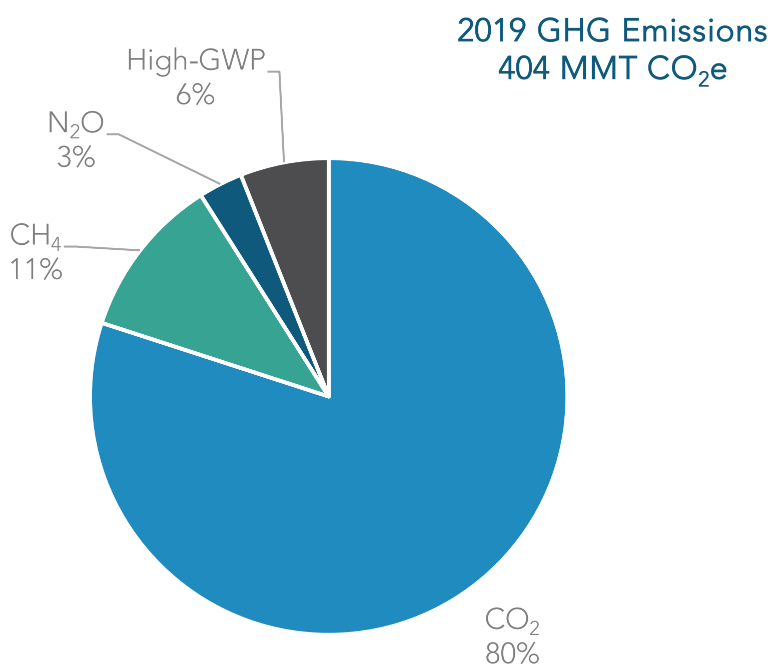
[106] Energy and Environmental Economics, Inc. 2020. *Achieving Carbon Neutrality.* https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf.
[107] CNRA. 2022. Natural and Working Lands Climate Smart Strategy. https://resources.ca.gov/Initiatives/Expanding-Nature-Based-Solutions.
[108] CARB. 2019. *Draft California 2030 Natural and Working Lands Climate Change Implementation Plan.* https://ww2.arb.ca.gov/resources/documents/nwl-implementation-draft.
[109] Appendix A (Public Process).
[110] CARB. Scoping Plan Meetings & Workshops. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/scoping-plan-meetings-workshops.
[111] CARB. Environmental Justice Advisory Committee Meetings and Events. https://ww2.arb.ca.gov/environmental-justice-advisory-committee-meetings-and-events.
[112] CARB. 2018. Tribal Consultation Policy. October. https://www.arb.ca.gov/regact/nonreg/2018/california_air_resources_board_tribal_consultation_policy.pdf.

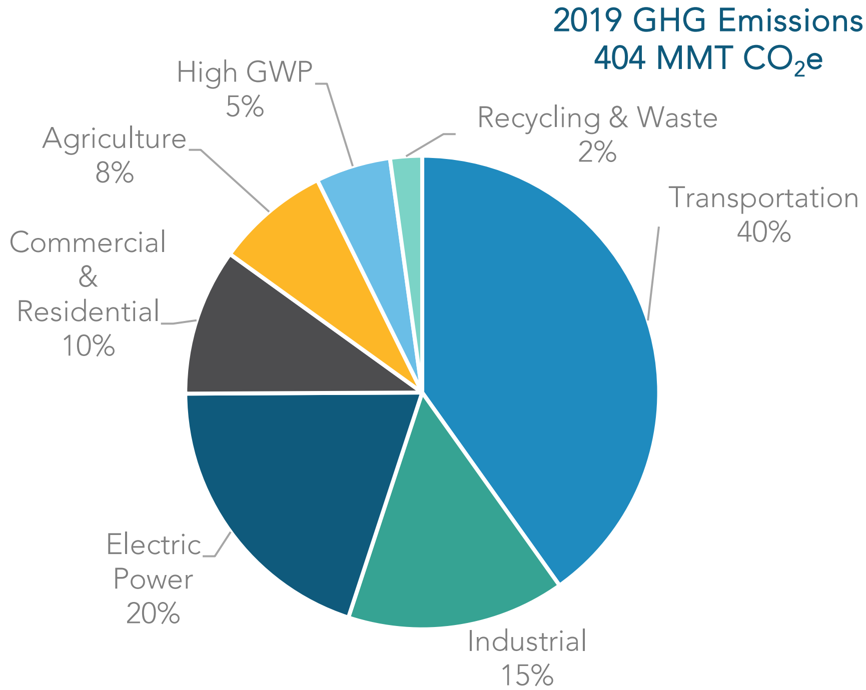
perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3). Carbon dioxide is the primary GHG emitted in California, accounting for 83 percent of the total GHG emissions in 2019, as shown in Figure 1-7 below. Figure 1-8 illustrates that transportation (primarily on-road travel) is the single largest source of CO_2 emissions in the state. Upstream transportation emissions from the refinery and oil and gas sectors are categorized as CO_2 emissions from industrial sources and constitute about 50 percent of the industrial source emissions. When including these emissions, the transportation sector accounts for approximately half of statewide GHG emissions. Other significant sources of CO_2 include electricity production, industrial sources like refineries and cement plants, and residential sources like fossil gas. Figures 1-7 and 1-8 show state GHG emission contributions by GHG and sector based on the 2020 Greenhouse Gas Emission Inventory; GHG emissions for 2019 are shown because 2020 was an outlier due to the global pandemic. Emissions in Figure 1-8 are depicted by Scoping Plan sector, which includes separate categories for high-global warming potential (GWP) and recycling/waste emissions that are otherwise typically included within other economic sectors.

Figure 1-7: 2019 State GHG emission contributions by GHG[113]



[113] CARB. 2022. *California Greenhouse Gas Emissions for 2000 to 2020: Trends of Emissions and Other Indicators.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf.

Figure 1-8: 2019 State GHG emission contributions by Scoping Plan sector[114]



The scope of the AB 32 GHG Inventory encompasses emission sources within the state's borders, as well as imported electricity consumed in the state. This construct for the inventory is consistent with IPCC practices to allow for comparison of statewide GHG emissions with those at the national level and with other international GHG inventories. Statewide GHG emissions calculations use many data sources, including data from other state and federal agencies. However, a significant source of data comes from reports submitted to CARB through the Regulation for the Mandatory Reporting of GHG Emissions (MRR). The MRR requires facilities and entities with more than 10,000 metric tons of carbon dioxide equivalent ($MTCO_2e$) of combustion and process emissions, all facilities belonging to certain industries, and all electric power entities to submit an annual GHG emissions data report directly to CARB. Furthermore, this regulation requires that reports from entities that emit more than 25,000 $MTCO_2e$ be verified by a CARB-

[114] The High GWP sector includes high global warming potential gas emissions from releases of ozone depleting substance (ODS) substitutes, SF_6 emissions from the electricity transmission and distribution system, and gases that are emitted in the semiconductor manufacturing process. ODS substitutes, which are primarily HFCs, are used in refrigeration and air conditioning equipment, solvent cleaning, foam production, fire retardants, and aerosols.

accredited third-party verification body. More information on MRR emissions reports can be found at CARB's Mandatory Greenhouse Gas Emissions Reporting website.[115]

All data sources used to develop the GHG Emission Inventory are listed in CARB's inventory supporting documentation.[116]

Natural and Working Lands

For natural and working lands, the 2018 ecosystem carbon inventory (NWL Inventory)[117] shows there are approximately 5,340 million metric tons (MMT) of carbon in the carbon pools[118] (reservoirs of carbon that have the ability to both take in and release carbon) that CARB has quantified (see Figure 1-9). For purposes of comparison, 5,340 MMT of ecosystem carbon stock is equivalent to 19,600 MMT of atmospheric CO_2. Forests and shrublands contain the majority of California's carbon stock because they cover the majority of California's landscape and have the highest carbon density of any land cover type. All other land categories combined comprise over 35 percent of California's total acreage, but only 15 percent of carbon stocks. Roughly half of the 5,340 MMT of carbon resides in soils and half in plant biomass.

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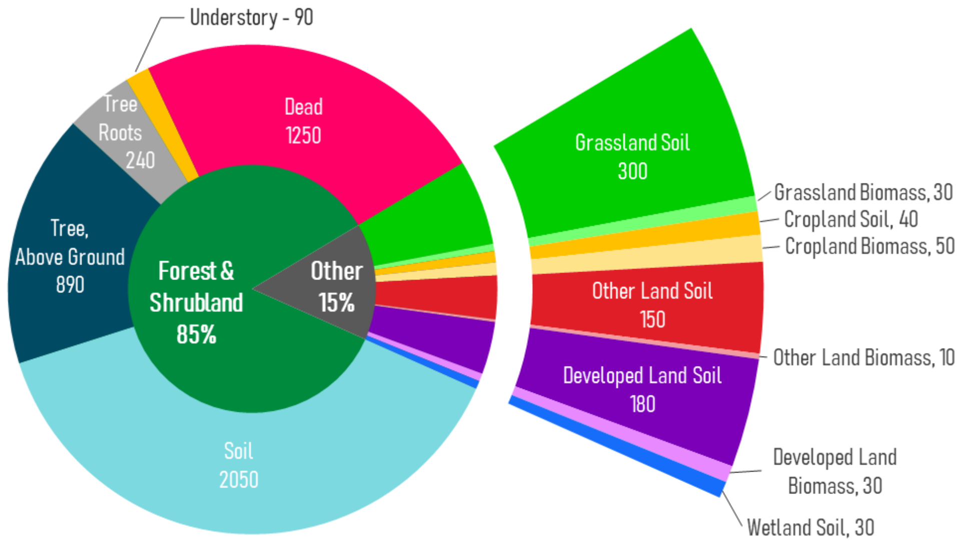
[115] CARB. Mandatory Greenhouse Gas Emissions Reporting. https://ww2.arb.ca.gov/our-work/programs/mandatory-greenhouse-gas-emissions-reporting.

[116] CARB. Current California GHG Emission Inventory Data. www.arb.ca.gov/cc/inventory/data/data.htm.

[117] CARB. 2018. *An Inventory of Ecosystem Carbon in California's Natural and Working Lands.* https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf.

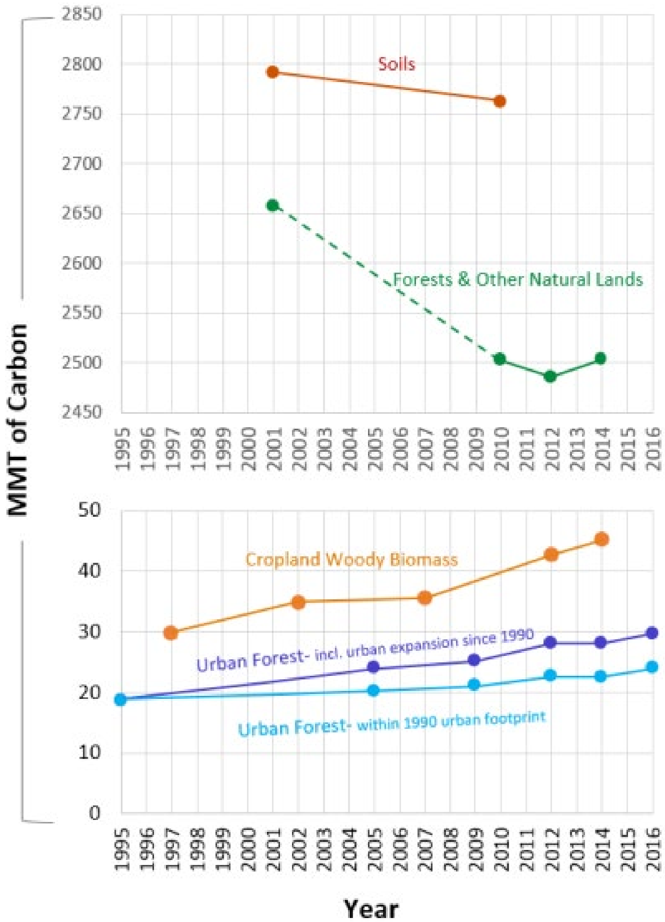
[118] "Carbon pools" are Above-Ground Live Biomass (boles, stems, and foliage in shrubs, trees, grasses, and herbaceous vegetation), Below-Ground Live Biomass (roots in shrubs, trees, grasses, and herbaceous vegetation), Dead Organic Matter (standing or downed dead wood and litter), Harvested Wood Products (all wood and bark material that leaves harvest sites regardless of whether it is eventually incorporated into merchandisable products), and Soil Organic Matter (organic carbon in the top 30 centimeters of soil).

Figure 1-9: Carbon stocks in natural and working lands (MMT carbon)



In addition to providing an estimate of the ecosystem carbon that exists on California's landscape, the NWL Inventory also shows how those carbon stocks are changing (see Figure 1-10). The inventory attributes stock change to human activity, such as land use change, or to disturbances, such as wildfire. CARB's inventory shows these lands were a source of GHG emissions from 2001 to 2011, releasing more carbon than they stored, and then they returned to be a slight carbon sink from 2012 to 2014. These trends highlight the interannual and interdecadal variability of lands and their ability to be both a source and a sink of carbon.

Figure 1-10: Changes in carbon stock by landscape type



For natural and working lands, California's inventory is also based on IPCC methods for tracking ecosystem carbon over time, providing for comparability with other national and subnational inventories and carbon accounting. As such, the NWL Inventory is an important tool for tracking both carbon stock changes in California over time and the impacts that interventions such as those identified in this Scoping Plan, actions identified in the Climate Smart Land Strategy, and others have on NWL carbon stocks.

All data sources used to develop the NWL Inventory are listed in the technical support documentation at CARB's California Natural & Working Lands Inventory website.[119]

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[119] CARB. California Natural & Working Lands Inventory. https://ww2.arb.ca.gov/nwl-inventory.

Black Carbon

In addition, CARB has developed a statewide emission inventory for black carbon in support of the SLCP Strategy. The inventory is reported in two categories: non-forestry (anthropogenic) sources and forestry sources.[120] The black carbon inventory is calculated using existing $PM_{2.5}$ emission inventories combined with speciation profiles that define the fraction of $PM_{2.5}$ that is black carbon. The black carbon inventory helps support implementation of the SLCP Strategy, but it is not part of California's GHG Inventory that tracks progress toward the state's climate targets under AB 32 or SB 32. The state's major anthropogenic sources of black carbon include off-road transportation, on-road transportation, residential wood burning, fuel combustion, and industrial processes. CARB estimated 2017 black carbon emissions to be approximately 8 $MTCO_2e$.[121] The majority of anthropogenic sources come from transportation—specifically, heavy-duty vehicles. The share of black carbon emissions from transportation is dropping rapidly and is expected to continue to do so between now and 2030 as a result of California's air quality programs. The remaining black carbon emissions will come largely from woodstoves/fireplaces, off-road applications, and industrial/commercial combustion. The forestry category includes non-agricultural prescribed burning and wildfire emissions.

Tracking Life-Cycle and Out-of-State Emissions

In recent years there has been increased interest in the embedded carbon in products, also known as *life-cycle emissions.* A life-cycle accounting framework refers to all of the GHG emissions generated from the sourcing, production, and transportation of products to an endpoint. In doing such assessments for a product, emissions may be associated with sourced materials and production activity outside a jurisdiction's borders. While life-cycle emissions can provide a more comprehensive picture of the emissions associated with the goods we consume and ongoing demand, life-cycle inventories are inconsistent with IPCC standards, as they would result in double counting of emissions across jurisdictions. Other countries and regions do produce their own inventory reports consistent with IPCC methods and are taking action to reduce emissions within their jurisdictions. In addition, jurisdictions often lack legal authority to regulate sources outside of their borders. Finally, it is difficult to obtain accurate data for sources and production activities outside of a region's border that would impact the accuracy of such an inventory. For these reasons, the inventory used in the Scoping Plan does not use a life-cycle

[120] SB 1383. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1383.

[121] This is a preliminary estimate developed for this Scoping Plan. Official Black Carbon emissions estimates are provided in the SLCP inventory here: https://ww2.arb.ca.gov/ghg-slcp-inventory.

approach and remains consistent with international accounting standards and consistent with how other countries and regions track emissions within their jurisdictions.

However, GHG mitigation action may cross geographic borders as part of subnational and international collaboration, or as a natural result of implementation of regional policies. In addition to the state's existing GHG inventory, CARB will develop an accounting framework that reflects the benefits of our policies accruing outside of the state. This accounting framework will be important to better understand the true impact of the state's policies on what is emitted into the atmosphere. For example, the LCFS incentivizes GHG reductions along the entire supply chain for the production and delivery of transportation fuel imported for use in the state. However, our inventory only captures the change in emissions from the tailpipe of when that fuel is used in California and does not capture any GHG reductions that occur in the production process if the fuel is produced out of state.

Natural and working lands forestry actions are another example, where California's policies are inspiring forest management actions in other states that result in increased permanent carbon sequestration. California's NWL inventory does not capture the increased carbon stocks resulting from forestry projects happening outside of California, and the CO_2 removals resulting from these projects are not applied in either CARB's NWL inventory or CARB's AB 32 GHG Emissions Inventory. For GHG reductions outside of the state to be attributed to our programs, those reductions must be real, quantifiable, verifiable, and permanent.

It also will be important to avoid any double counting (including claims to those reductions by other jurisdictions) and to transparently indicate whether any extra-jurisdictional emissions reductions might be included in another region's inventory. CARB is collaborating with other jurisdictions to ensure GHG accounting rules are consistent with international best practices, as robust accounting rules instill confidence in the reductions claimed and maintain support for joint action across jurisdictions. The policy goals of consistency and transparency are critical as we work together with other jurisdictions on our parallel paths to achieve our GHG targets with real benefits to the atmosphere.

Tracking Progress

Historically, the AB 32 GHG Inventory has been the primary metric to track progress toward achieving climate targets.[122] However, we must now deploy clean technology at unprecedented rates. The emissions modeling underpinning this Scoping Plan and

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[122] Starting with the 2022 Edition of the AB 32 GHG inventory, the inventory development now relies more directly on the annually reported and third-party verified emissions from the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions.

targets for clean technology in statute can serve as leading indicators across the economy on how our actions compare to the pace of action needed to be on track to achieve carbon neutrality. The California Climate Dashboard[123] was launched in 2022 and provides high-level metrics for clean energy production and technology deployment. Statistics such as the deployment of zero emission vehicles and clean electricity generation are just some of the examples of metrics across the economy that can be tracked, in addition to GHG emissions, to understand if the state is on track to meet its climate goals. A key indicator to track will be building of new energy infrastructure and deployment of clean technology as evaluated in the uncertainty analysis in Chapter 2. CARB will coordinate with state agencies to establish and make public similar metrics across all economic sectors to help provide transparency on the state's progress in deploying clean technology at the pace and scale needed to achieve carbon neutrality no later than 2045.

[123] CalEPA. California Climate Dashboard. https://calepa.ca.gov/climate-dashboard/.

Chapter 2: The Scoping Plan Scenario

This chapter describes the Scoping Plan Scenario, which for the first time includes sources in both the AB 32 GHG Inventory and Natural and Working Lands (NWL). It begins with a short description of the alternatives evaluated. Four scenarios for the AB 32 GHG Inventory and NWL were considered separately and helped to inform the Scoping Plan Scenario. Each of the alternatives were considered in terms of the important criteria and priorities that the state's comprehensive climate action must deliver, including the need for GHG reductions that are not only technologically feasible and cost-effective, but also can deliver health and economic benefits for the state. All the scenarios were set against what is called the *Reference Scenario*—that is, what the GHG emissions would look like if we did nothing at all beyond the existing policies that are required and already in place to achieve the 2030 target of at least 40 percent below 1990 levels, or those expected with no new actions in the NWL sector. For this Scoping Plan, two sets of modeling tools were used to evaluate the AB 32 GHG Inventory and NWL sectors because no single model can assess both AB 32 sectors and NWL together. As a result, two different sets of scenarios were developed for each sector type. While this chapter breaks out discussion separately for the two sector types, the Scoping Plan Scenario reflects the combined actions across both sectors by choosing an alternative from each sector type. The modeling provides point estimates; however, that does not imply precision. As discussed in the uncertainty section, several types of uncertainties are associated with any outcomes projected by the modeling results. There will be ranges of estimates associated with each point that are not shown in the graphs or results.

Scenarios for the AB 32 GHG Inventory Sectors

The Reference Scenario for the AB 32 GHG Inventory sectors shows continuing but modest GHG reductions beyond 2030 that level off toward mid-century. The comprehensive analysis of all four alternatives indicates that the Scoping Plan Scenario is the best choice to achieve California's climate and clean air goals while balancing the legislative direction on prioritizing direct emissions reductions, reducing anthropogenic emissions by at least 85 percent by 2045, being technologically feasible, and being cost-effective. It also protects public health, provides a solid foundation for continued economic growth, and drastically reduces the state's dependence on fossil fuel combustion and does not disproportionately impact disadvantaged communities. Each of the alternative scenarios was the product of a process of development informed by public input, the governor,[124] CARB, legislative direction, and input by the EJ Advisory Committee.[125,126] Future updates to the Scoping Plan may consider new clean technologies and fuels beyond those included in this Scoping Plan.

The four scenarios evaluated shared many similarities. They each embodied the following characteristics:

- Drastic reduction in fossil fuel dependence, with some remaining in-state demand for fossil fuels for aviation, marine, and locomotion applications, and for fossil gas for buildings and industry
- Ambitious deployment of efficient non-combustion technologies such as zero emission vehicles and heat pumps
- Rapid growth in the production and distribution of clean energy such as zero carbon electricity and hydrogen
- Progressive phasedown of fossil fuel production and distribution activities as part of the transition to clean energy
- Remaining emissions of fugitive SLCPs such as refrigerants and fugitive methane
- Strong consumer adoption of clean technology and fuel options
- Removal of remaining CO_2 emissions to achieve carbon neutrality
- Some reliance on carbon capture and sequestration (CCS)

While the four scenarios had a lot in common, they also had some differences:

- Year in which carbon neutrality is achieved (2035 or 2045)
- Rate of deployment of clean technology and production and distribution of zero carbon energy
- Remaining amount of demand for fossil energy in the year carbon neutrality is achieved
- Constraints on technology and fuels deployed in certain sectors
- Consumer adoption rates of clean technologies and fuels
- Degree of reliance on CO_2 removal
- Degree of reliance on CCS

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[124] Newsom, Gavin. July 22, 2022. Letter from Governor Newsom to CARB Chair Liane Randolph. Retrieved from https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf.

[125] EJ Advisory Committee. December 2, 2021. EJ Advisory Committee Responses for the CARB Scenario Inputs. https://ww2.arb.ca.gov/sites/default/files/2021-12/EJAC%20Final%20Responses%20to%20CARB%20Scenario%20Inputs_12_2_21.pdf.

[126] CARB. January 25, 2022. Update on PATHWAYS Scenario Modeling Assumptions. https://ww2.arb.ca.gov/sites/default/files/2022-01/Scenario%20Slides%20for%20Jan25%20EJAC%20Mtg_01242022.pdf.

The summary below provides an overview of the alternatives designed and considered for the energy and industrial sectors in this update. Full details of each scenario considered can be found in the *Draft 2022 Scoping Plan Update*

Scoping Plan Scenario (modeling scenario Alternative 3 from the Draft): carbon neutrality by 2045, deploy a broad portfolio of existing and emerging fossil fuel alternatives and clean technologies, and align with statutes, Executive Orders, Board direction, and direction from the governor

Alternative 1: carbon neutrality by 2035, nearly complete phaseout of all combustion, limited reliance on carbon capture and sequestration and engineered carbon removal, and restricted applications for biomass-derived fuels

Alternative 2: carbon neutrality by 2035 and aggressive deployment of a full suite of technology and energy options, including engineered carbon removal

Alternative 4: carbon neutrality by 2045, deployment of a broad portfolio of existing and emerging fossil fuel alternatives, slower deployment and adoption rates than the Scoping Plan Scenario, and a higher reliance on CO_2 removal

Other considerations for the AB 32 GHG Inventory sectors include the following:

- To what extent does an alternative meet the statewide targets and any sector targets, and also deliver clean air benefits (especially in the near term) to address ongoing healthy air disparities, prioritize reductions for mobile and large stationary sources, and emphasize continued investment in disadvantaged communities?
- Does an alternative support California in building on efforts to collaborate with other jurisdictions and include exportable policies based on robust science?
- Does an alternative provide for compliance options and a cost-effective approach to reduce GHG emissions?
- Does the alternative present a realistic and ambitious path forward consistent with statute and science, and support economic opportunities, particularly in anticipated growth sectors?

Scenarios for Natural and Working Lands

For the natural and working lands sector, the Reference Scenario shows that NWL will continue to emit GHGs and lose carbon stocks into the future as the combined effects of past unhealthy management practices and climate change impact our lands. Relative to the Reference Scenario, the four NWL scenarios represent different scales of land management on seven landscapes (forests, shrublands/chaparral, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands) to support carbon neutrality.

The analysis of the four NWL scenarios shows that the Scoping Plan Scenario is the preferred choice because it prioritizes sustainable land management to sequester carbon over the long term, GHG and air pollution reductions, ecosystem health and resilience, and implementation and technological feasibility and cost-effectiveness. The Scoping Plan Scenario reduces catastrophic wildfire risk to the state; increases the health and resilience of California's forests, shrublands, and grasslands; increases soil health; and protects, restores, and enhances California's natural and working lands for future generations. The Scoping Plan Scenario takes into consideration the priority landscapes and nature-based strategies identified in California's Climate Smart Strategy[127] and reflects the state's priorities to manage lands in ways that support the multiple benefits they provide. The Scoping Plan Scenario, as well as each of the alternative NWL scenarios, were informed by input from other agencies, the public, and the EJ Advisory Committee. Additional landscapes and land management activities will be added and evaluated in future Scoping Plan updates and in response to AB 1757.

Each of the NWL scenarios have several similarities, including the following:

- Prioritizing NWL management actions on forests, shrublands, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands. These actions can reduce GHG emissions from these lands, protect ecosystems against future climate change, protect communities, and enhance the ecosystem benefits they provide to nature and society.
- Exploring the potential impacts of different levels of NWL management actions that are designed to achieve the objective associated with each scenario.
- Analyzing the carbon impacts of land management actions, climate change, wildfire, and water use on California's diverse natural and working lands through 2045.

There are also differences across the four NWL scenarios. These include:

- The level of NWL management actions taken on each landscape, such as varying the acres of healthy soils practices for croplands.
- The types of NWL management actions taken on each landscape, such as prescribed burning or thinning for forests, grasslands, and shrublands.

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[127] CNRA. 2022. Natural and Working Lands Climate Smart Strategy. https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf.

The summary below provides an overview of the alternatives designed and considered for the NWL sectors in this Scoping Plan. Full details of each scenario considered can be found in the *Draft 2022 Scoping Plan Update*.

Scoping Plan Scenario (NWL Alternative 3 from the Draft): land management activities that prioritize restoration and enhancement of ecosystem functions to improve resilience to climate change impacts, including more stable carbon stocks

NWL Alternative 1: land management activities that prioritize short term carbon stocks in our forests and through increased climate smart agricultural practices on croplands

NWL Alternative 2: land management activities representative of California's current commitments and plans

NWL Alternative 4: land management activities that prioritize reducing catastrophic wildfires in forests, shrublands, and grasslands

Evaluation of Scoping Plan Alternatives

CARB staff solicited feedback from topical experts, affected stakeholders, and the EJ Advisory Committee, including a tribal representative, at public meetings to assemble input assumptions for four carbon neutrality scenarios to model using PATHWAYS. Revisions to the Draft Scoping Plan were informed by direction in statute, the Governor's Executive Orders, public comments, and the recommendations of the EJ Advisory Committee. The three alternative scenarios were designed to explore the potential speed, magnitude, and impacts of transitioning California's energy demand away from fossil fuels. The modeling assumptions listed below identify the primary fossil fuel alternative that is commercially available and technically feasible for widespread use by 2045 for each sector. CARB assumes that any energy demand that remains after the alternative technology or fuel is applied—such as on-road internal combustion engines, industrial processes, and gas use in existing buildings that have not yet decarbonized—will continue to be met by fossil fuels, resulting in residual GHG emissions.

NWL Scoping Plan Alternatives

For the NWL sectors, staff significantly expanded the scale of the scientific analysis for NWL from previous Scoping Plan efforts. CARB staff utilized modeling tools for this expanded analysis to assess both the carbon and other ecological, public health, and economic outcomes of management actions on forests, shrublands, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands. CARB staff aligned the scenarios with both the landscape types and actions identified in other efforts called for in Governor Newsom's Executive Order N-82-20 (e.g., California's Climate Smart Strategy and Pathways to 30x30). As part of this Scoping Plan, CARB staff modeled as many of the management actions identified in the Natural and Working Lands Climate

Smart Strategy as were feasible. The management actions that were included in the model were selected because of the State of California's previous work to quantify these actions' impacts. It was not feasible to model every land management strategy for NWL, and so it is possible that larger volumes of sequestration (e.g., in soils or in oceans) could result from additional non-modeled activities. California's Natural and Working Lands Climate Smart Strategy includes a more comprehensive listing of priority nature-based solutions and management actions. It is important to note that the absence of a particular management action or its climate benefit in the modeling is not an indication of its importance or potential contributions toward meeting the target or toward supporting the carbon neutrality target for California.

Forests: Management strategies were modeled for forests: biological/chemical/ herbaceous treatments (e.g., herbicide application), clearcut, various timber harvests (e.g., variable retention, seed tree / shelterwood, selection harvesting), mastication, other mechanical treatments (e.g., piling of dead material, understory thinning), prescribed burning, and thinning. Avoided land conversion to another land use was also included in the modeling. Wildfire was modeled and is responsive to management strategies and climate conditions.

Shrublands and chaparral: Management strategies were modeled for shrublands and chaparral: biological/chemical/herbaceous treatments, prescribed burning, mechanical treatment (e.g., mastication, crushing, mowing, piling), and avoided conversion from shrubland to another land use. Wildfire was modeled and is responsive to management strategies and climate conditions.

Grasslands: Management strategies were modeled for grasslands: biological/chemical/herbaceous treatments, prescribed burning, and avoided land conversion from grasslands to another land use. Wildfire was modeled and is responsive to management strategies and climate conditions.

Croplands: Management strategies were modeled for row crops: cover cropping, no till, reduced till, compost amendment, transition to organic[128] farming, avoided conversion of annual crop agricultural land through easements, establishing riparian forest buffers, alley cropping, establishing windbreaks/shelterbelts, establishing tree and shrubs in croplands, and establishing hedgerows. For perennial crops, windbreaks/shelterbelts, hedgerows, conversion from annual crops to perennial crops, and avoided conversion to other land uses were modeled.

[128] Note: N_2O reductions from decreases in synthetic fertilizer application in organic farming were not modeled.

Developed lands: Management strategies were modeled for developed lands: Increasing tree canopy cover through planting trees and improved management of existing trees, and removing vegetation surrounding structures in accordance with the CAL FIRE Defensible Space PRC 4291.

Wetlands: Management strategies were modeled for wetlands: Restoring wetlands through submerging cultivated land in the Sacramento-San Joaquin Delta and avoided land conversion in the Sacramento-San Joaquin Delta.

Sparsely vegetated lands: Management strategies were modeled for sparsely vegetated lands: Avoided conversion of sparsely vegetated lands to another land use.

Scoping Plan Scenario

The Scoping Plan Scenario achieves GHG emission reductions that exceed the levels expected based on existing policies represented in the Reference Scenario, keeping California on track to achieve the SB 32 GHG reduction target for 2030 and become carbon neutral no later than 2045. Actions that reduce GHG emissions and transition AB 32 GHG Inventory sources away from fossil fuel combustion affect each economic sector. Actions that lead to improved carbon stocks affect each landscape.

AB 32 GHG Inventory Sectors

The AB 32 GHG Inventory Sector Reference scenario is the forecasted statewide GHG emissions through mid-century, with existing policies and programs but without any further action to reduce GHGs beyond those needed to achieve the 2030 limit. The Reference Scenario was developed based on other projections of business-as-usual conditions. Sources of data and policies included are:

- California Energy Demand Forecast[129]
- The two transportation carbon neutrality studies required by AB 74[130]
- The Mobile Source Strategy[131]
- SB 100 60 percent Renewables Portfolio Standard
- A Low Carbon Fuel Standard carbon intensity reduction target of 20 percent

Policies that are under study or design, such the Advanced Clean Fleets regulation, are not included. The Reference Scenario reflects current trends and expected performance of policies identified in the 2017 Scoping Plan—some of which are performing better (such as the RPS and LCFS) and others that may not meet expectations (such as vehicle miles traveled [VMT] reductions and methane capture). Figure 2-1 provides the modeling results for a Reference Scenario for the AB 32 GHG Inventory sectors compared to the Scoping Plan Scenario.

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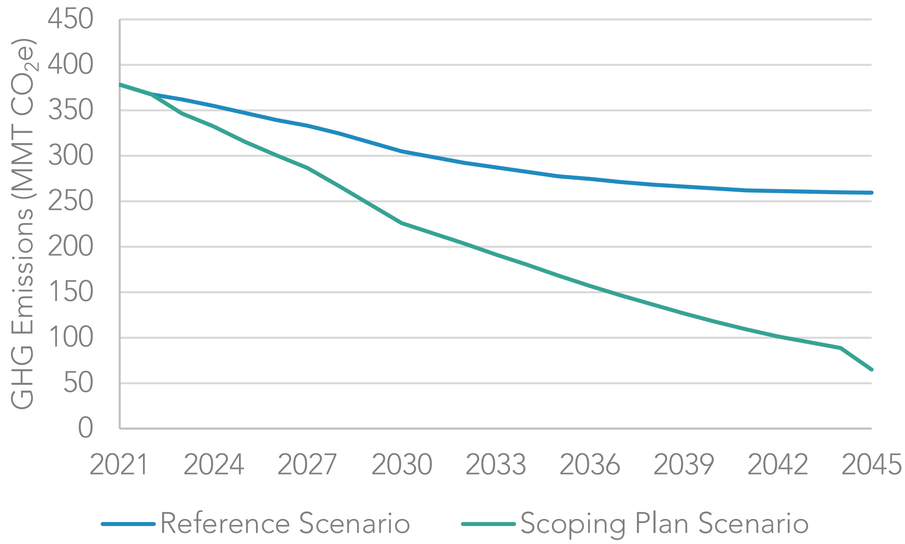
[129] California Energy Commission (CEC). 2020. *2019 Integrated Energy Policy Report.* https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2019-integrated-energy-policy-report.

[130] Brown et al. 2021. *Driving California's Transportation Emissions.* https://escholarship.org/uc/item/3np3p2t0 and Deschenes et al. 2021. *Enhancing equity.* https://zenodo.org/record/4707966#.YI72RNrMKUn.

[131] CARB. 2021. 2020 *Mobile Source Strategy.* https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf.

Figure 2-1: Reference and Scoping Plan Scenario GHG emissions[132]



The Scoping Plan Scenario is summarized in Table 2-1. The table shows the types of technologies and energy needed to drastically reduce GHG emissions from the AB 32 Inventory sectors. It also includes references to relevant statutes and Executive Orders, although it is not comprehensive of all existing new authorities for directing or supporting the actions described. Each action is expected to both reduce GHGs and help improve air quality, primarily by transitioning away from combustion of fossil fuels. The Scoping Plan Scenario achieves the AB 1279 target of 85 percent below 1990 levels by 2045 and identifies a need to accelerate the 2030 target to 48 percent below 1990 levels.

[132] The drop in emissions in 2045 reflects both the need to achieve an 85% reduction below 1990 levels in anthropogenic emissions per AB 1279 and Governor Newsom's request for a 100 MMT CO2e carbon removal and capture target in 2045. This was modeled by extending CCS to electric sector emissions.

Table 2-1: Actions for the Scoping Plan Scenario: AB 32 GHG Inventory sectors

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
GHG Emissions Reductions Relative to the SB 32 Target[133]	40% below 1990 levels by 2030	SB 32: Reduce statewide GHG emissions. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Smart Growth / Vehicle Miles Traveled (VMT)	VMT per capita reduced 25% below 2019 levels by 2030, and 30% below 2019 levels by 2045	SB 375: Reduce demand for fossil transportation fuels and GHGs, and improve air quality. In response to Board direction and EJ Advisory Committee recommendations
Light-duty Vehicle (LDV) Zero Emission Vehicles (ZEVs)	100% of LDV sales are ZEV by 2035	EO N-79-20: Reduce demand for fossil transportation fuels and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory 2035 target aligns with the EJ Advisory Committee recommendation.

[133] While the SB 32 GHG emissions reduction target is not an Action that is analyzed independently, it is included in this table for reference.

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Truck ZEVs	100% of medium-duty (MDV)/HDV sales are ZEV by 2040 (AB 74 University of California Institute of Transportation Studies [ITS] report)	EO N-79-20: Reduce demand for fossil transportation fuels and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Aviation	20% of aviation fuel demand is met by electricity (batteries) or hydrogen (fuel cells) in 2045. Sustainable aviation fuel meets most or the rest of the aviation fuel demand that has not already transitioned to hydrogen or batteries.	Reduce demand for petroleum aviation fuel and reduce GHGs. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory In response to Governor Newsom's July 2022 letter to CARB Chair Liane Randolph
Ocean-going Vessels (OGV)	2020 OGV At-Berth regulation fully implemented, with most OGVs utilizing shore power by 2027. 25% of OGVs utilize hydrogen fuel cell electric technology by 2045.	Reduce demand for petroleum fuels and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Port Operations	100% of cargo handling equipment is zero-emission by 2037. 100% of drayage trucks are zero emission by 2035.	Executive Order N-79-20: Reduce demand for petroleum fuels and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Freight and Passenger Rail	100% of passenger and other locomotive sales are ZEV by 2030. 100% of line haul locomotive sales are ZEV by 2035. Line haul and passenger rail rely primarily on hydrogen fuel cell technology, and others primarily utilize electricity.	Reduce demand for petroleum fuels and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Oil and Gas Extraction	Reduce oil and gas extraction operations in line with petroleum demand by 2045.	Reduce GHGs and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Petroleum Refining	CCS on majority of operations by 2030, beginning in 2028 Production reduced in line with petroleum demand.	Reduce GHGs and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Electricity Generation	Sector GHG target of 38 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) in 2030 and 30 $MMTCO_2e$ in 2035 Retail sales load coverage[134] 20 gigawatts (GW) of offshore wind by 2045 Meet increased demand for electrification without new fossil gas-fired resources.	SB 350 and SB 100: Reduce GHGs and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory In response to Governor Newsom's July 2022 letter, Board direction, and EJ Advisory Committee recommendation
New Residential and Commercial Buildings	All electric appliances beginning 2026 (residential) and 2029 (commercial), contributing to 6 million heat pumps installed statewide by 2030	Reduce demand for fossil gas and GHGs, and improve ambient and indoor air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory In response to Governor Newsom's July 2022 letter

[134] SB 100 speaks only to retail sales and state agency procurement of electricity. The *2021 SB 100 Joint Agency Report* reflects the agency authors' understanding that other loads—wholesale or non-retail sales and losses from storage and transmission and distribution lines—are not subject to the law.

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Existing Residential Buildings	80% of appliance sales are electric by 2030 and 100% of appliance sales are electric by 2035. Appliances are replaced at end of life such that by 2030 there are 3 million all-electric and electric-ready homes—and by 2035, 7 million homes—as well as contributing to 6 million heat pumps installed statewide by 2030.	Reduce demand for fossil gas and GHGs, and improve ambient and indoor air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory In response to Governor Newsom's July 2022 letter
Existing Commercial Buildings	80% of appliance sales are electric by 2030, and 100% of appliance sales are electric by 2045. Appliances are replaced at end of life, contributing to 6 million heat pumps installed statewide by 2030.	Reduce demand for fossil gas and GHGs, and improve ambient and indoor air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory In response to Governor Newsom's July 2022 letter
Food Products	7.5% of energy demand electrified directly and/or indirectly by 2030; 75% by 2045	Reduce demand for fossil gas and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Construction Equipment	25% of energy demand electrified by 2030 and 75% electrified by 2045	Reduce demand for fossil energy and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Chemicals and Allied Products; Pulp and Paper	Electrify 0% of boilers by 2030 and 100% of boilers by 2045. Hydrogen for 25% of process heat by 2035 and 100% by 2045 Electrify 100% of other energy demand by 2045.	Reduce demand for fossil energy and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Stone, Clay, Glass, and Cement	CCS on 40% of operations by 2035 and on all facilities by 2045 Process emissions reduced through alternative materials and CCS	SB 596: Reduce demand for fossil energy, process emissions, and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Other Industrial Manufacturing	0% energy demand electrified by 2030 and 50% by 2045	Reduce demand for fossil energy and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Combined Heat and Power	Facilities retire by 2040.	Reduce demand for fossil energy and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Agriculture Energy Use	25% energy demand electrified by 2030 and 75% by 2045	Reduce demand for fossil energy and GHGs, and improve air quality. AB 197: direct emissions reductions
Low Carbon Fuels for Transportation	Biomass supply is used to produce conventional and advanced biofuels, as well as hydrogen.	Reduce demand for petroleum fuel and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Low Carbon Fuels for Buildings and Industry	In 2030s biomethane[135] blended in pipeline Renewable hydrogen blended in fossil gas pipeline at 7% energy (~20% by volume), ramping up between 2030 and 2040 In 2030s, dedicated hydrogen pipelines constructed to serve certain industrial clusters	Reduce demand for fossil energy and GHGs, and improve air quality. AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

[135] *Biomethane* is also known as renewable natural gas (RNG).

Sector	Action	Statutes, Executive Orders, Other Direction, Outcome
Non-combustion Methane Emissions	Increase landfill and dairy digester methane capture. Some alternative manure management deployed for smaller dairies Moderate adoption of enteric strategies by 2030 Divert 75% of organic waste from landfills by 2025. Oil and gas fugitive methane emissions reduced 50% by 2030 and further reductions as infrastructure components retire in line with reduced fossil gas demand	SB 1383: Reduce short-lived climate pollutants.
High GWP Potential Emissions	Low GWP refrigerants introduced as building electrification increases, mitigating HFC emissions	SB 1383: Reduce short-lived climate pollutants.

Natural and Working Lands

The Reference Scenario for NWL represents the amount of land management that occurred between 2001 and 2014, and projects the outcomes from maintaining the 2001–2014 levels of land management until 2045. The management and land use practices that occur within the Reference Scenario were derived from empirical data used by staff. For forests, shrublands/chaparral, and grasslands, the Reference Scenario constitutes approximately 250,000 acres of annual statewide treatments. For croplands, the Reference Scenario represents no healthy soil practices because during this period the healthy soil program did not yet exist. For land use change within all land types that consider land use change, historical rates of land conversion from 2001–2014 also were taken from empirical data and modeled into the future for the Reference Scenario.

Table 2-2 summarizes the Scoping Plan Scenario. The table also includes references to relevant statutes and Executive Orders where available.

Table 2-2: Actions for the Scoping Plan Scenario: NWL sectors

Sector	Action	Statutes, Executive Orders, Outcome
Natural and Working Lands	Conserve 30% of the state's NWL and coastal waters by 2030. Implement near- and long-term actions to accelerate natural removal of carbon and build climate resilience in our forests, wetlands, urban greenspaces, agricultural soils, and land conservation activities in ways that serve all communities—and in particular low-income, disadvantaged, and vulnerable communities.	EO N-82-20 and SB 27: CARB to include an NWL target in the Scoping Plan. AB 1757: Establish targets for carbon sequestration and nature-based climate solutions. SB 1386: NWL are an important strategy in meeting GHG reduction goals.

Sector	Action	Statutes, Executive Orders, Outcome
Forests and Shrublands	At least 2.3 million acres[136] treated statewide annually in forests, shrublands/chaparral, and grasslands, comprised of regionally specific management strategies that include prescribed fire, thinning, harvesting, and other management actions. No land conversion of forests, shrublands/chaparral, or grasslands.	Restore health and resilience to overstocked forests and prevent carbon losses from severe wildfire, disease, and pests. Improve air quality and reduce health costs related to wildfire emissions. Improve water quantity and quality and improve rural economies. Provide forest biomass for resource utilization. EO B-52-18: CARB to increase the opportunity for using prescribed fire. AB 1504 (Skinner, Chapter 534, Statutes of 2010): CARB to recognize the role forests play in carbon sequestration and climate mitigation.

[136] The 2.3 million acre target is what the Scoping Plan modeling shows would be needed to realize the carbon stock target called for in this Scoping Plan by 2045.

Sector	Action	Statutes, Executive Orders, Outcome
Grasslands	At least 2.3 million acres[137] treated includes increased management of grasslands interspersed in forests to reduce fuels surrounding communities using management strategies appropriate for grasslands. No land conversion of forests, shrublands/chaparral, or grasslands.	Help to achieve climate targets, improve air quality, and reduce health costs.
Croplands	Implement climate smart practices for annual and perennial crops on ~80,000 acres annually. Land easements/ conservation on annual crops at ~5,500 acres annually. Increase organic agriculture to 20% of all cultivated acres by 2045 (~65,000 acres annually).	Reduce short-lived climate pollutants. Increase soil water holding capacity. Increase organic farming and reduce pesticide use. SB 859: Recognizes the ability of healthy soils practices to reduce GHG emissions from agricultural lands. Target increased in response to Governor Newsom's direction to prioritize sustainable land management.

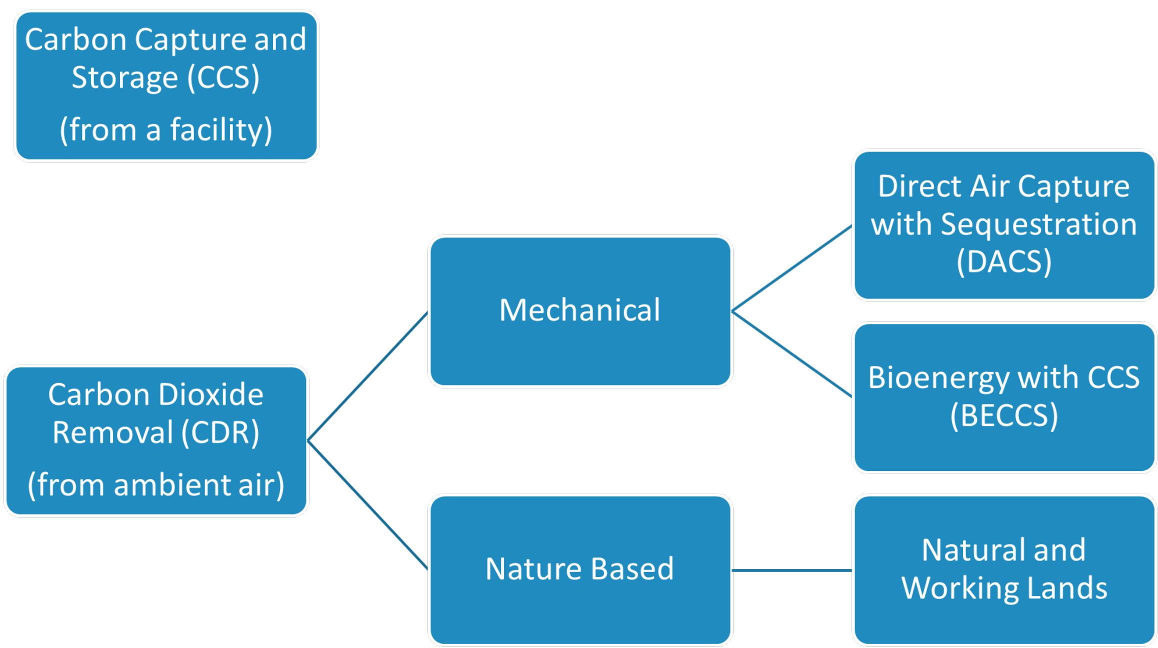
[137] The 2.3 million acre target is what the Scoping Plan modeling shows would be needed to realize the carbon stock target called for in this Scoping Plan by 2045.

Sector	Action	Statutes, Executive Orders, Outcome
Developed Lands	Increase urban forestry investment by 200% above current levels and utilize tree watering that is 30% less sensitive to drought. Establish defensible space that accounts for property boundaries.	Increase urban tree canopy and shade cover. Reduce heat island effects and support water infrastructure. Reduce fire risk via defensible space. AB 2251 (Calderon, Chapter 186, Statutes of 2022): Increase urban tree canopy 10% by 2035. Target increased in response to AB 2251 and Governor Newsom's direction on CO_2 removal targets in his July 2022 letter.
Wetlands	Restore 60,000 acres of Delta wetlands.	Increase carbon sequestration and reduce short-lived climate pollutants. Helps to reverse land subsidence while improving flood protection and providing critical habitat.
Sparsely Vegetated Lands	Land conversion at 50% of the Reference Scenario land conversion rate.	Reduce the rate of land conversion to more GHG-intensive land uses.

Strategies for Carbon Removal and Sequestration

To achieve carbon neutrality, any remaining emissions must be compensated for using carbon removal and sequestration tools. The following discussion presents more detail on the options available to capture and sequester carbon. Carbon removal and sequestration will be an essential tool to achieve carbon neutrality, and the modeling clearly shows there is no path to carbon neutrality without carbon removal and sequestration. Governor Newsom also recognized the importance of CO_2 removal strategies and directed CARB to establish CO_2 removal and carbon capture targets of 20 $MMTCO_2$ and 100 $MMTCO_2$ by 2030 and 2045, respectively, as well as signing 2022 legislation on carbon removal and sequestration, including: AB 1279, SB 905, SB 1137, and AB 1757. Carbon removal and sequestration can take different forms. Figure 2-2 illustrates the types of carbon removal and sequestration included in this Scoping Plan. There are numerous other carbon removal options undergoing research, development, and pilot deployment. As these options mature and new approaches emerge, they can be considered in future Scoping Plan updates.

Figure 2-2: Forms of carbon removal and sequestration considered in this Scoping Plan



The Role of Carbon Capture and Sequestration

Carbon capture and sequestration (CCS) will be a necessary tool to reduce GHG emissions and mitigate climate change while minimizing leakage and minimizing emissions where no technological alternatives may exist. CCS is a process by which large amounts of CO_2 are captured, compressed, transported, and sequestered. CCS projects are paired with a source of emissions, as the CCS project captures CO_2 as it leaves a facility's smokestack. CCS projects are often paired with large GHG-emitting facilities such as energy, manufacturing, or fuel production facilities. The sequestration component of CCS includes CO_2 injection into geologic formations (such as depleted oil and gas reservoirs and saline formations), as well as use in industrial materials (e.g., concrete). CCS is distinct from biological sequestration, which is typically accomplished through NWL management and conservation practices that enhance the storage of carbon or reduce CO_2 emissions with nature-based approaches. CCS is also distinct from mechanical CO_2 removal technologies, where CO_2 is removed directly from the atmosphere using mechanical and/or chemical processes.

CARB adopted a CCS Protocol in 2018 as part of amendments to the Low Carbon Fuel Standard.[138] At this time, no CCS projects have been implemented or have generated any credits under that protocol. However, CCS projects have been implemented elsewhere since the 1970s, largely on coal-fired power plants, with over two dozen projects operational around the world. Over 100 are at the stages of advanced or early development and are expanding beyond coal-fired plants to fossil gas, fuel production, and electricity generation facilities.[139] CCS projects are in development for addressing emissions from fuel, gas, energy production, and chemical production. As of November 2019, more than half of global large-scale CCS facilities (representing approximately 22 $MMTCO_2$/yr in capacity[140]) were in the U.S., mostly as a result of sustained governmental support for these technologies.[141] This support includes the federal 45Q tax credit for CCS[142,143] and research and deployment grants from federal agencies.[144,145] California's deep sedimentary rock formations in the Central Valley represent world-class

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[138] CARB. 2022. Carbon Capture & Sequestration. *https://ww2.arb.ca.gov/our-work/programs/carbon-capture-sequestration*.

[139] Global CCS Institute. 2021. *Global Status of CCS 2021. https://www.globalccsinstitute.com/wp-content/uploads/2021/11/Global-Status-of-CCS-2021-Global-CCS-Institute-1121.pdf*.

[140] IHS Markit. August 2021. Carbon Removal Potential: An Overview. *https://ww2.arb.ca.gov/sites/default/files/2021-08/ihsmarkit_presentation_sp_engineeredcarbonremoval_august2021.pdf*.

[141] Beck, Lee. 2019. *Carbon capture and storage in the USA: The role of US innovation leadership in climate-technology commercialization. https://academic.oup.com/ce/article/4/1/2/5686277*.

[142] Congressional Research Service. 2021. Carbon Storage Requirements in the 45Q Tax Credit. IF11639. *https://crsreports.congress.gov/product/pdf/IF/IF11639*.

[143] The Inflation Reduction Act of August 2022 expands and enhances the 45 Q tax credit for CCS. Pub.L. No. 117-169 (August 16, 2022).

[144] U.S. Department of Energy. 2020. U.S. Department of Energy Announces $131 Million for CCUS Technologies. *https://www.energy.gov/articles/us-department-energy-announces-131-million-ccus-technologies*.

[145] U.S. Department of Energy. 2021. Funding Opportunity Announcement 2515, Carbon Capture R&D for Natural Gas and Industrial Point Sources, and Front-End Engineering Design Studies for Carbon Capture Systems at Industrial Facilities and Natural Gas Plants. *https://www.energy.gov/fecm/articles/funding-opportunity-announcement-2515-carbon-capture-rd-natural-gas-and-industrial*.

CO_2 storage sites that would meet the highest standards, with storage capacities of at least 17 billion tons of CO_2.[146, 147]

In this Scoping Plan, CCS is included to address emissions from limited sectors, including electricity generation, cement production facilities, and refineries, to ensure anthropogenic emissions are reduced by at least 85 percent below 1990 levels in 2045, as directed in AB 1279. While the modeling outputs show CCS not being applied to the electricity sector until 2045, CCS could be implemented earlier on the electricity sector with a similar ramp up over time as that for refineries and cement plants. An earlier application of CCS in the electricity sector would yield additional reductions in years prior to 2045. In addition, CCS can support hydrogen production until such time as there is sufficient renewable power for electrolysis and an abundant water source.

Cement plants have emissions associated with combustion and process-related activities. Combustion emissions account for approximately 40 percent of the total emissions at cement plants. The remaining emissions are related to process-related activities. Due to the high heat content needed to produce cement, there is currently no technically feasible alternative to combustion. SB 596 calls for a 40 percent reduction in GHG intensity in cement emissions from 2019 levels by 2035, and then net zero emissions by 2045. To meet in-state demand, the state relies on cement both produced in state and imported. There are seven cement plants operating in California.[148] To minimize emissions leakage and address emissions from cement plants, the Scoping Plan Scenario includes CCS for cement plants. Additional reductions will need to be pursued and considered as part of implementation of SB 596, which calls for CARB to develop a comprehensive strategy by July 1, 2023, for the state's cement sector to achieve net-zero emissions of GHGs associated with cement used within the state as soon as possible, but no later than December 31, 2045. This effort began in the summer of 2022 and included sector specific workshops.

Even with implementation of EO N-79-20, and despite all of the ambitious efforts in the Scoping Plan Scenario, there will remain some demand for petroleum fuels for legacy vehicles on road applications, and in aviation, rail, and marine applications. Petroleum refineries will need to implement technology to decarbonize their operations and reduce their emissions. This Scoping Plan also assumes CCS at petroleum refineries as one of those potential strategies. Currently, there are seventeen petroleum refineries operating

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[146] For comparison purposes, California's emitted 418.2 million metric tons of CO_2e in 2019.
[147] Lawrence Livermore National Laboratory. 2020. *Getting to Neutral: Options for Negative Carbon Emissions in California.* Revision 1. https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf.
[148] CARB. Mandatory GHG Reporting – Reported Emissions. https://ww2.arb.ca.gov/mrr-data

in the state.[149] On the supply side, the modeling assumes all in-state demand is met through some very limited refining activities in California. Figure 2-3 shows the emissions from the refining sector with and without CCS. If CCS is not deployed, the emissions would be directly emitted into the atmosphere, and CO_2 removal by NWL or direct air capture would need to increase to compensate for the sector's emissions.

Refineries can have a variety of point sources that emit CO_2—such as steam methane reformers for producing hydrogen, combined heat and power units, and catalytic crackers—that are best suited for CCS. Each configuration of a refinery can be unique to its footprint, onsite operations, and the types of crude oils processed. There are newer technologies with smaller footprints[150] that can be deployed in modular configurations to capture CO_2 in space-constrained and multiple-point-source facilities such as refineries. CCS can provide a path to reducing GHG emissions from these facilities to meet petroleum demand while avoiding leakage and until such time as some refineries can be transitioned to produce clean energy to support the transition away from fossil fuels.

While the Scoping Plan modeled deployment of CCS on refineries and identifies significant emissions reductions that can be achieved, the refineries in California are large and complex. The actual deployment of CCS at these facilities as modeled in the Scoping Plan is uncertain. It will be important to closely monitor the evolution of CCS deployment in the refinery sector and, in the next Scoping Plan update, to evaluate the progress toward use in this sector to determine whether the projected reductions will be achieved.

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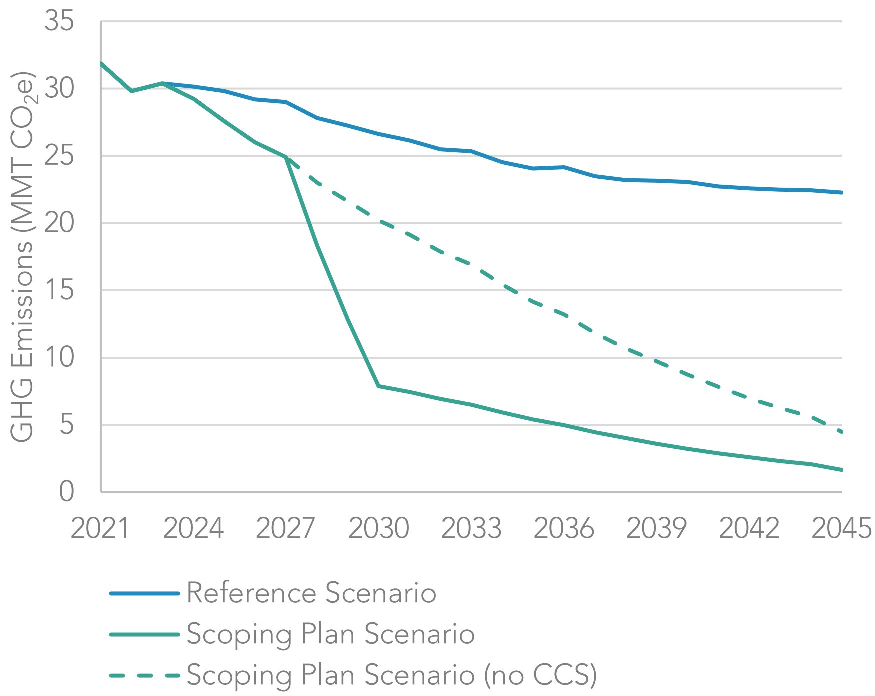
[149] CARB. Mandatory GHG Reporting. https://ww2.arb.ca.gov/mrr-data.
[150] Carbon Clean. Modular Carbon Capture Systems for Industry. https://www.carbonclean.com/modular-systems?hsLang=en.

Figure 2-3: Petroleum refining emissions with and without carbon capture and sequestration



This Scoping Plan also calls for accelerating the transition from combustion of fossil fuels to hydrogen. Hydrogen can be produced through electrolysis with renewable electricity or through steam methane reformation of biomethane. There is a high degree of uncertainty around the availability of solar to support both electrification of existing sectors and the production of hydrogen through electrolysis. Producing hydrogen required under the Scoping Plan Scenario with electrolysis would require about 10 gigawatts (GW)[151] of additional solar capacity. If steam methane reformation is paired with CCS, the hydrogen produced could potentially be low carbon. Additionally, the biomethane used to generate hydrogen could be sourced from gasification of forest or agricultural waste resulting from forest management and other NWL management practices, which could also lead to net negative carbon outcomes. Steam methane reformation paired with CCS can thus ensure a rapid transition to hydrogen and increase hydrogen availability until such time as

[151] The Draft Scoping Plan included an estimate for solar capacity (40 GW) to support only electrolysis to produce all hydrogen in the Proposed Scenario. The Scoping Plan now includes steam methane reformation of biomethane and biomass gasification with CCS to produce hydrogen, along with electrolysis from off-grid solar. See Appendix H (AB 32 GHG Inventory Sector Modeling) for additional details.

electrolysis with renewables can meet the ongoing need, assuming there is also sufficient water supply. Additional background and next steps for CCS can be found in Chapter 4.

The EJ Advisory Committee has raised multiple concerns related to the inclusion of CCS and mechanical CDR in the Scoping Plan. Concerns range from potential negative health and air quality impacts in communities from operation of facilities utilizing CCS that continue to emit other emissions, to safety concerns related to potential leaks, to the viability of the current technology. Additionally, the EJ Advisory Committee has policy concerns about the strategy and wants to ensure that engineered carbon removal is not used as a substitute for strategies to achieve emissions reductions onsite and that it does not result in delays in phasing out fossil fuel use. Given these and other concerns and the importance of building public awareness, CARB recognizes the need for a multi-stakeholder process including other state, federal, and local agencies; tribes; independent experts; and community residents to further understand and address community concerns related to CCS. CARB hosted a CCS Symposium with U.S. EPA Region 9 and the Stanford Doerr School of Sustainability to discuss some of these critical issues with community members and other participants. As CARB begins the process of implementing SB 905 in 2023, that will provide an opportunity for further engagement.

In the context of CCS deployment, the Council of Environmental Quality (CEQ) also highlighted the need to further assess and quantify potential impacts on local criteria air pollutants and other emissions resulting from carbon capture retrofits at industrial facilities in response to concerns regarding potential cumulative emissions from single and/or multiple sources.[152] An October 2020 Stanford report[153] discussed how the potential post-combustion capture for CO_2 could also reduce emissions of criteria air pollutant emissions from certain facilities. Exploring these potential outcomes will be important to ensure deployment of CCS does not exacerbate air pollution impacts in communities and maximizes any air pollution benefits. The need for these types of evaluations is also included in SB 905.

The Role of Natural and Working Lands Emissions and Sequestration

California's NWL assessments highlight the importance of increasing the pace and scale of NWL actions to ensure that our ecosystems are better equipped to withstand future climate change so they continue to provide the benefits that nature and society depend

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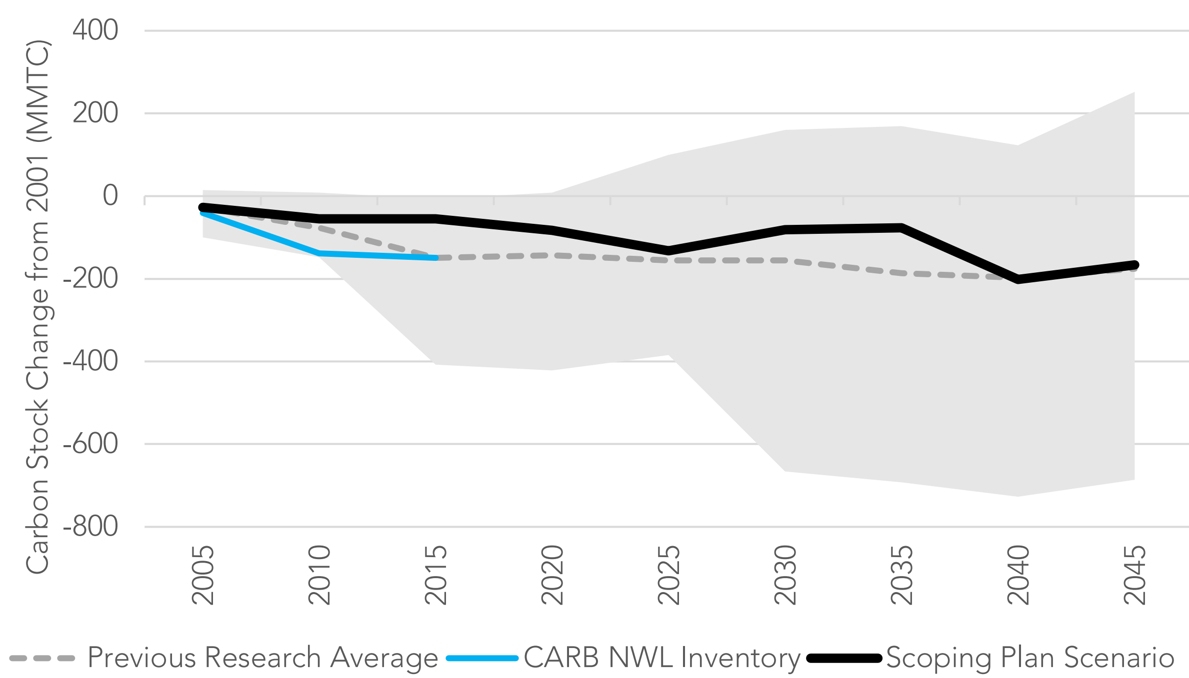
[152] Carbon Capture, Utilization, and Sequestration Guidance. 87 Fed. Reg. 8808 (Feb. 16, 2022), 2022-03205.pdf (govinfo.gov).

[153] Stanford Center for Carbon Storage. 2020. *An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions.* October. https://sccs.stanford.edu/ccs-in-ca/full-report-form?msclkid=6f9177f6c57811ecbebc473e75203b21.

upon for survival. As climate change increases the likelihood of extreme wildfires, drought, heat, and other impacts, carbon stocks in California's NWL will face increased risks and impacts. We know from previous climate change and Scoping Plan work[154] that lands can be a net source of GHG emissions or a net sink, and that the magnitude of carbon stock changes and GHG emissions and sequestration from NWL are dependent on the effects of climate change and land management. The expanded modeling conducted for this Scoping Plan shows that NWL are projected to be a net source of emissions through 2045 and indicates a probable decrease of carbon stocks into the future. This projection is further corroborated by previous, independent research that has reached the same conclusion, showing a range of varying levels of carbon stock loss. Figure 2-4 shows the modeling results of the Scoping Plan Scenario overlaid with the NWL inventory and findings from independent research.

Figure 2-4: Comparison of the Scoping Plan Scenario (NWL) with existing research



The modeling indicates that immediate and aggressive climate action can reduce the environmental impacts that would occur in the absence of this action. The results of the modeling demonstrate that regular NWL management over the next two decades can

154 CARB. 2019. January 2019. *Draft California 2030 Natural and Working Lands Climate Change Implementation Plan*. https://ww2.arb.ca.gov/sites/default/files/2020-10/draft-nwl-ip-040419.pdf.

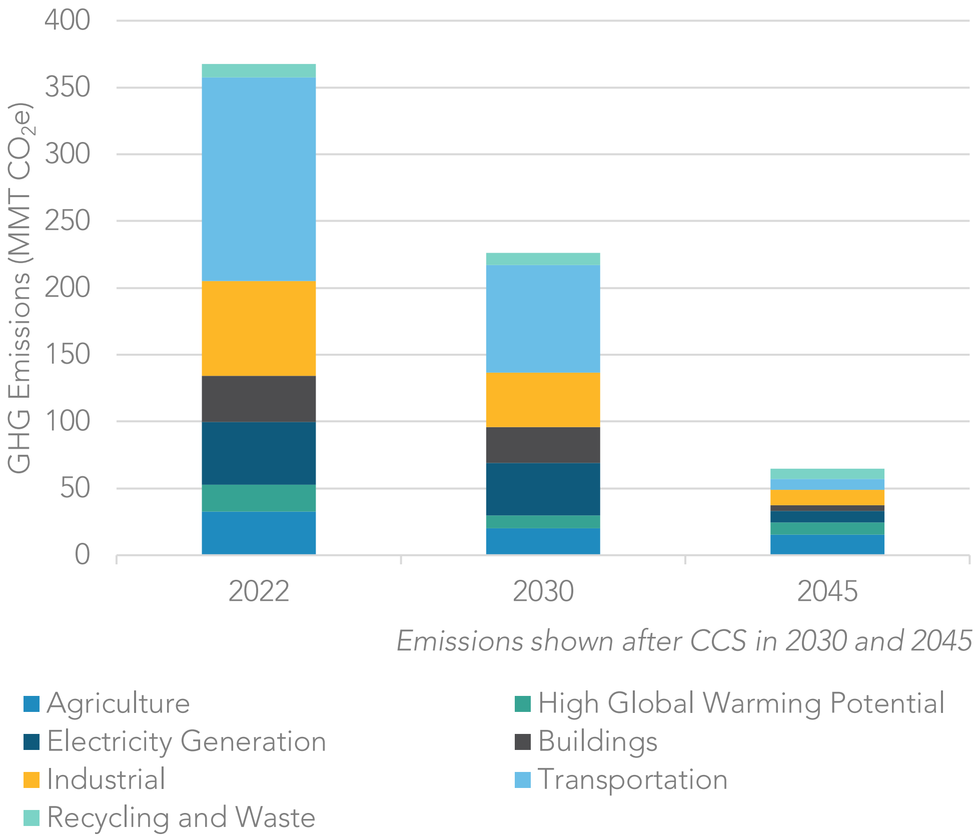
increase carbon stocks from the Reference Scenario trajectory, reduce GHG emissions from lands, and improve ecosystem and public health. This effort is the most comprehensive scientific effort taken by any government to include NWL within its overall climate strategy. Even so, we know that uncertainty exists about future climate and economic forces and the impacts they may have on our ecosystems, so it is important that the state take decisive and aggressive action to improve and diversify ecosystem structures and management.

The effects of climate change, including increased drought, wildfire, and extreme heat, play a significant role in determining the future of California's carbon stocks. And while management actions will help to reduce the impact that climate change will have on California, it is clear from the analysis that NWL sinks and sources are highly variable from year to year, and short time frames do not adequately demonstrate the impact that climate and management are having on ecosystems. For the purposes of climate planning, therefore, it is best to focus on carbon stock changes over longer periods rather than focusing on sequestration or emissions on shorter time frames. The Scoping Plan Scenario is estimated to result in additional NWL emissions of 7 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) annually from 2025–2045. The Reference Scenario is estimated to result in annual emissions of 9 $MMTCO_2e$ over the same time period, and so the Scoping Plan Scenario slows the rate of emissions and provides an approximate 2 $MMTCO_2e$ in additional annual sequestration relative to the Reference Scenario. Because NWL are projected to be a net emissions source, the annual NWL emissions of approximately 7 $MMTCO_2e$ from the Scoping Plan Scenario will need to be compensated by additional CO_2 removal approaches to ensure California can achieve carbon neutrality by 2045.

The Role for Carbon Dioxide Removal (Direct Air Capture)

Even if anthropogenic emissions are reduced to at least 85 percent below 1990 levels by 2045 as called for by AB 1279, there will still be residual emissions in the AB 32 GHG Inventory sectors in 2045 that must be addressed in order to achieve the California's carbon neutrality target. Figure 2-5 includes the emissions by sector for the AB 32 GHG Inventory Sectors in 2022, 2030, and 2045 for the Scoping Plan Scenario.

Figure 2-5: Residual emissions in 2022, 2030, and 2045 for the Scoping Plan Scenario[155]



To achieve carbon neutrality, mechanical CDR will therefore need to be deployed. Because NWL management is not estimated to be a significant carbon removal path in the near term, additional CDR options will be needed. *Mechanical CDR* refers to a range of technologies that capture and concentrate ambient CO_2. Direct air capture (DAC) is one available option that is under development today and could be widely deployed. Note that, unlike CCS, DAC technologies are not designed to be attached to a specific source or smokestack. These technologies include chemical scrubbing processes that capture CO_2 through absorption or adsorption separation processes. Another carbon removal

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[155] The High GWP sector includes high global warming potential gas emissions from releases of ozone depleting substance (ODS) substitutes, SF_6 emissions from the electricity transmission and distribution system, and gases that are emitted in the semiconductor manufacturing process. ODS substitutes, which are primarily hydrofluorocarbons (HFCs), are used in refrigeration and air conditioning equipment, solvent cleaning, foam production, fire retardants, and aerosols.

option that involves rapid mineralization of CO_2 at the Earth's surface is called *mineral carbonation.*[156] As is the case with CCS, mechanical CDR technologies will need governmental or other incentive support to overcome technology and market barriers. In the United States, the U.S. Department of Energy announced financing specifically for DAC in March 2020[157] and March 2021.[158] Additionally, almost $9 billion in CCS support was included in the $ 1 trillion Infrastructure Investment and Jobs Act of 2021.[159] This includes funding to establish four DAC hubs. The Inflation Reduction Act of 2022[160] increases the value of the 45Q tax credit to USD 85 per metric ton of CO_2 captured and stored in geologic formations from some industrial applications and USD 180 per metric ton for DAC with storage in geologic formations. In 2021, there were approximately 19 DAC facilities globally.[161]

Ultimately, the role for mechanical CDR will depend on the success of reducing emissions directly at the source in the AB 32 GHG Inventory sectors and the ability of the NWL to sequester carbon. However, mechanical CDR also provides an opportunity to not just achieve carbon neutrality, but also remove legacy GHG emissions from the atmosphere. As such, increased deployment of DAC can help achieve net negative emissions. This would further help avoid the most damaging impacts of climate change. While the federal incentives for DAC provide some support for this technology, the only California program that recognizes this technology is the LCFS program. Permitting must also happen across different levels of government and across multiple state agencies. Energy availability must also be addressed if DAC is to be implemented in remote areas. Additional information and next steps on DAC can be found in Chapter 4.

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[156] The National Academies Press. 2018. Direct Air Capture and Mineral Carbonation Approaches for Carbon Dioxide Removal and Reliable Sequestration: Proceedings of a Workshop–in Brief. *https://nap.nationalacademies.org/catalog/25132/direct-air-capture-and-mineral-carbonation-approaches-for-carbon-dioxide-removal-and-reliable-sequestration#:~:text=National%20Academies%20of%20Sciences%2C%20Engineering%2C%20and%20Medicine%3B%20Division,concentrate%20carbon%20dioxide%20%28CO%202%29%20from%20ambient%20air*.

[157] U.S. Department of Energy. 2020. Department of Energy to Provide $22 Million for Research on Capturing Carbon Dioxide from Air. *https://www.energy.gov/articles/department-energy-provide-22-million-research-capturing-carbon-dioxide-air*.

[158] U.S. Department of Energy. 2021. DOE Invests $24 Million to Advance Transformational Air Pollution Capture. *https://www.energy.gov/articles/doe-invests-24-million-advance-transformational-air-pollution-capture*.

[159] Pub.L. No. 117-58 (November 15, 2021). *https://www.congress.gov/bill/117th-congress/house-bill/3684/text*.

[160] Pub.L. No. 117-169 (August 16, 2022). *https://www.congress.gov/bill/117th-congress/house-bill/5376/text*.

[161] International Energy Agency (IEA). 2022. Direct Air Capture – Analysis. *https://www.iea.org/reports/direct-air-capture*.

Carbon Dioxide Removal and Capture Targets for 2030 and 2045

Recognizing the importance of CO_2 removal, Governor Newsom and the Legislature identified the need for targets to send policy and regulatory signals to pilot, deploy, and scale action for those efforts. Governor Newsom requested that CARB set a CO_2 removal and capture target of 20 MMT for 2030 and 100 MMT for 2045, first prioritizing sequestration in NWL. And while this Scoping Plan prioritizes and recommends significant increased climate-smart action on all NWL to support carbon neutrality and healthy and resilient lands, the modeling indicates that, across all NWL, lands will be a net source of emissions when accounting for both carbon sequestration and GHG (CO_2, CH_4, and N_2O) emissions from lands.

Some landscapes, however, are projected to have a net increase in carbon stocks under the Scoping Plan Scenario between 2025 and 2045 relative to the reference case, indicating that NWL actions can help California achieve Governor Newsom's CO_2 removal targets. Carbon stocks in urban forests and grasslands are projected to increase relative to historical levels from implementation of the 2022 Scoping Plan. To support the governor's CO_2 removal targets, CARB estimates that lands would contribute an average of 1.5 MMT of CO_2 removals each year between 2025 and 2045. Any carbon sequestration contributions from lands need to reflect both long-term storage and an overall net increase in carbon stocks over time to ensure these NWL actions are contributing toward California's achievement and maintenance of carbon neutrality over time.

CARB will work to update and revise these estimates as part of implementation of AB 1757, which was signed by the governor in September 2022 and requires that CARB and the California Natural Resources Agency (CNRA) work with an expert advisory committee to determine an ambitious range of carbon sequestration targets by January 1, 2024, for the years 2030, 2038, and 2045.

For the AB 32 GHG Inventory sectors, the Scoping Plan Scenario modeling indicates that the scenario would meet or exceed the 2030 SB 32 target through GHG reduction policies without the need for CDR. CDR will, however, be necessary to increase ambition for an accelerated 2030 target and in increasing amounts over the following decades to achieve carbon neutrality by 2045.[162] Given the likelihood of NWL to be a net source of emissions, and the need for CDR to compensate for residual emissions to achieve carbon neutrality

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[162] The modeled scenarios assume that residual emissions will be compensated using DAC technologies by including the direct cost in terms of dollars per ton CO_2 removed. The energy source for DAC is not modeled, but renewable electricity and/or hydrogen produced from electrolysis are zero carbon options consistent with the carbon neutrality targets in this Scoping Plan.

by 2045, California will need increasing deployment of mechanical CDR over the coming decades. In the immediate future, scaling nature-based CDR approaches also can help to provide some CO_2 removal quickly while mechanical CDR is scaled up between now and 2045. Table 2-3 provides estimates of CO_2 removal and capture needed in 2030[163] and 2045.

[163] As identified in Chapter 1, SB 27 (Skinner, Chapter 237, Statues of 2021) directed CARB to "establish carbon dioxide removal targets for 2030 and beyond" as part of this Scoping Plan. CARB is establishing these targets to satisfy both the requirements of SB 27 and the directive from Governor Newsom to establish CO_2 removal targets for 2030 and 2045.

Table 2-3: GHG emissions and removals needed to achieve carbon neutrality and meet the 20 $MMTCO_2$ removal and capture target in 2030 and the 100 $MMTCO_2$ removal and capture target in 2045.[164]

	2030 ($MMTCO_2e$)	2045 ($MMTCO_2e$)
GHG Emissions	233	72
AB 32 GHG Inventory Sector Emissions	226	65
Net NWL GHG Emissions Across All Landscapes (annual average from 2025–2045)	7	7
Carbon Capture and Sequestration (CCS): Avoided GHG Emissions from Industry and Electric Sectors	(13)	(25)
Carbon Dioxide Removal (CDR) including natural and working lands carbon sequestration,[165] Direct Air Capture, and Bioenergy with CCS (BECCS).	(7)	(75)
Net Emissions (GHG Emissions + CDR)	226	(3)

In 2030, the CO_2 removal and capture target is 20 MMT, but because the SB 32 target only encompasses the AB 32 GHG Inventory sectors, only CCS that reduces GHG emissions on AB 32 sources count toward achieving more ambitious GHG emission reductions in 2030. In 2045, the CO_2 removal and capture must compensate for any residual emissions from the AB 32 Inventory sectors and NWL emissions to support achieving carbon neutrality while also totaling at least 100 MMT. It is important to note that NWL, particularly forests, need a natural wildfire cycle to remain healthy. While the modeling projected wildfires, and implementing the Scoping Plan will result in a reduction in future wildfire emissions, getting to zero wildfires in the sector is not the goal, nor the

[164] Modeled estimates from the Scoping Plan Scenario indicate the relative quantity of emissions and removals to achieve carbon neutrality and meet carbon removal and capture targets. These estimates are not intended to imply precision, as the required policies are yet to be implemented and all models have some uncertainty in their forecasts.

[165] For the purposes of quantifying how to achieve the governor's 20 MMT and 100 MMT CO_2 removal and capture target, CARB included 1.5 $MMTCO_2e$ sequestration from NWL, which is the sequestration from urban forests. This is included as CO_2 removal because it is this sequestration that CARB can consider as having some permanence. Permanence is necessary for incorporating NWL into carbon neutrality. The net NWL emissions of 7 $MMTCO_2e$, identified in the second row of Table 2-3, includes *all* emissions and sinks from all NWL landscapes, which is inclusive of the 1.5 $MMTCO_2e$ sequestration. CARB will develop an accounting framework to accommodate NWL carbon stocks.

right approach to a sustainable forestry sector. In contrast in 2045, the reductions from programs and policies are estimated to reduce emissions by 169 $MMTCO_2e$ from business as usual.

The 2030 target for engineered CDR also provides a near term milestone for California and can serve as an important marker for progress in deploying CDR to support California's carbon neutrality goal. Preliminary estimates indicate that, globally, capacity from already announced projects will range from about 2 million metric tons per year ($MMTCO_2$/y) to 8 $MMTCO_2$/y from bioenergy paired with CCS, and from about 2,000 metric tons per year ($MTCO_2$/y) to 1 $MMTCO_2$/y from DACs by 2027,[166] which indicates that California's 2030 target is an ambitious, but achievable, goal.

Scenario Uncertainty

Greenhouse Gas Emissions Modeling

Several types of uncertainty are important to understand in both forecasting future emissions and estimating the benefits of emission reduction actions. In developing this Scoping Plan we forecasted a reference scenario and estimated the GHG emissions outcome of the AB 32 GHG Inventory sectors using the PATHWAYS[167] model. Inherent in the reference scenario modeling is the expectation that many of the existing programs will continue in their current form, and that the expected drivers for GHG emissions, such as energy demand, population growth, and economic growth, will match our current projections.

However, there is also the expectation that each of the policies included and implemented to achieve the 2030 target in the 2017 Scoping Plan will deliver their exact outcomes. It is unlikely the future will precisely match our projections, and this will lead to uncertainty in the forecast. For example, we never could have foreseen and forecasted economic and emissions impacts related to the extended disruptions from the COVID-19 pandemic. Thus, the single "reference" or "forecast" line should be understood to represent one possible future in a range of possible predictions. For this Scoping Plan, PATHWAYS utilized inputs that reflect technically feasible levels of deployment or adoption of low- or zero-carbon fuels and technologies. Each of the input assumptions provided to PATHWAYS has some uncertainty, which also contributes to uncertainty in the resulting reference scenario.

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[166] IHS Markit. August 2021. Carbon Removal Potential. https://ww2.arb.ca.gov/sites/default/files/2021-08/ihsmarkit_presentation_sp_engineeredcarbonremoval_august2021.pdf.
[167] See Appendix H (AB 32 GHG Inventory Sector Modeling).

Similarly, for the NWL modeling, CARB used a mix of individual modeling tools[168] to estimate the carbon and other ecological, public health, and economic outcomes. The Reference scenario assumes that the level of land management actions that occurred between 2001 and 2014 for forests, shrublands, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands continues into the future. Alternative scenarios assessed the effect of increasing levels of management actions from the reference scenario beginning in 2025. There is a great deal of uncertainty about exactly how lands are currently managed, and a larger uncertainty about how they may be managed in the future. For NWL, it is unlikely that the future will precisely match the carbon stock outcomes CARB has projected, particularly given the uncertainties around current and future land management and the effects climate change will have on our lands. For any modeling exercise these uncertainties exist; however, this modeling effort brings together the best available science, data, and models to quantify the impact our actions may have on the landscape under an unknown future.

Implementation

As this Scoping Plan is designed to chart a path to achieving carbon neutrality, additional work will be required to fully design and implement any policies and actions identified in this plan. During the subsequent development of policies, the Legislature, CARB, and other state agencies will learn more about the technologies and their costs, as well as how each industry works, as a more comprehensive evaluation is conducted in coordination with stakeholders, including community engagement. Significant areas of uncertainty include permitting wait times[169] and local ordinances that might limit or slow the build-out of utility scale renewables.[170,171] In another example, times to reach commercial operations for solar projects after securing an interconnection agreement also have increased in recent years, to 3.5 to 5.5 years.[172]

The level of natural and working lands climate action identified in this Scoping Plan is ambitious. Achieving the level of action needed to result in the quantified carbon,

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[168] See Appendix I (Natural and Working Lands Technical Support Document).

[169] CEC. 2021. *SB 100 Joint Agency Report.* https://www.energy.ca.gov/sb100#anchor_report.

[170] Roth, Sammy. 2019. "California's San Bernardino County slams the brakes on big solar projects." *Los Angeles Times.* https://www.latimes.com/business/la-fi-san-bernardino-solar-renewable-energy-20190228-story.html?fbclid=IwAR2qHGq3bahHme6SFErLsnyFi9UPIfBHIhvnOh3dU3OM7kUTMcEqYfN3pQA.

[171] Chediak, Mark. 2021. "California NIMBYs Threaten Biden's Clean Energy Goals." *BNN Bloomberg.* *https://www.bnnbloomberg.ca/california-nimbys-threaten-biden-s-clean-energy-goals-1.1634351?msclkid=668c9ae9c11311ec92e34035ea157ad4*.

[172] Rand, Joseph, et al. 2022. Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection as of the End of 2021. Power Point Presentation. Lawrence Berkeley National Laboratory. *https://emp.lbl.gov/sites/default/files/queued_up_2021_04-13-2022.pdf*.

emissions, health, and economic outcomes within this Scoping Plan requires coordination, investment, and partnerships across all levels of government and sectors of the economy. It is possible that not all of the actions at the identified level will begin in 2025. This uncertainty will result in diminished levels of beneficial outcomes quantified in the Scoping Plan Scenario. The levels of NWL action identified in this Scoping Plan represent CARB's assessment of the pace and scale of action needed to achieve the carbon stock targets and CO_2 removal targets identified in this Scoping Plan.

The Scoping Plan Scenario identifies that 2.3 million acres of forests, shrubland, and grassland management annually would achieve substantial levels of fire emissions reductions and the concomitant health and economics benefits. Currently, 1 million acres of forest treatment annually is the joint federal and state government goal (500,000 acres each). This target of one million acres annually by 2025 is for the purposes of increasing forest health and wildfire resilience in the near term, whereas the 2.3 million acre target is what the Scoping Plan modeling shows would be needed to realize the carbon stock target called for in this Scoping Plan by 2045. By identifying 2.3 million acres of climate action annually in forests, shrublands, and grasslands, this Scoping Plan emphasizes the importance of that 1 million acre annual goal as a milestone on the way to even more action and improved fire and air quality outcomes. The modeling indicates that substantial improvements to statewide fire emissions will occur at levels of action greater than 1 million acres per year. If these levels of action do not occur starting in 2025, the Scoping Plan has quantified climate benefits that will still occur, but to a lesser extent. In terms of fire emissions, compared to the Reference Scenario, 2.3 million acres of forest, shrubland and grassland management will result in a 10% reduction in wildfire emissions. At 1 million acres per year, this decreases to a 2.5% reduction. If 1 million acres per year is also not accomplished, then the emissions and health benefits are even lower.

Climate action in other NWL sectors also generates many co-benefits. Climate action identified in this Scoping Plan is aimed at not only fighting climate change but also improving air quality and public health. The climate action identified in the agricultural sector, for example, should result in decreased pesticide and synthetic fertilizer use. This decrease of synthetic chemical use in agriculture across California also should result in improved public health, especially for communities that work and live in and around agricultural lands. However, as with the forestry sector, the benefits of climate action in agricultural lands and in any other land are dependent on how much implementation takes place. Ramping up increased healthy soils practices and increasing organic agriculture in California will require continued and sustained implementation by private industry and public agencies. For example, achieving the carbon stock outcomes for the annual crops called for in this Scoping Plan would require deployment and maintenance of healthy soils practices on 80,000 additional acres of croplands in California every year between 2025 and 2045. For context, CDFA's Healthy Soils Program, which is an incentive program supporting healthy soils practices, took almost four years of sustained funding to achieve approximately 50,000 acres total under healthy soils practices.[173]

Given the uncertainty around the modeling assumptions, and performance uncertainty as specific policies are fully designed and implemented, estimates associated with the Scoping Plan Scenario are certain to be different than what is ultimately implemented. One way to mitigate for this is to develop policies that can adapt and increase certainty in GHG emissions reductions. Periodic reviews of progress toward achieving the 2030 target and longer term deeper decarbonization, as well as performance of specific policies, also provide opportunities for the state to consider any changes to ensure we remain on course to achieve the 2030 target and carbon neutrality. The need for this periodic review process was anticipated in AB 32, as it calls for updates to the Scoping Plan at least once every five years. For this Scoping Plan, the metrics provided on the rate of deployment of clean fuels and technologies, along with the annual AB 32 GHG Inventory, provide additional information that can be used to assess progress on sectors and aggregate emissions. This is also true of CARB's NWL carbon inventory. An uncertainty analysis for achieving an accelerated 2030 target is provided toward the end of this chapter.

Targeted Evaluations for the Scoping Plan: Oil and Gas Extraction and Refining

To achieve California's air quality and climate goals, we must end our dependence on petroleum. This will not happen overnight. There are about 28 million combustion engine heavy- and light-duty trucks and passenger vehicles in California, and these are almost always replaced at their end of life. The ZEV Executive Order (EO N-79-20) calls for 100 percent new ZEV car sales beginning in 2035 and a 100 percent ZEV medium- and heavy-duty fleet sales by 2045 where feasible. The result is an ongoing, albeit shrinking, pool of vehicles that will continue to require petroleum fuels. To avoid leakage, as called for in AB 32, and to meet that remaining demand for petroleum fuel, a complete phaseout of oil and gas extraction and refining is not possible by 2045. This Scoping Plan assumes a phasedown in both oil and gas extraction as well as petroleum refining in line with the reduction in demand for in-state on-road petroleum fuel demand. Since the transportation sector is the largest source of GHG emissions and harmful local air pollution, we must continue to research and invest in efforts to deploy zero emissions technologies and clean fuels, and to reduce VMT. An assessment of ongoing progress and efforts to reduce

[173] California Department of Food and Agriculture. 2021. *Incentives Program 2017–2020 Summary by the Numbers.* https://www.cdfa.ca.gov/oefi/healthysoils/docs/HSP_Incentives_program_level_data_funded_projects.pdf.

demand for petroleum fuels and of opportunities to phase down oil and gas extraction and refining will be included in the next Scoping Plan update.

In addition to supplying in-state demand, California is a net exporter of gasoline, diesel, and jet fuel. California pipelines supply the Nevada and Arizona regions[174] with approximately 87 million barrels gasoline equivalent of refined products annually.[175] California pipelines deliver approximately 85% of Nevada's and 40% of Arizona's refined product. Most finished fuels flowing from California to Nevada and Arizona are currently produced by California refineries. To manage the phasedown of oil and gas extraction and petroleum refining in California, exports of finished fuels must be considered and factored into that process, in addition to the declining in-state demand. The authorities and considerations related to supply and demand of petroleum fuels span federal, state, and local agencies. If supply of fossil fuels is to decline along with demand, a multi-agency discussion is needed to systematically evaluate and plan for the transition to ensure that it is equitable.

This inter-agency work should also consider related topics, such as the following:

- Direct and indirect job and economic impacts
- Demand for other liquid fuel types such as renewable fuels, and expected volumes
- Legal considerations
- Public health benefits
- Demand and supply strategies for petroleum fuels, including how to avoid short term supply constraints that may impact low-income consumers

Some of these topics were also discussed as part of two studies[176] supported by the California Environmental Protection Agency, which can serve as a starting point for a working group to analyze these questions and develop policy recommendations.

Oil and Gas Extraction

On April 23, 2021,[177] Governor Newsom directed CARB to evaluate the phaseout of oil and gas extraction no later than 2045 as part of this Scoping Plan. As noted above, this Scoping Plan still has some California demand for finished fossil fuels (gasoline, diesel,

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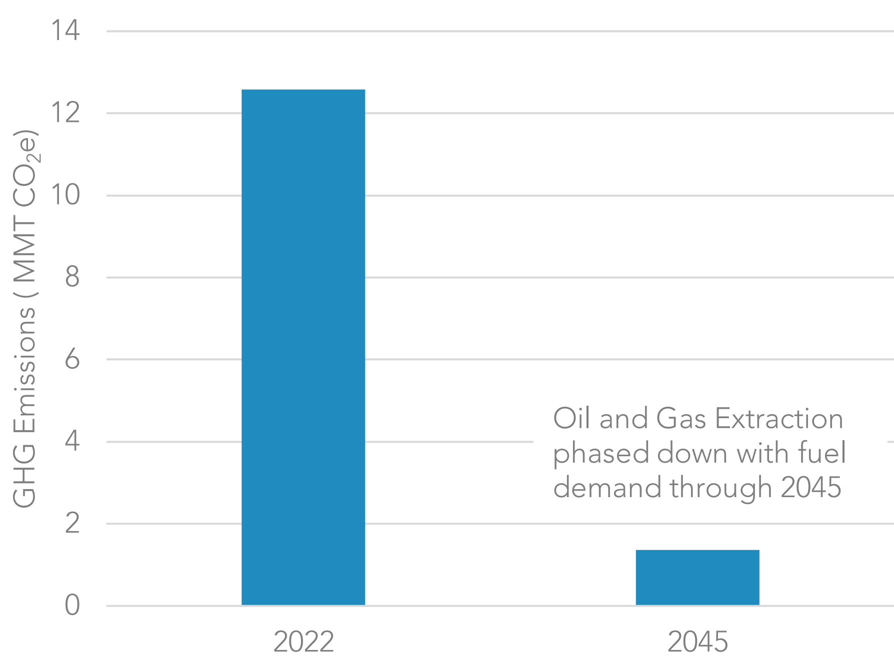
[174] CEC. August 2021. A Primer on California's Pipeline Infrastructure. *Petroleum Watch.* https://www.energy.ca.gov/sites/default/files/2021-08/August_Petroleum_Watch_ADA.pdf.
[175] CEC. March 2020. *Petroleum Watch.* https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.
[176] CalEPA. 2021. Carbon Neutrality Studies: https://calepa.ca.gov/climate/carbon-neutrality-studies/.
[177] Governor Newsom. April 23, 2021. Governor Newsom Takes Action to Phase Out Oil Extraction in California. Press Release. https://www.gov.ca.gov/2021/04/23/governor-newsom-takes-action-to-phase-out-oil-extraction-in-california/.

and jet fuel) in 2045. This demand is primarily for transportation, including for sectors that are directly regulated by the state and some that are subject to federal jurisdiction, such as interstate locomotives, marine, and aviation. As discussed more fully below, while significant GHG reductions from oil and gas extraction could be achieved as demand for fossil fuels is reduced due to strategies in this Scoping Plan, it is not feasible to phase out oil and gas production fully by 2045 given this remaining demand.

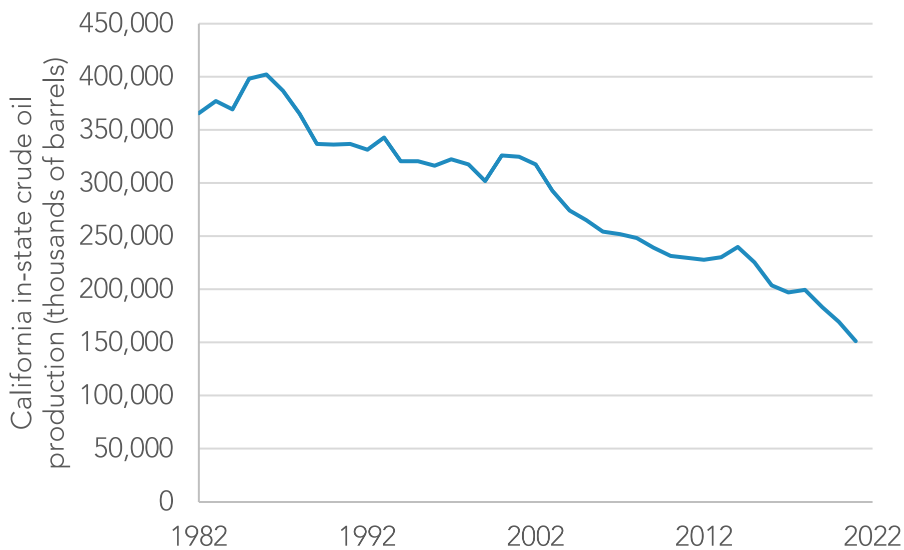
In the Scoping Plan Scenario, with successful deployment of zero carbon fuels and non-combustion technology to phase down petroleum demand, GHG emissions from oil and gas extraction could be reduced by approximately 89 percent in 2045 from 2022 levels if extraction decreases in line with in-state finished fuel demand. If in-state extraction were to be phased out fully, the future petroleum demand by in-state refineries would be met through increased crude imports to the state relative to the Scoping Plan Scenario. AB 32 defines leakage as, “a reduction in emissions in greenhouse gases within the state that is offset by an increase in emissions of greenhouse gases outside the state.” AB 32 also requires any actions undertaken to reduce GHGs to “minimize leakage.” Increases in imported crude could result in increased activity outside California to extract and transport crude into California. Therefore, our analysis indicates that a full phaseout of in-state extraction could result in GHG emissions leakage and in-state impacts to crude oil imported into the state. Figure 2-6 compares the 2022 emissions from this sector with the modeled results when the sector is phased down with in-state petroleum demand.

Figure 2-6: Oil and gas extraction sector GHG emissions in 2022 and 2045 when activity is phased down with in-state fuel demand



According to California Energy Commission (CEC) data used in Figure 2-7, the total oil extracted in California peaked at 402 million barrels in 1986. Since then, California crude oil production has decreased by an average of 6 million barrels per year, to about 200 million barrels in 2020. This steadily decreasing production of crude in California is expected to continue as the state's oil fields deplete.

Figure 2-7: California in-state crude oil production[178]



A UC Santa Barbara report estimated that, under business-as-usual conditions, California oil field production would decrease to 97 million barrels in 2045.[179] The business-as-usual model assumed no additional regulations limiting oil extraction in California.

Any crude oil demand by California refineries not met by California crude oil will be met by marine imports of Alaskan and foreign crude.[180] As shown in Figure 2-8, approximately 99 percent of crude imports into California are delivered by marine transportation. The

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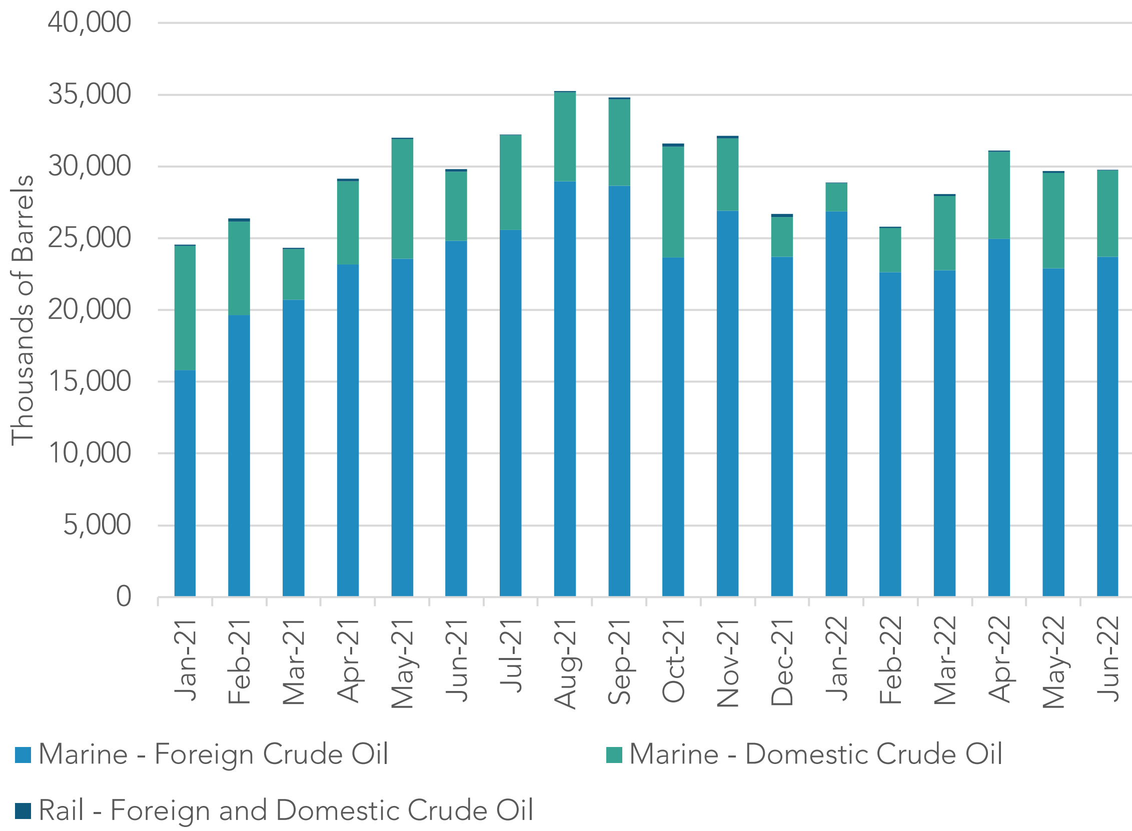
[178] CEC. No date. Oil Supply Sources to California Refineries. Accessed April 21, 2022. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/oil-supply-sources-california-refineries.

[179] University of California, Santa Barbara. 2021. Enhancing Equity While Eliminating Emissions in California's Supply of Transportation Fuels.

[180] CEC. 2020. *Petroleum Watch: How Petroleum Products Move.* March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf, and CEC. 2020. *Petroleum Watch: What Types of Crude Oil Do California Refineries Process?* February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.

remaining imports occur by rail.[181] There are no pipelines that bring crude oil into California from out of state.[182]

Figure 2-8: Crude oil imports by transportation type[183]



Crude oil delivered by marine tankers is delivered to onshore storage tanks and subsequently to refineries via pipeline. Most crude oil produced in California is delivered to California refineries by pipeline. Using historical trends, any increases in imported crude above historic levels would result in increased deliveries through the marine ports. This increased activity could require more infrastructure to store and move larger volumes of crude to the refineries in state.

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[181] CEC. June 2021. Crude Oil Imports by Transportation Type. Accessed March 16, 2022. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/crude-oil-imports-source.

[182] CEC. 2020. *Petroleum Watch: How Petroleum Products Move.* March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.

[183] CEC. June 2021. Crude Oil Imports. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/crude-oil-imports-source.

California refineries import a variety of crude oils to meet refinery needs. California petroleum refineries are generally designed to process relatively heavy crude relative to other U.S. refineries. In 2018, crude inputs to California refineries had an average American Petroleum Institute (API) gravity of 26.18 and an average sulfur content of 1.64 percent. Processing significantly lighter or heavier crude blends would require significant changes to a refinery.[184] Most crude imported from Alaska and the Middle East is relatively light (API gravity > 30) compared to California crude (API gravity < 20).[185] If California crude production is insufficient to meet the demand at California refineries, then California refineries will need access to a similarly heavy source of crude so that the average API gravity of crude remains within their established operating window. South American crude oil imports into California are the heaviest relative to other regions, and therefore they may be the most likely to replace decreased California crude oil supply.[186]

In summary, the modeling indicates that demand for petroleum will persist due to legacy fleets that will not be replaced until end of life. The modeling also shows what the GHG emissions reductions would be if oil and gas extraction activities were phased down in line with the reduction of in-state petroleum demand. Trend data shows that oil and gas extraction already has been on the decline and will continue to decline. It is possible to anticipate the likely regions and types of crude that would be imported to meet in-state petroleum demand if in-state extraction was fully phased out by 2045. Importantly, activity at the ports would increase, and new infrastructure would be needed to store and deliver crude to in-state refineries. And while GHG emissions from this sector would go to zero in our AB 32 GHG Inventory with a full phaseout, emissions related to the production and transport of crude to California might increase elsewhere, resulting in emissions leakage.

As the state continues to reduce demand for petroleum, efforts to protect public health for communities located near oil and gas extraction sites must also continue. In October 2021, Governor Newsom directed action to prevent new oil drilling near communities and

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[184] CEC. 2020. *Petroleum Watch: What Types of Crude?* February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.
[185] CEC. 2020. *Petroleum Watch: What Types of Crude?* February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.
[186] CEC. 2020. *Petroleum Watch: What Types of Crude?* February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.

expand health protections.[187,188] In 2022, the Legislature passed, and the governor signed, SB 1137 to protect communities from existing and any new oil and gas extraction activities through 3,200 foot setbacks.

Petroleum Refining

In the Scoping Plan Scenario CARB modeled a phasedown of refining activity in line with petroleum demand. Meeting petroleum demand means sufficient availability of finished fuel (gasoline, diesel, and jet fuel). Crude is processed at in-state refineries to produce finished fuel. In response to stakeholder requests,[189] this evaluation focuses on the Scoping Plan Scenario, but with an evaluation of a complete phasedown of refinery operations in state.

The Scoping Plan Scenario results in California petroleum refining emissions of 4.5 $MMTCO_2e$ in 2045; a reduction of approximately 85 percent relative to 2022 levels, which is in line with the decline in in-state finished fuel demand.[190] Emissions from refining can be reduced further through the application of CCS technology, as shown in Figure 2-9. If in-state refining is phased down to zero and the demand for the finished fuels produced by that refining persists, imported finished fuels may be needed to meet the remaining in-state demand.[191] The current data shows unmet demand for liquid petroleum transportation fuels would most likely be met by marine imports. A CEC report notes, “The only way for California to receive large amounts of crude and refined products is by marine.”[192]

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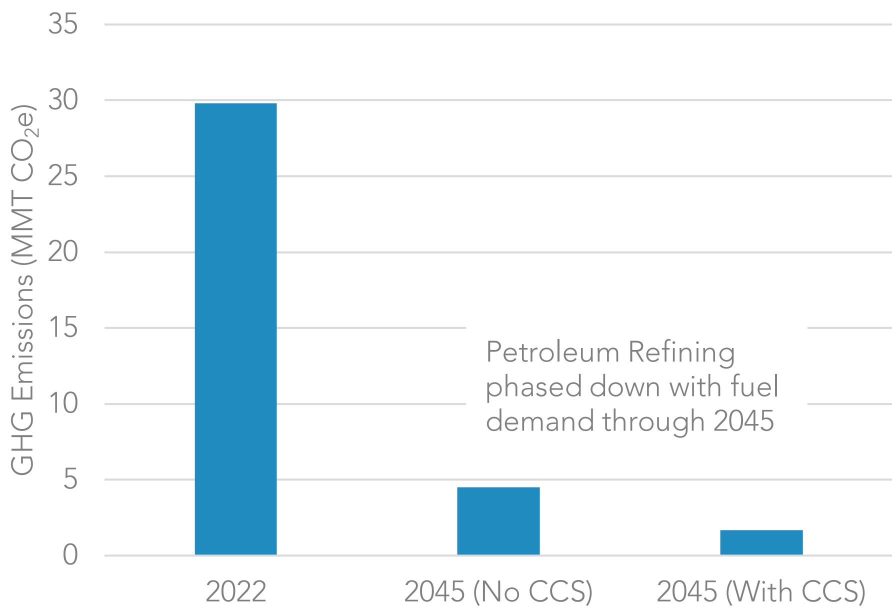
[187] Office of Governor Gavin Newsom. 2021. California Moves to Prevent New Oil Drilling Near Communities, Expand Health Protections. https://www.gov.ca.gov/2021/10/21/california-moves-to-prevent-new-oil-drilling-near-communities-expand-health-protections-2/?msclkid=6c0da86bc58e11ecb81cf596d4d8a735.
[188] California Department of Conservation Geologic Energy Management Division. October 2021. Draft Rule for Protection of Communities and Workers from Health and Safety Impacts from Oil and Gas Production Operations. https://www.conservation.ca.gov/calgem/Pages/Public-Health.aspx?msclkid=45660232cf2511ecb1c56119097e3b0c.
[189] California Environmental Justice Alliance. October 22, 2021. Comment on 2022 Scoping Plan Update - Scenario Inputs Technical Workshop. https://www.arb.ca.gov/lists/com-attach/68-sp22-inputs-ws-WzhdPlI5AjACW1Qx.pdf.
[190] This reduction in demand does not assume any need for ongoing operations to support exports to neighboring states.
[191] If demand assumes an ongoing need to support exports to neighboring states, the residual demand would require a five-fold increase in finished fuel imports.
[192] CEC. 2020. *Petroleum Watch: How Petroleum Products Move.* March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.

There are currently no pipelines capable of bringing refined products to the state, and rail imports of refined products have historically made up less than 1 percent of all imports.[193] Significant increases in marine imports would likely require significant reconfiguring, retrofitting, or replacement of crude pipelines and storage tanks at current marine terminals, and possible reconfiguring of existing finished fuel infrastructure to account for changes in volumes and locations of supply points.

Figure 2-9: Petroleum refining sector GHG emissions in 2022 and 2045 (with and without CCS) when activity is phased down with fuel demand



If California's finished fuel demand is not met by continued refining activity in California, the state would need to import finished fuels to meet the ongoing demand. This would likely result in a two- to five-fold increase in the number of finished fuel ship deliveries to marine terminals. Marine tankers delivering refined products are often much smaller than crude oil tankers, so changes in fuel use and emissions cannot be easily estimated from the change in both the type and the number of ship deliveries.[194]

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[193] CEC. 2020. *Petroleum Watch: How Petroleum Products Move.* March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.
[194] Personal communication with CEC staff, March 2022; U.S EIA. 2017. *World Oil Transit Chokepoints*. 3. https://www.eia.gov/beta/international/regions-topics.php?RegionTopicID=WOTC.

If refining ceased in California, the rail and marine deliveries currently needed to support both refining processes and the export of waste products, such as petroleum coke, would cease.

In summary, the modeling indicates that demand for petroleum will persist through 2045. The modeling also shows what the GHG emissions reductions would be if refining activities were phased down in line with the reduction in in-state petroleum demand. CCS can further reduce emissions for this sector. Importantly, activity at the ports would increase, and new infrastructure would be needed to store and deliver finished fuel across the state, if in-state refining were fully phased down by 2045. And while GHG emissions from this sector would go to zero in our AB 32 GHG Inventory with a full phaseout, emissions related to the refining and transport of finished fuel to California might increase elsewhere, resulting in emissions leakage.

Progress Toward Achieving the Accelerated 2030 Target

The 2017 Scoping Plan laid out a path to achieving the SB 32 target of at least a 40 percent reduction of GHG emissions below 1990 levels by 2030 that focused on reducing emissions in the state and was technologically feasible and cost-effective, reflecting statutory direction. Many of the programs to achieve the 2030 target increased in stringency beginning January 1, 2021. However, the 2030 target must be increased to help achieve the deeper reductions needed to meet the state's statutory carbon neutrality target specified in AB 1279 and Executive Order B-55-18.

Starting in 2020 and extending into 2022, the COVID-19 pandemic impacts reverberated across the globe in a multitude of ways, including the devastating loss of millions of lives. The pandemic also had a significant impact on GHG emissions by virtue of its impact on global economies and lifestyle changes for Californians, with extended work and school disruptions. Thus, assessing our progress toward meeting our SB 32 target is confounded by the unprecedented nature of the pandemic. Nevertheless, an assessment of progress toward the 2030 target is critical, in particular the accelerated 2030 target called for in this Scoping Plan, since achieving the accelerated 2030 target would make the state well positioned to achieve its carbon neutrality goals and bring critical near-term air quality benefits to address historical and ongoing disparities in access to healthy air. Because there is only one year of data available for this decade, the analysis takes a prospective look using projected emissions over the remainder of this decade.

Estimating GHG emissions in 2030 requires projecting the effect of policies or measures that are currently deployed and undergoing implementation. Table 2-4 shows three distinct estimates of GHG emissions in 2030 that were created at different times and used different modeling approaches.

Table 2-4: Estimates of 2030 GHG emissions

Scenario Description	2030 GHG Emissions ($MMTCO_2e$)
2017 Scoping Plan: the projected outcome from implementing policies identified in the 2017 Scoping Plan that was approved by the CARB Board in December 2017.	320
Reference Scenario: the assessment of current trends and expected performance of policies identified in the 2017 Scoping Plan, as of February 2022, using the PATHWAYS model (E3).	305
Reference Scenario (Rhodium): the analysis of projected emissions from 2021 to 2030 from state and federal policies implemented as of July 2022, including the estimated impact of the Inflation Reduction Act and Advanced Clean Cars II using RHG-NEMS and other Rhodium Taking Stock 2022 methods (https://rhg.com/wp-content/uploads/2022/07/Taking-Stock-2022_US-Emissions-Outlook.pdf).	324

These three estimates of 2030 GHG emissions differ, which is expected. The estimates reflect different outcomes of the current and future impact of policies and measures. They also vary due to fundamental differences in the way these models work. For example, PATHWAYS is an economy-wide, scenario-based GHG accounting tool that tracks energy demands and supplies in line with scenario assumptions and is benchmarked to historical values. RHG-NEMS optimizes both the supply and demand sides of the energy system while factoring in consumer constraints and dynamic economic and energy systemwide feedback. Importantly, while these point estimates give the appearance of certainty and accuracy, there is significant uncertainty in future emissions projections that is documented thoroughly in each of the three emissions scenarios described above. No model can predict the future given unforeseen factors such as notable economic swings and implementation delays for programs. However, the range of emissions estimates provides a useful indication of possible outcomes from successful implementation of policies and measures.

An important source of uncertainty is the impact of delayed implementation of policy measures and market actions. The successful rate of deployment of clean technology and fuels—including consumer adoption patterns, economic recovery from the pandemic, and the permitting and build-out of necessary new assets and reuse of existing assets to produce and deliver clean energy—is essential to reach GHG emission reduction targets. Any delays will only increase GHG emissions in 2030.

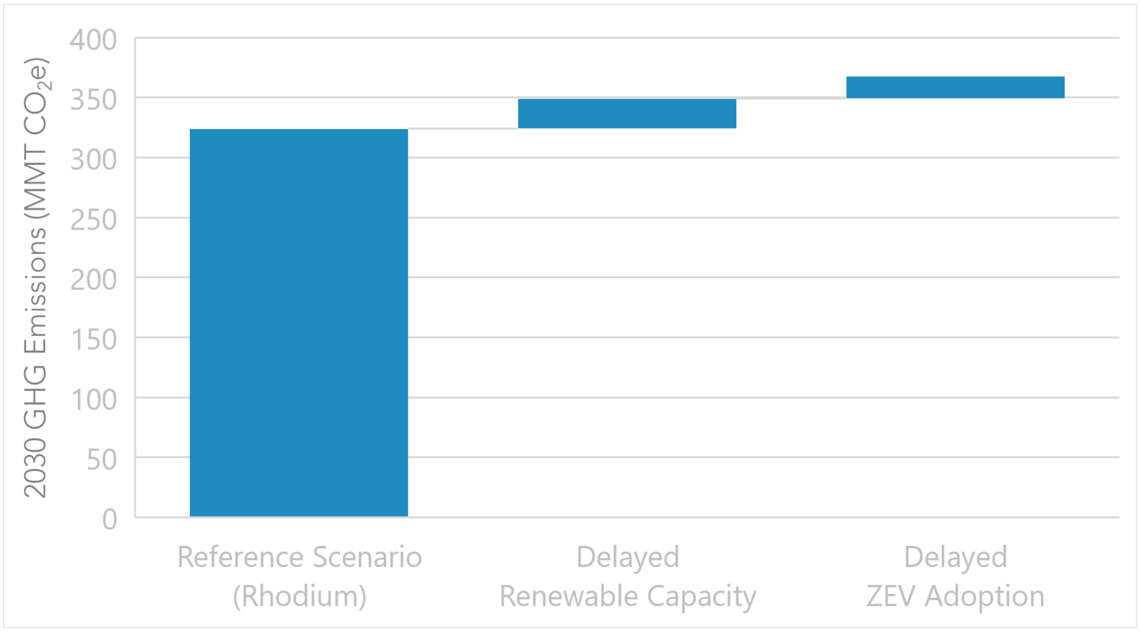
It is important to note that incentives, carbon pricing, and regulations all can result in similar types of responses including, but not limited to:

- Build-out of clean energy and infrastructure
- Deployment of clean technology
- Reduced demand for fossil energy
- Efficiency improvements

As such, the uncertainty analysis discussion focuses on implementation (technology and infrastructure deployment), and not any specific programs or policies. It is successful implementation that must ultimately happen for emissions reductions to be realized.

The uncertainty analysis described in Appendix J (Uncertainty Analysis) quantifies the impact of delayed permitting and building of renewable generation and transmission in the power sector and delayed adoption of ZEVs across all vehicle fleets in the transportation sector. The Reference Scenario (Rhodium) estimates emissions in 2030 to be 324 MMTCO2e. A five-year delay in renewable capacity would increase emissions by 8 percent in 2030 (25 MMTCO2e) relative to the Reference Scenario. If similar delays in clean energy production and deployment occur in other sectors, a larger increase in emissions relative to the reference scenario would be expected, jeopardizing the state's ability to achieve the 2030 target. Similarly, a delay in consumer adoption of zero emission vehicles (LDV, MDV, HDV) would increase emissions by 6 percent in 2030 (19 MMTCO2e) relative to the Reference Scenario. Delays in transitioning to electric equipment and appliances in homes and businesses would also lead to increased emissions in 2030. Figure 2-10 illustrates the impact on projected emissions in 2030 associated with delayed renewable capacity and delayed transportation vehicle electrification.

Figure 2-10: Impact of delayed implementation on 2030 GHG emissions[195]



Appendix J (Uncertainty Analysis) includes additional details on the assumptions and model used for the uncertainty analysis and the risks to achieve the emissions reductions from 2022 to 2030 that are anticipated in the Scoping Plan Reference Scenario. While the analysis focuses on renewable capacity and transportation, the analysis identifies a common set of themes that can impact emissions reductions across economic sectors, including permitting, technology availability, and consumer adoption. The impact of delayed emissions reductions will vary by sector and by the specific policy at risk of delay.

We give these quantitative examples of the impact implementation delays can have on GHG reductions, but almost every economic sector will have the need for permitting to enable at least a 40 percent reduction below 1990 levels. If we consider the increased ambition of the Scoping Plan Scenario, which identifies an accelerated 2030 target, the same types of uncertainty manifest themselves in successful implementation of the Scoping Plan Scenario, with the added need for CCS and CDR and a need to grow other energy sectors such as hydrogen.

[195] The implementation delay scenarios were modeled separately and do not necessarily reflect the combined impact of delayed renewable capacity and transportation vehicle electrification.

Cap-and-Trade Program Update

Since the adoption of the first Scoping Plan in 2008, carbon pricing in the form of a Cap-and-Trade Program has been part of the portfolio to achieve the state's GHG reduction targets, and it will remain critical as we work toward carbon neutrality. This section provides an update on the program and its role in achieving the 2030 target.

The Cap-and-Trade Program first came into effect in 2012, under AB 32, and included declining allowance caps through 2020. In 2017, AB 398[196] was passed by a supermajority in the Legislature and included prescriptive direction on the design of the program from 2021 through 2030. The AB 398 Cap-and-Trade Program came into effect on January 1, 2021, and it included the following changes:

- Doubling of stringency with an annual cap decline of 4 percent per year from 2021–2030
- AB 398 price ceiling
- AB 398 redesigned allowance price containment reserve with two tiers
- AB 398 100 percent leakage assistance factor for industry
- AB 398 lower offset limits: Usage limit cut from 8 percent to 4 percent, and half of offsets must provide direct benefits to California

The reduction in the role of offsets in the program was in recognition of ongoing concerns raised by environmental justice advocates regarding the ability of companies to use offsets for compliance instead of investing in actions on site to reduce GHG emissions that could also potentially reduce criteria or toxic emissions.[197,198] Note that data show the relationship between facility emissions of GHGs and co-pollutants is highly variable by sector and pollutant.[199] Changes to the allowance price containment reserve and the addition of the price ceiling were included to ensure protections against price spikes in the program, while the changes to the leakage assistance factors were to ensure the maximum protection against leakage in the program. The original design of the program included an auction floor price that increases by 5 percent plus inflation each year, and

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[196] Assembly Bill 398 (Garcia, Chapter 135, Stats. of 2017). California Global Warming Solutions Act of 2006: market-based compliance mechanisms: fire prevention fees: sales and use tax manufacturing exemption. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB398.

[197] OEHHA. 2022. *Impacts of Greenhouse Gas Emission Limits Within Disadvantaged Communities*. https://oehha.ca.gov/media/downloads/environmental-justice/impactsofghgpoliciesreport020322.pdf.

[198] The OEHHA report also found that companies that use the most offsets often own the facilities that contribute to local $PM_{2.5}$ exposure. However, there was no causal relationship found to indicate that implementation of the Cap-and-Trade Program was contributing to increases in local air pollution. Also see: CARB. FAQ Cap-and-Trade Program. https://ww2.arb.ca.gov/resources/documents/faq-cap-and-trade-program.

[199] OEHHA. 2022. *Impacts of Greenhouse Gas Emission Limits Within Disadvantaged Communities*. https://oehha.ca.gov/media/downloads/environmental-justice/impactsofghgpoliciesreport020322.pdf.

that escalation factor is retained in the post-2020 program and is also applied to the allowance price containment reserve and price ceiling. These features, combined with the self-ratcheting mechanism for unsold allowances at auctions,[200] help to ensure the program is able to handle periods of high and low demand for allowances while continuing to ensure a steadily increasing price signal for regulated entities to invest in GHG reduction technologies.

As a result of achieving the 2020 target several years earlier than mandated by law, there are unused allowances in circulation. CARB estimated the amount to be approximately 310 million allowances after the conclusion of the third compliance period (2018–2020).[201] AB 398 had also called for a similar analysis, which was completed in 2018.[202] This bank represents approximately 5 percent of the total number of vintage 2013–2030 allowances issued within the joint market. This bank of allowances can only remain banked if year-over-year the covered emissions are declining by 14 MMT. If the annual decline in actual emissions is less than 14 MMT, regulated entities will need to use the banked allowances to cover their compliance obligations. It is likely that the existing bank of 310 million allowances will be needed over the early part of this decade and will be exhausted by the end of the decade. During the same period, prices for allowances will continue to increase at least 5 percent plus inflation year-over-year, sending a steadily increasing price signal to spur investment in onsite reductions for covered entities.

With the passage of AB 1279, the state has a statutory target to achieve carbon neutrality no later than 2045. This Scoping Plan demonstrates that planning on a longer time frame for the new carbon neutrality target means we must accelerate our near-term ambition for 2030 in order to be on track to achieve our longer-term target. CARB will use the modeling for this Scoping Plan to assess what changes may be warranted to the Cap-and-Trade or other programs to ensure we are on track to achieve an accelerated 2030 target. Since the original adoption of the Cap-and-Trade regulation, the program has been amended eight times through a robust public process. Moreover, then-California Environmental Protection Agency Secretary Jared Blumenfeld testified at a Senate hearing in 2022 that CARB will report back to the Legislature by the end of 2023 on the status of the allowance supply with any suggestions on legislative changes to ensure the number of allowances

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[200] The self-ratcheting mechanism temporarily removes unsold allowances from the market until either sufficient demand manifests for two consecutive auctions and they are incrementally reintroduced at future auctions, or they are permanently removed from general circulation if demand remains low.
[201] CARB. 2022. BR 18-51 Cap-and-Trade Allowance Report. Attachment A. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/Allowance%20Report_Reso18_51.pdf.
[202] CARB. 2018. Staff Report: Initial Statement of Reasons: Proposed Amendments to the Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms Regulation. September 4. https://www.arb.ca.gov/regact/2018/capandtrade18/ct18398.pdf?_ga=2.134288305.1735610122.1664813952-1100516233.1657841496.

is appropriate to help the state achieve its 2030 target of at least 40% below 1990 levels. As part of that status update, CARB will also provide information on any potential program changes that may be needed to allowance supply to help achieve an accelerated target for 2030 identified in this Scoping Plan as necessary to achieve carbon neutrality no later than 2045. Engaging in this process in 2023 will allow for the consideration of this Scoping Plan, inclusion of additional data points for the second year of operation of the AB 398-designed program (which only came into force in January 2021), and an opportunity to hold public workshops.

It is also worth noting that the COVID-19 pandemic had significant impacts on economic activity in California and elsewhere.[203] Emissions were significantly lower in 2020 due to the impacts of the global pandemic. There is an expectation that emissions will increase as the economy recovers and behaviors continue to shift from the impacts of the ongoing pandemic. As a result, 2020 should be regarded as an outlier in the emissions trends. This scenario of increasing emissions is similar to what happened in the first compliance period for Cap-and-Trade, where the state economy was recovering from the Great Recession and does not correlate to a problem with the structure of this program or other programs that cover emissions related to the manufacturing or transportation sectors. In any assessment of this and other programs, it is essential to consider external factors such as economic activity and availability of zero carbon energy such as hydropower, among others.

To better understand the role of the Cap-and-Trade Program in achieving the 2030 target, Table 2-5 compares the 2030 GHG emissions estimates from the three reference scenarios described in Table 2-4. The 2017 Scoping Plan projection is from the PATHWAYS model for the Scoping Plan Scenario approved by the Board in late 2017. It excludes the contribution of the Cap-and-Trade Program, without any consideration of uncertainty factors (i.e., a characterization of the uncertainty that a given GHG reduction measure included in the 2017 Scoping Plan will actually achieve the GHG reductions it is projected to deliver). The Reference Scenario represents what GHG emissions would look like if we did nothing beyond the existing policies that are required and already in place to achieve the 2030 target; this scenario is based on the recent PATHWAYS modeling, excluding the contribution of the Cap-and-Trade Program, and without any consideration of uncertainty factors. It indicates that GHG emissions will be lower over this decade than originally projected when the 2017 Scoping Plan was approved. The

[203] CARB. November 4, 2021. Mandatory Greenhouse Gas Reporting - 2020 Emissions Year Frequently Asked Questions. https://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/2020mrrfaqs.pdf?_ga=2.264251343.1760432228.1650736660-1644197524.1577749754.

Reference Scenario (Rhodium) which also does not include uncertainty bounds, is the modeling used for the uncertainty analysis above.

Importantly, PATHWAYS is not able to explicitly model a carbon pricing policy, and therefore the Cap-and-Trade Program is not represented in the 2017 Scoping Plan or the Reference Scenario. Carbon pricing is included in RHG-NEMS, which reflects state and federal policies included in the U.S. Energy Information Administration (EIA) Annual Energy Outlook 2022 and the National Energy Systems Model (NEMS), which is the basis for RHG-NEMS.[204]

As detailed in EIA's documentation, California's Cap-and-Trade Program is represented through increased energy prices, which flow across economic sectors.[205] However, many of the emissions covered by the California Cap-and-Trade Program are not energy- and fuel-related emissions. Given that, the energy systems model RHG-NEMS was used to model the impact of California Cap-and-Trade on the energy system. However, RHG-NEMS does not explicitly model the entire program, which includes non-energy related emissions from the industrial, agricultural, waste, and transportation sectors.

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[204] U.S. EIA. 2022. *Summary of Legislation and Regulations Included in the Annual Energy Outlook 2022.* March. https://www.eia.gov/outlooks/aeo/assumptions/pdf/summary.pdf.

[205] U.S. EIA. 2022. Electricity Market Module. https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf.

Table 2-5: Comparison of 2017 Scoping Plan and two Reference Scenarios

	2030 GHG Emissions ($MMTCO_2e$) (2017 Scoping Plan)	2030 GHG Emissions ($MMTCO_2e$) (Reference Scenario)	2030 GHG Emissions ($MMTCO_2e$) (Reference Scenario-Rhodium)
Reference Scenarios	320	305	324
Gap to Accelerated 2030 Target under the Scoping Plan Scenario (226)[206]	94	79	98

Under the Scoping Plan Scenario, in 2030 California emissions are anticipated to be 48% below 1990 levels. This represents an acceleration of the current SB 32 target of a 40% reduction below 1990 levels. Table 2-5 includes the gap between the different reference scenarios and the accelerated 2030 target achieved under the Scoping Plan Scenario. It also shows that depending on the modeling, there are a range of potential emissions levels in 2030 prior to accounting for the full impact of the Cap-and-Trade Program on emissions. That range is from 305 to 324 $MMTCO_2e$ in 2030. That represents a 19 $MMTCO_2e$ spread, or about 8.4 percent of the accelerated 2030 target of 226 $MMTCO_2e$. Importantly, none of these scenarios includes all of the actions identified in the Scoping Plan Scenario for this Scoping Plan; many of those actions, such as SB 596, CCS, and a more stringent LCFS program, will only begin to happen in this decade, and their contributions toward meeting the accelerated 2030 target are therefore not included in the reference scenarios. The actual emissions for the remainder of this decade will therefore likely be lower than in each of the scenarios in Table 2-5 once policies and regulations are in place to support an accelerated 2030 target. However, the degree of this difference between actual and projected emissions will differ across the modeled reference scenarios.

[206] Table 3 from the 2017 Scoping Plan included a range of 34 to 79 $MMTCO_2e$ for reductions needed from the Cap-and-Trade Program to achieve a 2030 target of 40 percent below 1990 levels.

Regardless of the uncertainty and differences in the models, it is clear additional GHG reductions must happen over this decade to achieve an accelerated 2030 target. This will require an evaluation of all major programs to assess the need to increase their stringency between now and 2030. As the actual reductions from non-Cap-and-Trade Program measures increase, California will be less reliant on the Cap-and-Trade Program to “fill the gap” to meet an accelerated 2030 reduction target. For example, CARB is developing a proposal to increase the stringency of the LCFS program for 2030, the recently adopted Advanced Clean Cars II regulation is more stringent than modeled for the 2030 40 percent target in the 2017 Scoping Plan, and SB 596 requires specific reductions in the cement sector over this decade and beyond. However, we also know we are not on track to achieve the VMT reduction called for in the 2017 Scoping Plan and will need to double down to achieve the even more ambitious target called for in the Scoping Plan Scenario. Also, we will need additional actions over the coming years to reduce short-lived climate pollutants to meet the emission reductions called for in SB 1383.

Collectively, any additional legislation or prescriptive policies for sectors, delays in successful implementation of non-Cap-and-Trade programs and policies, increases in incentive program funding, and delays in economic recovery from the pandemic will continue to affect the role the Cap-and-Trade Program will need to play over this decade to meet the state’s GHG reduction obligations. In summary, the Cap-and-Trade Program must continue to be able to scale across a range of possibilities. With passage of AB 1279 and the need to accelerate the 2030 target, CARB will initiate a public process to utilize the modeling results from this Scoping Plan, specifically the Scoping Plan Scenario, to evaluate and potentially propose changes to the design of the Program, including the annual caps. This process will ensure that the Program supports an increased ambition for 2030 while retaining the ability to scale as other factors, such as changing economic conditions and implementation of non Cap-and-Trade programs, impact the actual emissions at the sources covered by the Program. Any changes to the Program must continue to support a well-designed system that continues to send a steadily increasing price signal, minimizes for leakage, reduces emissions in the covered sectors toward the state’s targets, is cost-effective and technologically feasible, and avoids energy rate spikes. Importantly, the Program should support air quality benefits, especially in overly burdened communities, and not exacerbate existing air quality disparities.

Chapter 3: Economic and Health Evaluations

This chapter provides two approaches for quantifying the economic and health outcomes of the Scoping Plan Scenario. One approach is to consider the combined impact of all measures[207] in a scenario. The other approach is required by AB 197, where each measure within a scenario is evaluated independently. In addition to these two evaluation approaches, this chapter also includes a discussion of the Public Health implications for the Scoping Plan Scenario, an overview of the Climate Vulnerability Metric, and the Environmental Analysis conducted in accord with the California Environmental Quality Act (CEQA).

It is important to note that all of the analyses in this chapter use a variety of data sources, but because the modeling is economy-wide at the state level, none of them produce community specific detail outputs. The AB 32 GHG Inventory Sector analysis relies on PATHWAYS data at the state level that is proportionally applied across all regions of the state to translate changes in state level fuel combustion to local level changes. The NWL analysis similarly utilizes a variety of data sources and a suite of models that produce data that are scaled up to the statewide level. All of the models, except the Wildland Urban Interface (WUI) defensible space model, which is conducted at the county level, create aspatial projections that are not applicable at the community level.

Economic Analysis

As part of the process to develop this Scoping Plan, alternative scenarios that transition energy needs away from fossil fuels and achieve carbon neutrality no later than 2045 were developed. Alternative scenarios that assess the impact of different land management strategies on carbon stocks in NWL were also developed. These alternatives are described in Appendix C (AB 197 Measure Analysis). The following sections describe the Scoping Plan Scenario in terms of direct cost, the economy, employment, and health outcomes.[208]

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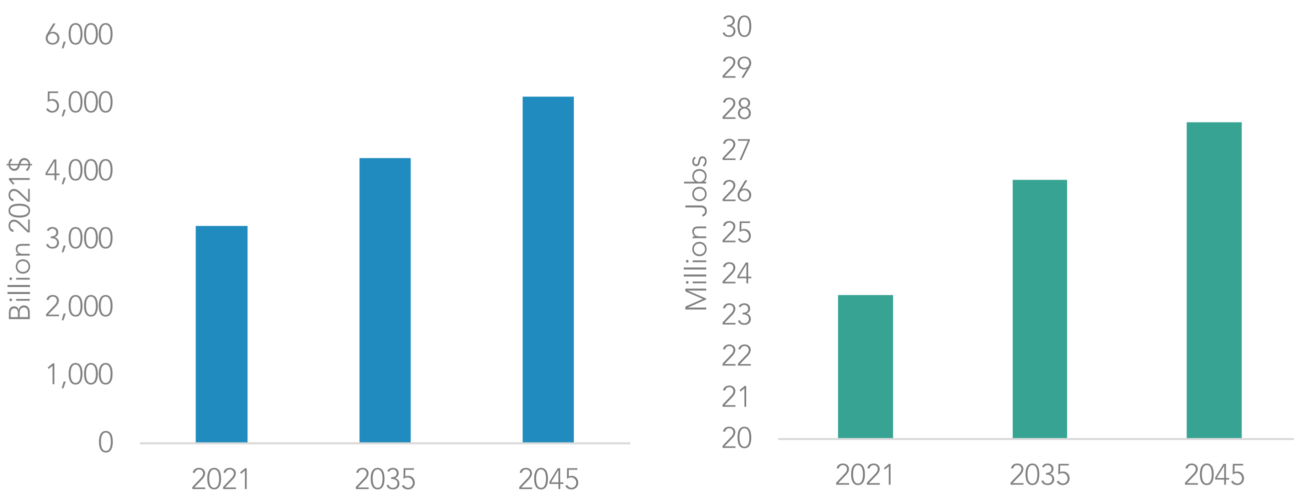
[207] AB 197 calls for the evaluation of "measures." This Scoping Plan treats each action and its variants on stringency as measures for the purposes of this chapter. Appendix C (AB 197 Measure Analysis) lists the measures and corresponding modeling assumptions for each alternative and the Scoping Plan Scenario. The modeling assumptions for the Scoping Plan Scenario are summarized in Table 2-1.

[208] For the Draft 2022 Scoping Plan Update, achieving carbon neutrality in 2035 and 2045 was evaluated. The AB 32 GHG Inventory sector direct cost, the economy, employment, and health outcomes were assessed in those years. Similarly, the Scoping Plan Scenario assessments that are presented in this chapter were made for years 2035 and 2045.

The California economy is growing, and it is projected to continue to grow about 2 percent each year, from $3.2 trillion in 2021 to $5.1 trillion in 2045, as shown in Figure 3-1. Similarly, employment in California is anticipated to grow 0.7 percent per year, from 23.5 million jobs in 2021 to 27.7 million jobs in 2045. It is in this context, termed the *Reference Scenario,* that CARB evaluates the Scoping Plan Scenario in terms of its impact on economic growth and employment. The projections shown in Figure 3-1 were produced by CARB to evaluate the incremental impact of regulations.

Figure 3-1: Projected California gross state product (left) and employment growth (right) from 2021 to 2035 and 2045



Source: California Air Resources Board

Transitioning away from fossil fuels to alternatives and increasing action on NWL will affect employment opportunities, household spending, businesses, and other economic aspects of our lives. Sectors expected to see growth include renewable electricity and hydrogen production, while other sectors may shrink. The deployment of clean technology may require higher upfront costs for things like heat pumps and induction stoves, but those could be offset by energy efficiency savings. Employment and economic development in NWL-related industries and sectors are expected to increase as land management actions increase, especially for the Forestry sector (in which a significant increase is called for under the Scoping Plan Scenario). The net impact of these actions on employment and jobs is presented in this chapter.

Estimated Direct Costs

One key metric is the direct cost, or net investment, reflecting any savings that result from actions. Similar approaches were used to estimate direct costs for the AB 32 GHG Inventory sectors and for the NWL, as described in this section.

AB 32 GHG Inventory Sectors

Transitioning away from fossil fuels requires investment in new equipment and infrastructure throughout the economy. It involves developing the capacity to produce fuels and electricity from renewable sources rather than producing fossil energy. This transition also takes time. One approach is to eliminate combustion of fossil fuels by replacing all equipment in a specified year. Another approach is to establish a future point at which all sales of new equipment rely on alternative energy sources and allow the transition to occur over time as equipment is replaced upon its end of life.

To evaluate the investment required through 2045, the PATHWAYS model was used to represent equipment stock and its turnover to non-fossil fuel alternatives over time. The annualized, incremental cost of infrastructure in excess of the annualized cost of the Reference Scenario[209] was computed for each year from 2022 through 2045. These costs were computed by first taking the absolute cost in each year—which includes both new equipment investment and also expenditures on energy, operations, and maintenance in each year—and then levelizing the costs (in the same way car or house payments are annualized or spread out over time) to arrive at an annualized cost. Fuel savings, and resulting cost savings, associated with changing energy demand—from gasoline to electricity for vehicles, for example—are included as a result of this methodology. Carbon dioxide removal includes DAC technology powered primarily by off-grid solar, BECCS to produce hydrogen or other fuels, and NWL sequestration, as discussed in Chapter 2.[210]

Figure 3-2 shows the stock investment cost, fuel/efficiency savings, and CDR cost. The Scoping Plan Scenario allows end-of-life transition of equipment. The cost of investing in new equipment is partially offset by savings associated with efficiency gains and reduced demand for fuels like gasoline. This is particularly relevant in the transportation sector, which leads to the majority of savings in 2045 in the Scoping Plan Scenario, which models near complete electrification of transport relying only on end-of-life replacement of vehicles. Appendix H (AB 32 GHG Inventory Sector Modeling) includes additional detail on direct costs in each sector and how costs change over time.

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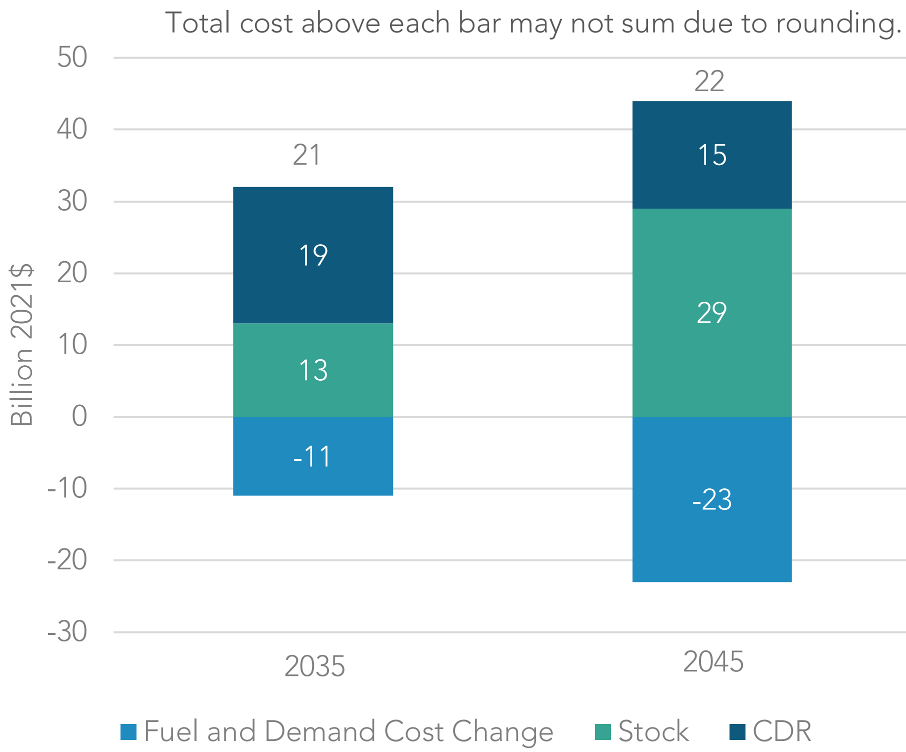
[209] The Reference Scenario described in Chapter 2 and in Appendix H (AB 32 GHG Inventory Sector Modeling) was the basis for the direct cost comparison.

[210] The energy source for DAC is not modeled, but renewable electricity and/or hydrogen produced from electrolysis are zero-carbon options consistent with the carbon neutrality targets in this Scoping Plan. The economic analysis associated the investment in DAC with the solar industry for consistency with the carbon neutrality targets.

Figure 3-2: Cost and savings relative to the growing California economy for the Scoping Plan Scenario in 2035 and 2045 (AB 32 GHG Inventory sectors)



Natural and Working Lands

For NWL, the direct costs of each management strategy were estimated using available academic literature, monitoring and reporting data, survey data, and cost data from existing subsidy programs on the per acre cost of implementing the management strategy. These cost data, in combination with the acreage of each management strategy under the scenarios, provided estimates of the overall direct cost to either the government or the private sector. The direct costs are independent of the policy lever used to implement the action and do not include many important benefits and externalities of the actions. They are assumed to be constant for each scenario and into the future. Avoided or secondary costs, such as those from reductions in wildfire suppression expenses, are not included. Appendix I (NWL Technical Support Document) includes additional direct cost details.

Table 3-1 includes the direct cost estimates for the Scoping Plan Scenario compared to the Reference Scenario.[211] Direct costs for the NWL sector are expected to be significant due to the ambitious level of action for each land type.

Table 3-1: Cost and savings relative to a growing California economy for the Scoping Plan Scenario (NWL)

Measure	Scoping Plan Scenario: Average Direct Annual Cost, 2025–2045 (millions $/year)
Forests / Shrublands / Grasslands	1,780
Annual Croplands	284
Perennial Croplands	4
Urban Forest	4,230
Wildland Urban Interface (WUI)	114
Wetlands	28
Sparsely Vegetated Lands	4
Totals	6,460
Note: Table values may not add to total due to rounding.	

CARB estimates that all jurisdictions, including private landowners, currently spend approximately $4 billion dollars annually on planting, maintenance, sidewalk repair, tree removal, and other expenses related to urban forests, and that reaching the theoretical maximum tree cover would require increasing that spending by a factor of 20. The cost of the Scoping Plan Scenario is predominantly a mix of urban forests and forests, shrubland, and grasslands spending.

[211] The Reference Scenario described in Chapter 2 and in Appendix I (NWL Technical Support Document) was the basis for the direct cost comparison.

Economy and Employment

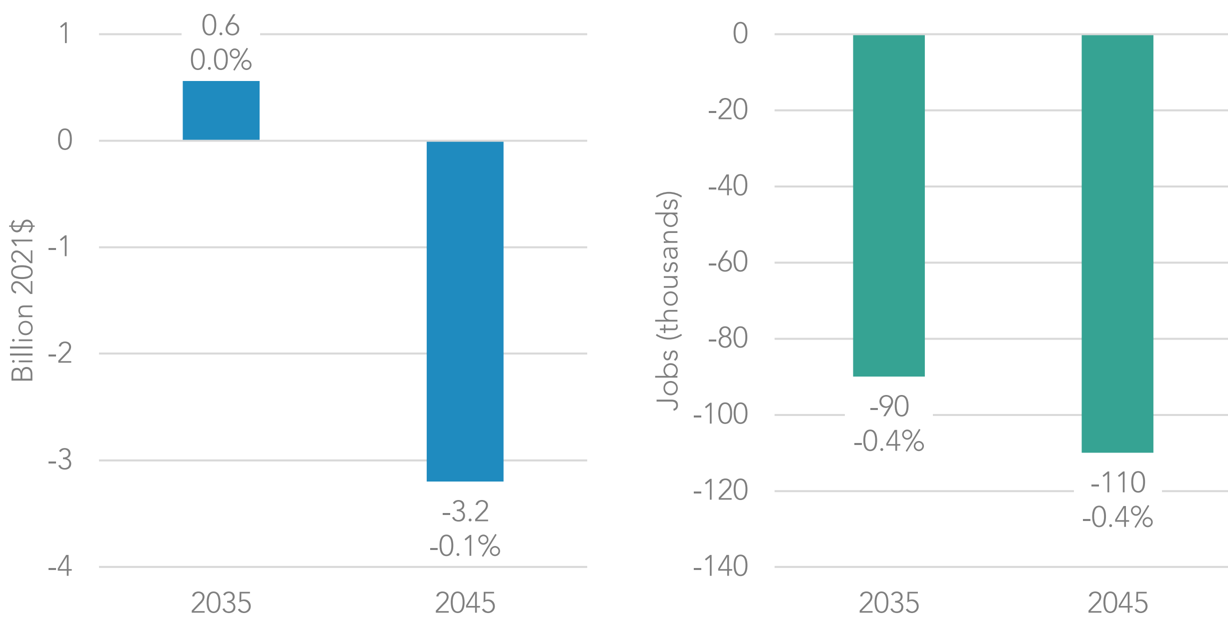
Two different models were used to estimate the overall impact that investing in a transition away from fossil fuels and in our NWL may have on the growing California economy. The transition away from fossil fuels was evaluated using the IMPLAN economic analysis model. The NWL investments were evaluated using the REMI PI+ economic model. These models provide similar outputs relative to the same economic and employment forecasts used to develop a Reference Scenario for use in each model.

AB 32 GHG Inventory Sectors

To estimate the overall impact that investing in a transition away from fossil fuels may have on the California economy, CARB used the IMPLAN model. Additional detail regarding the model, assumptions, and methodology are included in Appendix H (AB 32 GHG Inventory Sector Modeling). The IMPLAN model is a multisector representation of private industries in the U.S. economy that maps economic relationships across industries, households, and governments. This model translates direct costs and savings associated with transitioning away from fossil fuels with indirect effects such as wages, purchases of goods and services, business tax impacts, and supply chain effects. In addition, the induced effects of household purchases, local and import purchases, wages paid, and household tax impacts are estimated. This comprehensive assessment of the interactions between capital investment in fossil fuel alternatives and household purchases provides an indication of the response of the California economy to the Scoping Plan Scenario.

The Scoping Plan Scenario results in a small impact on the Gross State Product (GSP) and employment relative to the Reference Scenario, as shown in Figure 3-3. Economic growth is largely unaffected by the Scoping Plan Scenario in 2035 and slowed by 0.1 percent in 2045. Employment growth is also slowed a small amount, 0.4 percent in 2035 and in 2045, and employment still grows. Assuming annual growth rates of 0.7 percent means there would be more than 193,000 additional jobs in 2045.

Figure 3-3: Gross state product (left) and employment (right) relative to a growing California economy for the Scoping Plan Scenario in 2035 and 2045 (AB 32 GHG Inventory sectors)



California households will see increased costs from the purchase of new capital stock and savings from reduced spending on fuel, as shown in Figure 3-2. Households also will face increased costs associated with CDR, costs associated with energy efficiency measures, and commercial stock purchases—all of which are assumed to be passed directly to consumers. The impact to California households, however, is not limited to these direct costs, as changes in relative prices, employment, and wages can affect household well-being. Personal income, which captures the direct, indirect, and induced impacts, is a metric commonly used to evaluate the impact of policies on households.

Personal income in California is projected to grow from $2.7 trillion in 2021 to $3.6 trillion in 2035 and $4.4 trillion in 2045. Household projections are based on California Department of Finance population projections, which estimate the state's population to grow an average of 0.3 percent each year from 2021 to 2045.[212] California households are projected to increase from 13.3 million in 2020 to 14.6 million in 2035 and 15.0 million in 2045.

[212] California Department of Finance. Population Projections (Baseline 2019). https://dof.ca.gov/forecasting/demographics/projections/.

While the transition away from combustion of fossil fuels will improve air quality for all Californians (and even, more so in overly burdened communities), the economic impacts of the Scoping Plan Scenario are unlikely to be equal among Californians. Table 3-2 presents the change in income by household income group relative to the Reference Scenario in 2035 and 2045. While in 2035 there is a net decrease in personal income of $600 million, total income for households that make less than $100,000 per year is estimated to decline by $4.1 billion dollars, and the total income for households that make more than $100,000 per year will increase by $3.5 billion under the Scoping Plan Scenario. In 2045, although there is no net change in personal income across all California households, results vary by income level. Total income for households that make less than $100,000 per year are estimated to decline by $5.3 billion dollars, while the total income for households that make more than $100,000 per year will increase by $5.3 billion under the Scoping Plan Scenario.

Table 3-2: Income Impacts by California household income group in 2035 and 2045 for the Scoping Plan Scenario (AB 32 GHG Inventory Sectors)

Household Income Group ($2021)	Percentage of 2021 California Households[213]	Change in Income (Billion $2021)	
		2035	2045
Less than $50,000	30	-2.9	-3.9
$50,000 to $100,000	27	-1.2	-1.4
$100,000 to $200,000	28	2.5	4.0
More than $200,000	15	1.0	1.3
Total	100	-0.6	0.0

[213] U.S. Census Bureau. 2021. Household Income. California. https://data.census.gov/cedsci/table?q=california%20income.

In addition to income level, there is likely to be an impact to California personal income that varies based on race/ethnicity.[214] Table 3-3 shows the percentage of households within each income group based on eight race/ethnicity categories identified in the American Community Survey 2021. As shown in Table 3-2, households in lower income groups are anticipated to see negative impacts, while households in higher income groups are anticipated to see positive impacts from the Scoping Plan Scenario in both 2035 and 2045. Because more than 60% of households in the race/ethnicity categories of Hispanic, Black alone, Native Hawaiian (HI) or Pacific Islander, American Indian or Alaskan Native, Other, and Two or More make less than $100,000 per year, these populations generally are likely to experience reduced income. White and Asian households will generally experience both increased and decreased income because these households are distributed more evenly across all four income groups.

The state recognizes the need to ensure that accessibility to clean technology and energy do not further exacerbate health and opportunity gaps for low-income households and communities of color. The Climate Change Investments program exceeds the statutory minimums to invest in projects to benefit disadvantaged communities.[215] Utilities implement programs for reduced energy bills for qualifying low-income customers.[216] There are also resources for waste and water bills that leverage federal funds.[217] CARB also coordinated with the CPUC to ensure that the Climate Credit[218] funded from the sale of Cap-and-Trade allowances provided to utilities on behalf of ratepayers is credited equally to households and not based on how much energy is used. These are just a few examples of how the state is designing and implementing programs to avoid increasing existing disparities. The state must continue to find ways to relieve economic burdens on low-income households.

[214] The number of households in each bracket and the race/ethnicity categories are from American Community Survey 2021 results. Population changes through 2035 and 2045 are not forecast. U.S. Census Bureau. 2021. Household Income. California. https://data.census.gov/cedsci/table?q=california%20income.

[215] CARB. Priority Populations — California Climate Investments. https://www.caclimateinvestments.ca.gov/priority-populations.

[216] CPUC. CARE/FERA Program. https://www.cpuc.ca.gov/lowincomerates/.

[217] California Department of Community Services and Development. Low Income Household Water Assistance Program. https:/www.csd.ca.gov/lihwap.

[218] CPUC. California Climate Credit - FAQ. https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit/california-climate-credit---faq.

Table 3-3: Percentage of households in each race/ethnicity category by household income group

Household Income Group ($2021)	Households in Income Group (%)							
	White Not Hispanic	Hispanic	Black Alone	Asian Alone	Native HI or Pacific Islander	American Indian or Alaskan Native	Other	Two or More
Less than $50,000	26	35	45	25	30	35	37	32
$50,000 to $100,000	25	32	27	21	31	33	33	30
$100,000 to $200,000	29	25	21	30	30	26	24	27
More than $200,000	19	7	7	24	9	7	5	11

Natural and Working Lands

The macroeconomic impact of the NWL scenario was evaluated separately in the REMI PI+ model. For the Scoping Plan Scenario, the macroeconomic impact was modeled by assuming that economic activity in the relevant industries grows in proportion to the proposed implementation spending in that industry. All funds for implementing the actions were assumed to be sourced from within the state. For urban forests, the funds were modeled as being sourced from a combination of state government and private property owners in proportion to the current estimated private/public spending ratio. For all other actions, funds were assumed to be sourced from the state government. In each modeled scenario, government spending and income to property owners were reduced relative to the Reference Scenario in proportion to the annual costs of implementation. None of the proposed spending was modeled as being sourced from increased taxes. Additional details on the methodology for evaluating macroeconomic impacts are in Appendix I (NWL Technical Support Document).

While the macroeconomic model does count the increased economic activity in the affected industries as part of GSP, it does not quantify many of the important economic, health, and environmental benefits that would occur if these actions were implemented. While these benefits—like the reduced use of pesticides, value of urban trees, and increased recreational opportunities—would be very significant, they are outside the scope of the macroeconomic model.

The macroeconomic model also makes projections about the total level of employment in the state. The model forecasts that the Scoping Plan Scenario, which greatly increases the level of NWL management actions, channels economic activity toward related industries and would lead to a slight increase in total employment. (Table 3-4). While the model does aim to accurately represent many labor market dynamics, including adjustments of wages and migration rates, it does not account for many costs that might be associated with dramatically scaling up employment in a particular industry, such as the cost of job training.

Table 3-4: Gross state product and employment relative to a growing California economy for the Scoping Plan Scenario in 2035 / 2045 (NWL)

	Scoping Plan Scenario (%)
Gross State Product	0.00 / 0.01
Employment	0.12 / 0.10
Personal Income	-0.04 / -0.04
Personal Income per Capita	-0.04 / -0.14

Health Analysis

Air quality is affected by pollutant emissions from various processes associated with energy systems, including the combustion of fossil fuels, as well as the combustion of vegetation biomass from NWL during wildfires. Pollutants that are important contributors to degraded air quality in California include nitrogen oxides (NO_x), particulate matter (PM), reactive organic gases (ROG), and others. Further, in the atmosphere these pollutants are transported away from the locations of the emissions by wind and other phenomena, and undergo chemical reactions that result in the formation of new pollutants such as ground-level ozone and fine particulate matter ($PM_{2.5}$). Both primary (emitted) and secondary (formed) pollutants are important from a public health standpoint and contribute to the incidence of air pollution-related mortality and disease within California populations. Measures focused on GHGs do not incorporate specific targets to reduce emissions of $PM_{2.5}$ or air toxics like benzene. These co-pollutants, which are emitted from many of the same pollution sources as GHGs, affect local air quality and pose known risks to public health, such as the risk of asthma and cardiovascular disease. Generally, for stationary sources, certain harmful pollutants are regulated via local rules and regulations that are reflected in permits for stationary sources and are enforced by local air districts, with CARB also regulating air toxics contaminants from stationary sources with the air districts.

AB 32 GHG Inventory Sectors

To assess health impacts for the AB 32 GHG Inventory sectors, an integrated modeling approach was used to quantify and value the air pollution-related public health benefits of the Scoping Plan Scenario relative to the Reference Scenario. Additional details about the models, assumptions, and methodology are included in Appendix H (AB 32 GHG Inventory Sector Modeling). Using output from the PATHWAYS model, projections of pollutant emissions to 2045 were developed for stationary, area, and mobile source emissions using a detailed base year CARB pollutant emissions inventory. Further, the emissions are processed, including for where and when they occur in California, using the Sparse Matrix Operator Kernels Emissions (SMOKE) model. For example, on-road vehicle emissions were allocated along existing roadways, and refining emissions were assigned to the locations of existing refineries. It should be noted that the emissions projections represent statewide average reductions associated with high-level assumptions about alternative fuels and technologies. For example, emissions occurring from refineries to produce liquid fuels are reduced in line with petroleum demand. This reduction is applied equally to all refineries in the Scoping Plan Scenario and does not specify individual facility responses to changing demand. Similarly, the Scoping Plan Scenario does not specify which refineries transition to biofuel production or where new electricity generation facilities are built.

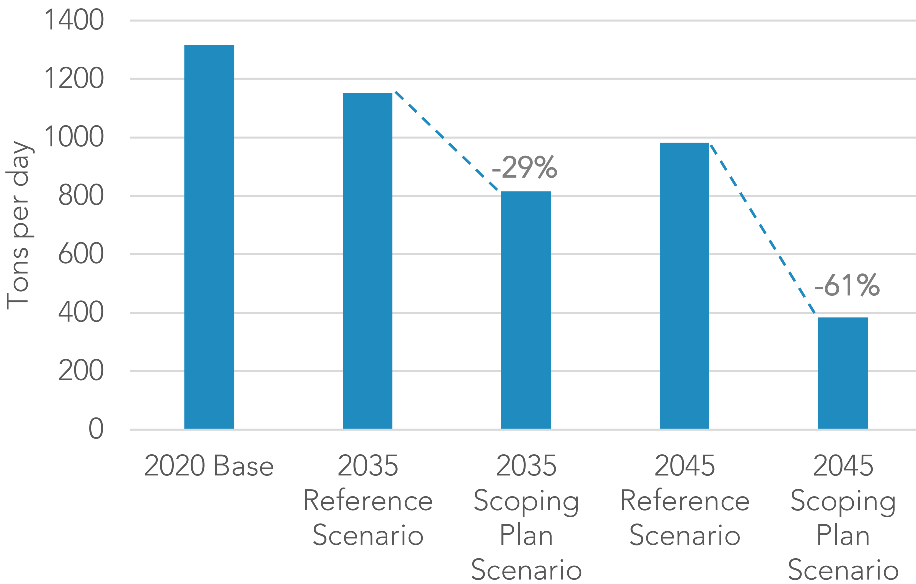
Next, emission changes were translated into impacts on atmospheric pollution levels, including ground-level ozone and $PM_{2.5}$, via an advanced photochemical air quality model called the Community Multiscale Air Quality (CMAQ) model, which accounts for atmospheric chemistry and transport. A comprehensive assessment of how pollutant concentrations are impacted throughout the year was achieved by simulating all months in 2035 and 2045 for the Scoping Plan Scenario.[219] Health benefits were estimated using the U.S. EPA's environmental Benefits Mapping and Analysis Program (BenMAP) model to translate pollutant changes into avoided incidence of mortality, hospital admissions, emergency room visits, and other outcomes as a result of reduced exposure to ozone and $PM_{2.5}$. These outcomes are associated with an economic value in order to aggregate health impacts.

The Scoping Plan Scenario shows a substantial reduction in pollutant emissions relative to the Reference Scenario, including NO_x, $PM_{2.5}$, and ROG. Reductions in NO_x are shown in Figure 3-4. Even under a business-as-usual trajectory, emissions are reduced from present levels by 26 percent in 2045 in the Reference Scenario, demonstrating the impact of current regulations and trends in energy sectors. The Scoping Plan Scenario further reduces NO_x

[219] This annual approach differs from the episodic modeling approach applied to the Proposed Scenario and Alternatives in the Draft 2022 Scoping Plan Update. Appendix H (AB 32 GHG Inventory Sector Modeling) describes both approaches.

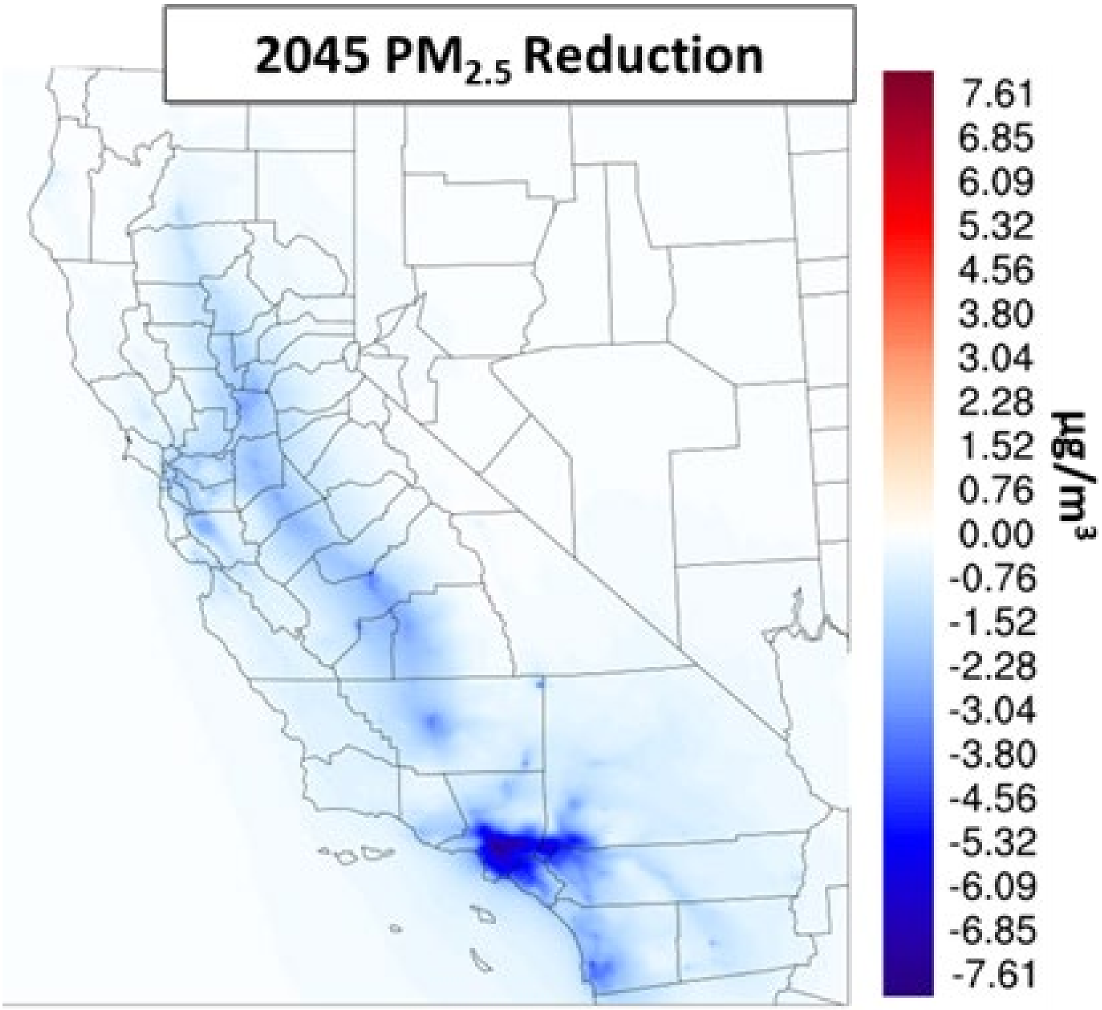
emissions from the Reference Scenario by 29% in 2035 and 61% in 2045. Emission reductions occur throughout the state with particular prominence in urban areas, including the South Coast Air Basin, due to the large presence and activity of emission sources. Appendix H (AB 32 GHG Inventory Sector Modeling) contains additional information about the pollutant emissions modeling and results.

Figure 3-4: Illustration of NOx emission reductions from current levels for the Reference Scenario and the Scoping Plan Scenario (AB 32 GHG Inventory sectors)



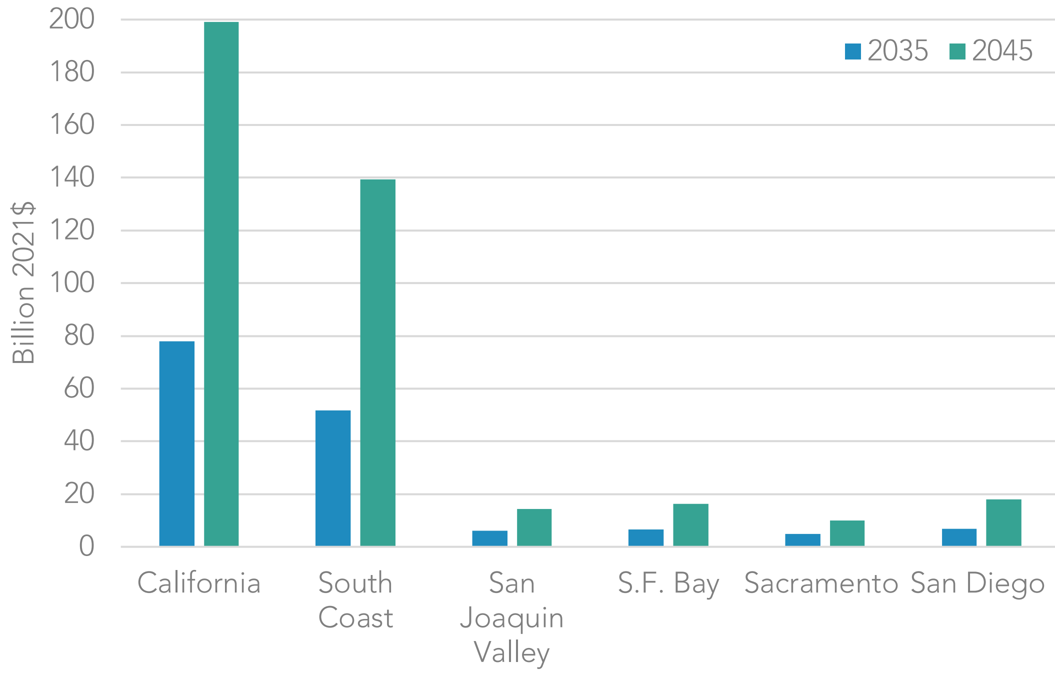
The emission reductions achieve important improvements in air quality throughout California, including reductions in the levels of ozone and $PM_{2.5}$. Reductions in annual $PM_{2.5}$ levels are shown in Figure 3-5. The greatest reductions are evident in Southern California, the San Joaquin Valley, the San Francisco Bay area, and the Greater Sacramento area due to the large presence and activity of emission sources, meteorology, topography, and others. To highlight the extent of the air quality improvements: reductions reach nearly 8 micrograms per cubic meter (μg/m^3) in 2045 and lead to 76% fewer exceedances of the health-based National Ambient Air Quality $PM_{2.5}$ standard of 12 μg/m^3. Similarly, ozone improvements reach 19 parts per billion (ppb) and yield 62% fewer exceedance events. Furthermore, the locations of improvements carry important implications for human health as these areas support large urban populations and generally experience the most degraded ozone and $PM_{2.5}$ pollution. Appendix H (AB 32 GHG Inventory Sector Modeling) provides details regarding the atmospheric modeling and results, including differences in ozone and $PM_{2.5}$.

Figure 3-5: Difference in annual average $PM_{2.5}$ ($\mu g/m^3$) in the Scoping Plan scenario relative to the Reference scenario in 2045 (AB 32 GHG Inventory sectors)



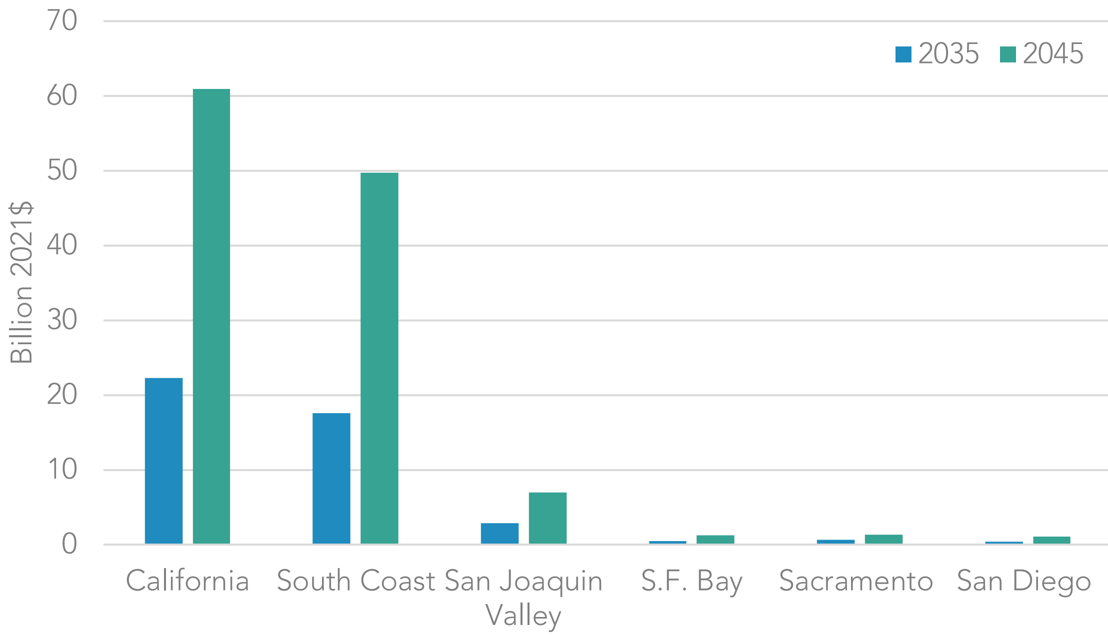
Notable health benefits representing the economic value of the avoided incidence of health effects are associated with the Scoping Plan Scenario. In total, the benefits reach \$78 billion in 2035 and \$199 billion in 2045, as shown in Figure 3-6. Populations in Southern California benefit the most due to preexisting air quality challenges, significant emission sources and activity, and the presence of a large, dense urban population. Additional details regarding the health impact assessment are provided in Appendix H (AB 32 GHG Inventory Sector Modeling).

Figure 3-6: Total health benefits estimated from air quality improvements in the Scoping Plan Scenario (AB 32 GHG Inventory sectors)



Furthermore, these benefits accrue within socially and economically disadvantaged communities identified by CalEnviroScreen, where they are most needed. Total health benefits within census tracts identified as disadvantaged communities using CalEnviroScreen 4.0 reach $22 billion in 2035 and $61 billion in 2045, as shown in Figure 3-7. Similarly to the statewide health benefits, the largest share of benefits occurs within disadvantaged communities in Southern California. Additional information on the health benefits within disadvantaged communities can be found in Appendix H (AB 32 GHG Inventory Sector Modeling).

Figure 3-7: Disadvantaged community health benefits relative to the Reference Scenario for the Scoping Plan Scenario (AB 32 GHG Inventory sectors)



Natural and Working Lands

For NWL, health benefits were evaluated based on projected $PM_{2.5}$ wildfire emissions on forests, shrublands, and grasslands, discussed in the AB 197 Measure Analysis section of the chapter that follows.[220] The health endpoints for the Scoping Plan Scenario and in Appendix I (NWL Technical Support Document) for the alternative scenarios were the basis for the estimated health benefits shown in Figure 3-8. Health benefits were derived from the preliminary University of California, Los Angeles (UCLA) study that estimated annual health impacts and associated costs from California's wildfires from 2008–2018. Additional details are included in Appendix I (NWL Technical Support Document). These costs were applied to the health endpoints discussed in the AB 197 Measure Analysis section of the chapter.

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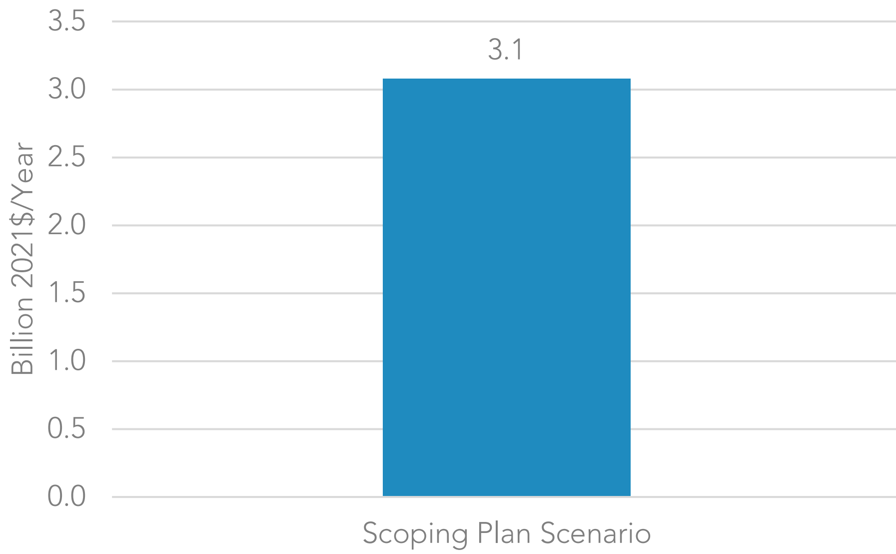
[220] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N11, N14. *finalejacrecs.pdf (arb.ca.gov)*.

Figure 3-8: Total average annual health benefits relative to the Reference Scenario for the Scoping Plan Scenario (NWL)



As health impacts analyzed here are driven by wildfire emissions, the health benefits for the Scoping Plan Scenario are directly related to the amount of forest, shrubland, and grassland management action. These management actions reduce vegetation fuels and, as a result, wildfire activity. The Scoping Plan Scenario increases the amount of these management actions, reducing wildfire emissions and avoiding incidence of emission-related health effects. The health benefits, or economic value of the avoided incidence of health effects, correspondingly increase with an increasing management implementation rate. Additional details are included in Appendix I (NWL Technical Support Document).

Estimated health benefits do not include the direct impact of wildfires on injuries, deaths, or mental health, nor the indirect costs of lost ecosystem benefits to wildfire. Additional direct health costs may result from wildfire that would likely increase the health benefits from increased forest, shrubland, and grassland management to reduce wildfire activity. Nonetheless, the conservative health benefits under the Scoping Plan Scenario are estimated to be $3.1 billion per year relative to the Reference Scenario for all NWL actions identified in the Scoping Plan Scenario.

AB 197 Measure Analysis

This section provides estimates for information associated with GHG emissions reduction measures evaluated in this Scoping Plan.[221] These estimates, which were developed as part of the process for meeting the requirements of AB 197 (E. Garcia, Chapter 250, Statutes of 2016), provide information on the relative impacts of the evaluated measures when compared to each other. To support the design of a suite of policies that result in GHG reductions, air quality co-benefits, and cost-effective measures, it is important to understand if a measure will increase or reduce criteria pollutants or toxic air contaminant emissions, or if increasing stringency at additional costs yields few additional GHG reductions. To this end, AB 197 requires the following for each potential emissions reduction measure evaluated in any Scoping Plan update:

- The range of projected GHG emissions reductions that result from the measure;
- The range of projected criteria pollutant emission reductions that result from the measure; and
- The cost-effectiveness, including avoided social costs, of the measure.

The following sections describe the evaluation of measures for the AB 32 GHG Inventory sectors and NWL. For the purposes of this Scoping Plan, the identified emissions reduction measures for the analysis required by AB 197 are actions grouped by sectors where several policies and programs are expected to overlap. This approach reflects the most granular feasible analysis given the modeling tools available,[222] the overlap and interaction effects among policies and incentive programs, the longer planning horizon used for this Scoping Plan compared to previous efforts, and the scale of transition needed to achieve carbon neutrality. To implement this Scoping Plan, dozens of individual regulations, policies, and incentive programs are anticipated that work together to drive down emissions across all economic sectors and support actions. Every specific policy or incentive program that could contribute to the deployment of clean technology and energy called for in this plan may overlap in ways that make it infeasible to tease out those policies and programs' individual effects with any reasonable degree of certainty. For example, in the transportation sector, deploying ZEVs and reducing driving demand may be achieved through a combination of the implementation of new or existing regulations, fuels programs, incentive programs, and VMT reduction initiatives that can each contribute to reductions in emissions for the sector. It is not feasible to isolate each sub action from each other at this time in terms of the share of contribution to total reductions. The estimated emission

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[221] AB 197 calls for the evaluation of "emission reduction measures." This Scoping Plan treats each action and its variants on stringency as emission reduction measures for the purposes of this chapter. Appendix C (AB 197 Measure Analysis) lists the measures and corresponding modeling assumptions for each alternative.
[222] See Appendix H (AB 32 GHG Inventory Sector Modeling and Appendix I (NWL Technical Support Document).

reductions, health endpoints, and costs by measure for the Scoping Plan Scenario are presented in this chapter, and the corresponding estimates for the Proposed Scenario and Alternatives 1, 2, and 4 are included in Appendix C (AB 197 Measure Analysis).

Because many of the measures and underlying assumptions interact with each other, isolating the GHG emission reductions, corresponding changes to fuel combustion, and associated cost of an individual measure is analytically challenging. Each measure is evaluated by examining the change in fuel combustion, cost, and emissions associated with just that measure using the PATHWAYS model. The difference between the Scoping Plan Scenario and the Reference Scenario is estimated for each measure. Starting from the Scoping Plan Scenario, the modeling assumptions for an individual measure are reverted to the Reference Scenario values, resulting in GHG reductions, changes to fuel combustion, and costs (or savings). This approach does not reflect interactions between sectors in PATHWAYS that influence the results for each complete alternative, presented earlier. As such, the values associated with each measure should not be added to obtain an overall scenario estimate.

To arrive at the 2045 target for NWL, CARB modeled the ecological impact that climate smart land-based management strategies (suites of on-the-ground actions, or *treatments,* that are used across the landscape to manipulate an ecosystem) will have on ecosystem carbon; and whenever possible, additional co-benefits from those actions. The Scoping Plan Scenario incorporates a set of land management actions at varying scales of implementation for each land type to achieve the GHG emission reductions. Each land type, and its associated management actions, was considered a measure for this analysis. For modeling individual landscapes and management actions, CARB used a suite of models. The complexity of these models varies by land type, depending on the existing science, data, and availability of existing models to use. Appendix I (NWL Technical Support Document) provides detailed modeling assumptions for each NWL type. The estimated emission reductions, health endpoints, and costs by measure under the Scoping Plan Scenario for each NWL type are presented in this chapter, and the corresponding estimates for the Proposed Scenario and NWL Alternatives 1, 2, and 4 are included in Appendix C (AB 197 Measure Analysis).

Estimated Emissions Reductions

Both GHG emissions reductions and emissions of criteria air pollutants were evaluated for the AB 32 GHG Inventory sectors and for NWL. The methods and results are described in this section.

AB 32 GHG Inventory Sectors

In the absence of having direct modeling results for criteria pollutant estimates from PATHWAYS, CARB estimated criteria pollutant emissions impacts by using changes in fuel combustion in units of exajoules from PATHWAYS and emission factors in units of tons per exajoule to estimate the change in emissions in tons per year. Emission factors from a variety of sources for each sector were utilized, including but not limited to CARB's mobile source emissions models,[223] U.S. EPA's AP 42 Emissions Factors,[224] and the South Coast Air Quality Management District's (AQMD's) District Rules.[225] These emission factors were applied to fuel burn change by fuel type, sector, equipment type, and process, where applicable. Statewide annual average emissions were estimated for three criteria pollutants: NO_x, $PM_{2.5}$, and ROG.

Table 3-5 provides the estimated GHG and criteria pollutant emission reductions for the measures in the Scoping Plan Scenario in 2035 and 2045. The other alternatives are presented in Appendix C (AB 197 Measure Analysis). Based on the estimates below, these measures are expected to provide air quality benefits. The estimates provided in this chapter and Appendix C (AB 197 Measure Analysis) are appropriate for comparing across alternatives considered for the development of this Scoping Plan, but they are not precise estimates.

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[223] CARB. MSEI - Modeling Tools. https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-modeling-tools.

[224] U.S EPA. AP-42: Compilation of Air Emissions Factors. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors.

[225] South Coast AQMD. South Coast AQMD Rule Book. https://www.aqmd.gov/home/rules-compliance/rules/scaqmd-rule-book.

Table 3-5: Estimated GHG and criteria pollutant emission reductions relative to the Reference Scenario for the Scoping Plan Scenario in 2035/2045 (AB 32 GHG Inventory sectors)

Measure	GHG Reductions ($MMTCO_2$)	NOx Reductions (Short Tons/Year)	$PM_{2.5}$ Reductions (Short Tons/ Year)	ROG Reductions (Short Tons/Year)
Deploy ZEVs and reduce driving demand	-46 / -84	-51,620 / -122,806	-2,008 / -6,506	-18,967 / -30,410
Coordinate supply of liquid fossil fuels with declining California fuel demand	-25 / -30	-1,601 / -2,707	-978 / -1,705	-747 / -1,323
Generate clean electricity	-8 / -31	-92 / -1,555	-177 / -1,382	-41 / -425
Measure	**GHG Reductions ($MMTCO_2$)**	**NOx Reductions (Short Tons/Year)**	**$PM_{2.5}$ Reductions (Short Tons/ Year)**	**ROG Reductions (Short Tons/Year)**
Decarbonize industrial energy supply	-9 / -22	-21,172 / -34,876	-1,188 / -2,527	-3,710 / -6,298
Decarbonize buildings	-14 / -35	-8,105 / -94,455	-826 / -6,877	-1,093 / -8,109
Reduce non-combustion emissions[a]	-0.41 / -0.52 ($MMTCH_4$)	N/A	N/A	N/A
Compensate for remaining emissions	-25 / -64	N/A	N/A	N/A

[a] Methane emissions reductions are reported for this measure.

The measures related to reducing non-combustion emissions and compensating for the remaining emissions do not include changes to fuel combustion, and therefore are not associated with changes to air pollutants. Biomethane combustion is captured in measures that reduce combustion of fossil gas, such as decarbonizing industrial energy supply and buildings.

Natural and Working Lands

NWL ecosystems naturally vary between being a source and a sink for carbon over time. The NWL ecosystem carbon stock changes projected through mid-century by the suite of models were used to estimate net emissions or emissions reductions relative to the Reference Scenario. These changes in carbon stocks were affected by projected climate change, the implementation of management actions under the various scenarios, land conversion, and (for forests, shrublands, grasslands) wildfire. Each NWL type was evaluated, and an overview of all NWL is presented in Table 3-6. More detailed results for each NWL type can be found in Appendix C (AB 197 Measure Analysis).

Table 3-6: Estimated average annual GHG and criteria pollutant emission reductions relative to the Reference Scenario for the Scoping Plan Scenario from 2025–2045 (NWL)

Measure	GHG Reductions ($MMTCO_2e$/year)	$PM_{2.5}$ Reductions (MT/Year)
Forests/Shrublands/Grasslands	-0.12	-17,500
Annual Croplands	-0.25	N/A
Perennial Croplands	-0.01	N/A
Urban Forest	-1.29	N/A
Wildland Urban Interface (WUI)	0.75	N/A
Wetlands	-0.43	N/A
Sparsely Vegetated Lands	<-0.01	N/A

Fine particulate wildfire emissions were evaluated for forests, shrublands, and grasslands only. Wildfire emissions decreased under the Scoping Plan Scenario compared to the Reference Scenario. The Scoping Plan Scenario's higher level of management actions that reduce tree or shrub densities, protect large trees, reintroduce fire to the landscape, and diversify species and structures result in greater reductions in wildfire emissions.

Estimated Health Endpoints

Climate change mitigation will result in both environmental and health benefits. This section provides information about the potential health benefits of the Scoping Plan Scenario. Health benefits are primarily the result of reduced $PM_{2.5}$ pollution, both from stationary and mobile sources, as well as wildfire in forests, shrublands, and chaparral.

AB 32 GHG Inventory Sectors

CARB used the criteria pollutant emissions in Table 3-5 to understand potential health impacts. Similar to the air quality estimates, this information should be used to understand the relative health benefits of the various measures and should not be taken as absolute estimates of health outcomes. CARB used the incidence-per-ton (IPT) methodology to quantify the health benefits of emission reductions. The IPT methodology is based on a methodology developed by the U.S.

EPA.[226,227,228,229] Under the IPT methodology, changes in emissions are approximately proportional to the resulting changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to $PM_{2.5}$ for a baseline scenario using measured ambient concentrations and dividing that number by the emissions of $PM_{2.5}$ or a precursor. To estimate the reduction in health outcomes, the emission reductions are multiplied by the IPT factor. For future years, the number of outcomes is adjusted to account for population growth. IPT factors were computed for the two types of $PM_{2.5}$: primary $PM_{2.5}$ and secondary $PM_{2.5}$ of ammonium nitrate aerosol formed from precursors.

For this AB 197 analysis, CARB calculated the health benefits associated with the five key measures that are represented by changes to fuel combustion. The health benefits associated with emission reductions for the Scoping Plan Scenario were estimated for each air basin and then aggregated for the entire state of California. CARB assumed that the statewide emission reductions distribution among the air basins is proportional to the baseline emissions in that air basin.

Calculated health endpoints include premature mortality, cardiovascular emergency department (ED) visits, acute myocardial infarction, respiratory ED visits, lung cancer incidence, asthma onset, asthma symptoms, work loss days, hospitalizations due to cardiopulmonary illnesses, hospitalizations due to respiratory illnesses, hospital admissions for Alzheimer's disease, and hospital admissions for Parkinson's disease.[230,231,232] These health endpoints were calculated using the IPT method for estimated emission reductions. Table 3-7 compares the health benefits of emission reductions associated with each measure for the Scoping Plan Scenario in the year

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226 CARB. CARB's Methodology for Estimating the Health Effects of Air Pollution. Retrieved February 9, 2021. https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution.

227 Fann, N., C. M. Fulcher, and B. J. Hubbell. 2019. "The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution." *Air Quality, Atmosphere & Health* 2:169–176. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/.

228 Fann, N., K. R. Baker, and C. M. Fulcher. 2012. "Characterizing the $PM_{2.5}$-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S." *Environ Int*. 49:141–51. November 15. https://www.sciencedirect.com/science/article/pii/S0160412012001985.

229 Fann, N., K. Baker, E. Chan, A. Eyth, A. Macpherson, E. Miller, and J. Snyder. 2018. "Assessing Human Health $PM_{2.5}$ and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025." *Environ. Sci. Technol.* 52 (15), 8095–8103. https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050.

230 CARB. CARB's Methodology. https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution.

231 CARB. 2022. Updated Health Endpoints in CARB's Health Benefits Methodology. Evaluating New Health Endpoints for Use in CARB's Health Analyses.

232 Cardio-pulmonary mortality, hospitalizations due to cardiopulmonary illnesses, and hospital admissions due to respiratory illnesses endpoints utilize studies documented in CARB's methodology document. For future assessments, CARB will use more recent studies to estimate cardiovascular hospital admissions and respiratory hospital admissions, as documented in CARB's updated health endpoints memo.

specified (2035 or 2045). The other alternatives are presented in Appendix C (AB 197 Measure Analysis).

Table 3-7: Estimated avoided incidence of mortality, cardiovascular and respiratory disease onset, work loss days and hospital admissions relative to the Reference Scenario for the Scoping Plan Scenario (AB 32 GHG Inventory sectors)

Measure	Mortality	Cardiovascular ED Visits	Acute Myocardial Infarction	Respiratory ED Visits	Lung Cancer Incidence	Asthma Onset	Asthma Symptoms	Work Loss Days	Hospital Admissions, Cardiovascular	Hospital Admissions, Respiratory	Hospital Admissions, Alzheimer's Disease	Hospital Admissions, Parkinson's Disease
Deploy ZEVs and reduce driving demand in 2035	635	170	70	400	45	1,475	128,930	92,510	95	115	245	40
Deploy ZEVs and reduce driving demand in 2045	1,820	475	200	1,115	135	3,995	343,095	255,800	295	350	745	125
Coordinate supply of liquid fossil fuels with declining CA fuel demand in 2035	115	30	15	70	10	275	23,530	16,880	20	20	50	10

Measure	Mortality	Cardiovascular ED Visits	Acute Myocardial Infarction	Respiratory ED Visits	Lung Cancer Incidence	Asthma Onset	Asthma Symptoms	Work Loss Days	Hospital Admissions, Cardiovascular	Hospital Admissions, Respiratory	Hospital Admissions, Alzheimer's Disease	Hospital Admissions, Parkinson's Disease
Coordinate supply of liquid fossil fuels with declining CA fuel demand in 2045	215	55	25	130	15	490	40,860	30,445	35	40	95	15
Generate clean electricity in 2035	20	5	0	10	0	45	3,930	2,820	5	5	10	0
Generate clean electricity in 2045	170	45	20	105	15	385	32,065	23,890	25	30	75	10
Decarbonize industrial energy supply in 2035	300	80	35	190	20	695	60,660	43,520	45	55	115	20
Decarbonize industrial energy supply in 2045	595	155	65	365	45	1,310	111,925	83,435	95	115	245	40

Measure	Mortality	Cardiovascular ED Visits	Acute Myocardial Infarction	Respiratory ED Visits	Lung Cancer Incidence	Asthma Onset	Asthma Symptoms	Work Loss Days	Hospital Admissions, Cardiovascular	Hospital Admissions, Respiratory	Hospital Admissions, Alzheimer's Disease	Hospital Admissions, Parkinson's Disease
Decarbonize buildings in 2035	155	40	15	95	10	360	31,130	22,335	25	30	60	10
Decarbonize buildings in 2045	1,610	420	175	985	120	3,550	303,830	226,500	260	310	665	115
Note: All values are rounded to the nearest 0 or 5.												

The measures related to reducing non-combustion emissions and compensating for remaining emissions do not include changes to fuel combustion and therefore are not associated with changes to air pollutants or health endpoints. Biomethane combustion is captured in measures that reduce combustion of fossil gas, such as decarbonizing industrial energy supply and buildings.

Although the estimated health outcomes presented are based on a well-established methodology, they are subject to uncertainty. For instance, future population estimates are subject to increasing uncertainty as they are projected further into the future, and baseline incidence rates can experience year-to-year variation. Also, the relationship between changes in pollutant concentrations and changes in pollutant or precursor emissions is assumed to be approximately proportional.

In addition, emissions are reported at an air basin level and do not capture local variations. These estimates also do not account for impacts from global climate change, such as temperature rise, and are only based on the scenarios in this Scoping Plan.

The fuel changes for each AB 197 measure are estimated based on the impact of each measure compared to the Reference Scenario for the years 2035 and 2045. Therefore, aggregating the effect of each measure would overestimate the impacts of the Scoping Plan Scenario because the implementation of each measure would affect the level of benefits of the other measures. This measure-by-measure analysis uses a different methodology for calculating health endpoints than does the health analysis for the complete Scoping Plan Scenario provided earlier.

Natural and Working Lands

Implementation of NWL management strategies to mitigate and adapt to climate change will result in both environmental and health benefits. This section provides information about the potential health benefits of measures evaluated for the Scoping Plan Scenario. For this analysis, health benefit estimates were focused on increases or decreases to $PM_{2.5}$ resulting from wildfire emissions on forests, shrublands, and grasslands.[233] Other health benefits resulting from NWL management actions in the Scoping Plan Scenario are not quantified here but are important for all Californians. This includes, but is not limited to, reductions in exposure to synthetic pesticides when switching to organic agricultural systems, improvements in shade availability and mental health with increasing urban forest cover, improved mental health from opportunities for recreation in resilient and healthy environments, and protection from floods and rising sea levels.

[233] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N11, N14. finalejacrecs.pdf (arb.ca.gov).

These examples are by no means exhaustive, as our natural and working lands provide immense health benefits to everyone.

For this analysis, CARB used the $PM_{2.5}$ emissions in Table 3-6 to understand potential health impacts. This information should be used to understand the relative health endpoints of the various measures and should not be taken as absolute estimates of health outcomes of this Scoping Plan statewide or within a specific community. The IPT methodology was used to calculate health endpoints, similar to the AB 32 GHG Inventory Sector analysis. CARB calculated the annual health endpoints associated with the wildfire emissions changes resulting from the implementation of management strategies on forests, shrublands, and grasslands under each alternative. The annual health endpoints associated with emission reductions for the Scoping Plan Scenario were estimated for the entire state. Calculated health endpoints include emissions-caused mortality, hospital admittance, and emergency room visits from asthma; hospital admittance from chronic obstructive pulmonary disease; and emergency room visits from respiratory and cardiovascular outcomes. Table 3-8 compares the average annual health endpoints of wildfire emission reductions associated with the Scoping Plan Scenario over the period 2025–2045. The other alternatives are presented in Appendix C (AB 197 Measure Analysis).

Table 3-8: Estimated average annual avoided incidence of hospital admissions, emergency room visits, and mortality relative to the Reference Scenario for the Scoping Plan Scenario resulting from forest, shrubland, and grassland wildfire emissions (NWL)

Health Endpoints from Forest, Shrubland, and Grassland Wildfire Emissions	Average Annual Avoided Incidence
Hospital admissions from asthma	22
Hospital admissions from chronic obstructive pulmonary disease without asthma	19
Hospital admissions from all respiratory outcomes	63
Emergency room visits from asthma	155
Emergency room visits from all respiratory outcomes	419
Emergency room visits from all cardiovascular outcomes	156
All causes of mortality	394

Estimated Social Cost

Social costs are generally defined as the cost of an action on people, the environment, or society and are widely used to understand the impact of regulatory actions. One tool, the social cost of greenhouse gases (SC-GHG), is an estimate of the present value of the costs associated with the emission of GHGs in future years. It combines climate science and economics to help understand the benefits of reducing GHG emissions. The estimates of the social cost of carbon (SC-CO_2) and social cost of methane (SC-CH_4), two types of SC-GHGs presented here, estimate the value of the net harm to society associated with adding GHGs to the atmosphere in a given year; they do not represent the cost of actions taken to reduce GHG emissions (known as the *cost of abatement*) nor the cost of GHG emissions reductions. In principle, the SC-GHG includes the value of climate change impacts, including but not limited to, changes in net agricultural productivity, human health effects, property damage from increased flood risk and other natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. It reflects the societal value of reducing emissions of the gas in question by one metric ton.[234] Many of these damages from GHG emissions today will affect economic outcomes throughout the next several centuries.

In 2008, federal agencies began incorporating SC-CO_2 estimates into the analysis of their regulatory actions. U.S. EPA has used various models and discount rates to determine the value of future impacts. Generally, these models begin with assumptions to predict economic activity over time, along with projected GHG emissions. The modeled emissions are input into a model of the global climate system, which then translates into estimates of surface temperature, sea level rise, and other impacts. These outputs are used to estimate economic damages per ton of GHG emitted in a given year in the future. Since the models are calculating the present value of future damages, a discount rate is applied. For example, the SC-CO_2 for the year 2045 represents the value of climate change damages from a release of CO_2 in 2045 discounted back to today. The present value is significantly affected by the discount rate used; a higher discount rate results in a lower present value. For example, in 2021 dollars the SC-CO_2 in 2045 is $31 using a 5 percent discount rate, $88 using a 3 percent discount rate, and $122 using a 2.5 percent discount rate. Additional detail is included in Appendix C (AB 197 Measure Analysis).

The 2017 Scoping Plan utilized SC-CO_2 and SC-CH_4 Obama Administration-era values developed by the Council of Economic Advisors and the Office of Management and Budget-convened Interagency Working Group on the Social Cost of Greenhouse Gases (IWG)[235] to consider the social costs of actions to reduce GHG emissions. The Biden Administration reinstated these values in February 2021,[236] after they had been rescinded and significantly revised by the Trump Administration. The reinstatement was considered an interim step, and the Biden Administration also reconvened the IWG to continue its work to evaluate and incorporate the latest climate science and economic research and

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[234] U.S. Government. Interagency Working Group on Social Cost of Greenhouse Gases. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide – Interim Estimates under Executive Order 13990. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

[235] Originally titled the “Interagency Working Group on the Social Cost of Carbon,” the IWG was renamed in 2016. 82 Fed. Reg. 16093, 16095-96 (Mar. 28, 2017). https://www.govinfo.gov/content/pkg/FR-2017-03-31/pdf/2017-06576.pdf.

[236] Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis, Executive Order 13990 (Jan. 20, 2021), 86 Fed. Reg. 7037 (Jan. 25, 2021). https://www.energy.gov/sites/default/files/2021/02/f83/eo-13990-protecting-public-health-environment-restoring.pdf. IWG, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990 (February 2021), https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf See also, The White House. 2021. A Return to Science: Evidence-Based Estimates of the Benefits of Reducing Climate Pollution. https://www.whitehouse.gov/cea/written-materials/2021/02/26/a-return-to-science-evidence-based-estimates-of-the-benefits-of-reducing-climate-pollution/.

respond to the National Academies' recommendations from 2017 as it develops a more complete revision of the estimates.

It is important to note that the models used to produce SC-GHG estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate literature. There are additional costs to society, including the costs associated with changes in co-pollutants and costs that cannot be included due to modeling and data limitations. The IWG has stated that the range of the interim SC-GHG estimates likely underestimates societal damages from GHG emissions.[237] The revised estimates were originally slated to be released in early 2022 but were stalled.[238] CARB staff is applying the interim values presented in the IWG February 2021 Technical Support Document (TSD), which reflect the best available science in the estimation of the socioeconomic impacts of GHGs.[239] This Scoping Plan utilizes the TSD standardized range of discount rates, from 2.5 to 5 percent, to represent varying valuation of future damages.

AB 32 GHG Inventory Sectors

Table 3-9 presents the estimated social cost, in terms of avoided economic damages, for each measure of the Scoping Plan Scenario. For each measure, Table 3-9 includes the range of the SC-CO_2 and SC-CH_4 that results from the GHG emissions reductions in 2035 and 2045 at 2.5 and 5 percent discount rates. Additional background on the SC-GHG and methodology for calculating the SC-CO_2 and SC-CH_4 estimates in this Scoping Plan, as well as estimates for the alternatives, are provided in Appendix C (AB 197 Measure Analysis).

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[237] Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

[238] See *Louisiana v. Biden* (W.D. La. 2022) 585 F.Supp.3d 840, stayed pending review (5th Cir. Mar. 16, 2022) 2022 WL 866282. A federal district court ruling issued in early February 2022 had granted a preliminary injunction blocking the Biden Administration from using the interim IWG SC-GHG estimates. However, a federal appeals court overturned the lower court's preliminary injunction in March 2022, which allows the Biden Administration to continue using the policy as legal proceedings continue. CARB will continue to monitor the litigation. However, the federal action does not prohibit CARB from using social cost of carbon and CARB will use the best available science regardless of politics. A separate federal appeals court upheld the Biden administration's use of the IWG SC-GHG estimates in October 2022. *Missouri v. Biden* (8th Cir. 2022) ____ F.4th ____.

[239] Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

Table 3-9: Estimated social cost (avoided economic damages) of measures considered in the Scoping Plan Scenario (AB 32 GHG Inventory sectors)

Measure	Social Cost of Carbon in 2035, 5%–2.5% Discount Rate Billion USD (2021 dollars)	Social Cost of Carbon in 2045, 5%–2.5% Discount Rate Billion USD (2021 dollars)
Deploy ZEVs and reduce driving demand	1.12–4.87	2.64–10.23
Coordinate supply of liquid fossil fuels with declining California fuel demand	0.61–2.63	0.95–3.67
Generate clean electricity	0.20-0.88	0.97–3.75
Decarbonize industrial energy supply	0.23–1.01	0.69–2.67
Decarbonize buildings	0.35–1.52	1.11–4.32
Reduce non-combustion emissions	0.51–1.29 (SC-CH_4)	0.86–2.01 (SC-CH_4)
Compensate for remaining emissions	0.61–2.66	2.03–7.84
Scoping Plan Scenario SC-CO_2 **Scoping Plan Scenario SC-CH_4** **Scoping Plan Scenario (Total)**[a]	2.4–10.4 0.51–1.3 2.9–11.7	5.6–21.9 0.86–2.0 6.5–23.9

[a] CARB staff could not precisely separate some CO_2 and CH_4 from other GHGs from PATHWAYS outputs, but the contribution is believed to be small for purposes of calculating the social cost of carbon. The approach used to estimate GHG emissions reductions for individual measures in PATHWAYS does not reflect cross-sector interactions. Therefore, the GHG values for each measure do not sum to the overall scenario total. The total GHG emissions reduction used in this calculation is 97 $MMTCO_2e$ in 2035 and 180 $MMTCO_2e$ in 2045.

Natural and Working Lands

The SC-CO_2 estimates for the NWL measures shown in Table 3-10, in terms of avoided economic damages, reflect 2021 IWG interim values, updated for inflation, similar to the AB 32 GHG Inventory Sector analysis. This analysis utilizes the 2.5 percent and 5 percent discount rate and the average annual emissions reductions from each NWL type from 2025–2045. Estimates for all alternatives are included in Appendix C (AB 197 Measure Analysis).

Table 3-10: Estimated social cost (avoided economic damages) of measures considered in the Scoping Plan Scenario (NWL)

Measure	Social Cost of Carbon in 2035, 5%–2.5% Discount Rate Billion USD (2021 dollars)	Social Cost of Carbon in 2045, 5%–2.5% Discount Rate Billion USD (2021 dollars)
Forests/Shrublands/Grasslands	0.003–0.012	0.004–0.014
Annual Croplands	0.006–0.027	0.008–0.031
Perennial Croplands	<0.001–0.001	0.000–0.001
Urban Forest	0.032–0.138	0.041–0.157
Wildland Urban Interface (WUI)	(0.018) – (0.080)[a]	(0.023) – (0.090)
Wetlands	0.011–0.046	0.014–0.053
Sparsely Vegetated Lands	<0.001	<0.001

[a] Parentheses indicate an increase in estimated social cost, i.e., an increase in economic damages. This is only the case for WUI measures where emissions are increased, shown in Table 3-6. The estimated social cost does not account for the decrease in wildfire risk or decrease in wildfire damages resulting from the WUI measures.

Social Costs of GHGs in Relation to Cost-Effectiveness

AB 32 includes a requirement that rules and regulations "achieve the maximum technologically feasible and cost-effective" greenhouse gas emissions reductions.[240] Under AB 32, *cost-effectiveness* means the relative cost per metric ton of various GHG reduction strategies,[241] which is the traditional cost metric associated with emission control. In contrast, the SC-CO_2, SC-CH_4, and social cost of nitrous oxide (SC-N_2O), because they are estimates of the cost to society of additional GHG emissions, can be used to estimate of the economic benefits of reducing emissions, but do not take into account the cost of the actions that must be taken to achieve those GHG emissions reductions.

There may be technologies or policies that do not appear to be cost-effective when compared to the SC-CO_2, SC-CH_4, and SC-N_2O associated with GHG reductions. However, these technologies or policies may result in other benefits that are not reflected in the IWG social costs. Examples include the evaluation of social diversification of the portfolio of transportation fuels (a goal outlined in the Low Carbon Fuel Standard) and reductions in criteria pollutant emissions from power plants (as in the Renewables Portfolio Standard). Additionally, costs for new technology may be higher early on in a technology's development cycle and may drop over time as use of the technology is scaled up.

Estimated Cost per Metric Ton

AB 197 requires an estimation of the cost-effectiveness of the measures evaluated for this Scoping Plan. The cost (or savings)[242] per metric ton of CO_2e reduced for each measure is one metric for comparing the performance of the measures. Additional factors beyond the cost per metric ton that could be considered include continuity with existing laws and policies, implementation feasibility, contribution to fuel diversity and technology transformation goals, and health and other benefits to California. These considerations are not reflected in the cost per metric ton estimates presented below. It is important to understand the relative cost-effectiveness of individual measures as presented in this section. However, the economic analysis presented earlier in this chapter, in Appendix H

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[240] AB 32 Air pollution: greenhouse gases: California Global Warming Solutions Act of 2006. (AB 32, Nuñez, Chapter 488, Statutes of 2006). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

[241] Health & Saf. Code § 38505(d).

[242] Similarly, to the direct costs reported earlier, the cost per metric ton of a measure reflects the stock costs and any fuel or efficiency savings associated with a measure divided by the GHG emission reduction achieved by the measure. Costs are reported as positive values, and savings are reported as negative values.

(AB 32 GHG Inventory Sector Modeling), and in Appendix I (NWL Technical Support Document) provides a more comprehensive analysis of how the Scoping Plan Scenario and alternative scenarios affect the state's economy and jobs.

AB 32 GHG Inventory Sectors

The cost per metric ton for the AB 32 GHG Inventory sectors was computed for each measure independently relative to the Reference Scenario using the sensitivity calculations based on PATHWAYS and RESOLVE outputs. The difference in the annualized cost between the Scoping Plan Scenario and the Reference Scenario was computed for each measure in 2035 and in 2045. The incremental cost was divided by the incremental GHG emissions impact to calculate the cost per metric ton in each year. To capture the fuel and GHG impacts of investments made from 2022 through 2035, or from 2022 through 2045, CARB computed an average annual cost per metric ton. The incremental cost in each year was averaged over the period. This value is divided by the corresponding annual, incremental GHG impact averaged over the same period.

The cost metric includes the annualized incremental cost of energy infrastructure, such as zero-emission vehicles, electric appliances, and required revenue to support all electric assets. A residual value for equipment such as vehicles or appliances that are retired early is included. The annual fuel cost or avoided fuel cost that results from efficiency improvements or changes to demand for fuels associated with transitioning to alternative fuels is included. Not included in this cost metric are costs that represent transfers within the state, such as incentive payments for early retirement of equipment.

It is important to note that this cost per metric ton does not represent an expected market price value for carbon mitigation associated with these measures. In addition, the values do not capture fuel savings or GHG reductions associated with the full economic lifetime of measures that have been implemented by the target date of 2035 or 2045 but whose impacts extend beyond the target date.

Table 3-11 includes the cost per metric ton and annual average cost per metric ton estimates for the Scoping Plan Scenario. The other alternatives are presented in Appendix C (AB 197 Measure Analysis). Measures that are relatively less costly in 2035 or 2045 are also less costly over the extended period. As noted earlier, incremental costs of new vehicles are generally offset by gains in efficiency and avoided fuel consumption resulting in negative cost per metric ton.

Table 3-11: Estimated cost per metric ton of reduced CO_2e relative to the Reference Scenario for measures considered in the Scoping Plan Scenario (AB 32 GHG Inventory sectors)

Measure	Annual Cost, 2035 ($/ton)	Average Annual Cost, 2022–2035 ($/ton)	Annual Cost, 2045 ($/ton)	Average Annual Cost, 2022–2045 ($/ton)
Deploy ZEVs and reduce driving demand	-171	-99	-103	-122
Coordinate supply of liquid fossil fuels with declining CA fuel demand	60	109	-50	39
Generate clean electricity[a]	101	156	145	161
Decarbonize industrial energy supply	290	217	257	274
Decarbonize buildings	235	230	112	213
Reduce non-combustion emissions	93	94	106	99
Compensate for remaining emissions	745	823	236	485

[a] Note: The denominator of this calculation (2045) does not include GHG reductions occurring outside of California resulting from SB 100. If these reductions were included, this number would be lower.

Natural and Working Lands

The cost per metric ton for NWL measures were computed for the Scoping Plan Scenario relative to the Reference Scenario using the projected carbon stock/sequestration data from the NWL modeling and the direct cost estimates for each management action, described earlier. Direct costs represent the cost of implementing a certain management action. The projected emissions reductions take into account the loss of carbon that results from the management action, such as fuels reduction treatments in forests, as well as climate change effects on growth. The direct cost for each NWL measure was divided by the average annual emission reductions presented in Table 3-6 to produce the cost per metric ton. The increasing effect of climate change on diminished future growth reduces the ability of the land to sequester or store carbon, driving up the cost per ton.

It is important to note that this cost per metric ton does not represent an expected market price value for carbon mitigation associated with these measures. In addition, emissions benefits of NWL management actions often take longer time periods to accrue, and these values only capture GHG reductions up to 2045.

Table 3-12 includes the average cost per metric ton estimates for the average annual CO_2e reductions from 2025 through 2045 for the Scoping Plan Scenario. The other alternatives are presented in Appendix C (AB 197 Measure Analysis).

Table 3-12: Estimated average cost per metric ton of reduced CO_2e relative to the Reference Scenario for measures considered in the Scoping Plan Scenario (NWL)

Measure	Average Cost per Reduced Ton CO_2e (\$/Ton)
Forests/Shrublands/Grasslands	15,500
Annual Croplands	1,100
Perennial Croplands	412
Urban Forest	3,270
Wildland Urban Interface (WUI)	N/A
Wetlands	64
Sparsely Vegetated Lands	451,000

Climate Vulnerability Metric

As California invests in climate mitigation and adaptation, it is essential to understand that the relative impact of climate change will vary across the state's communities. Due to persisting health and opportunity gaps, not all communities are equally resilient in the face of climate impacts. A global metric such as the Social Cost of Carbon cannot adequately capture the incremental additional economic impact faced by overly burdened communities. The Climate Vulnerability Metric (CVM) is specifically focused on quantifying the community-level impacts of a warming climate on human welfare and the additional costs. Additional details and results are included in Appendix K (Climate Vulnerability Metric).

The CVM aggregates the impacts of climate change that can be quantified at the census tract level using robust and currently available research. The CVM includes the projected impacts of climate change on human welfare across four categories (hours worked, household energy costs, human mortality, and flood-related property damage) through midcentury. The CVM identifies nine components of the four climate impacts as shown in Figure 3-9 and aggregates the data to generate a total CVM result for each census tract. To ensure that the CVM represents the diversity of California communities, it is reported as the aggregate monetized impact of climate change as a percentage of census tract-specific incomes.[243] For example, a CVM value of 3 implies that by 2050, a census tract is projected to experience human welfare impacts of climate change that amount to 3% of annual income in that tract.

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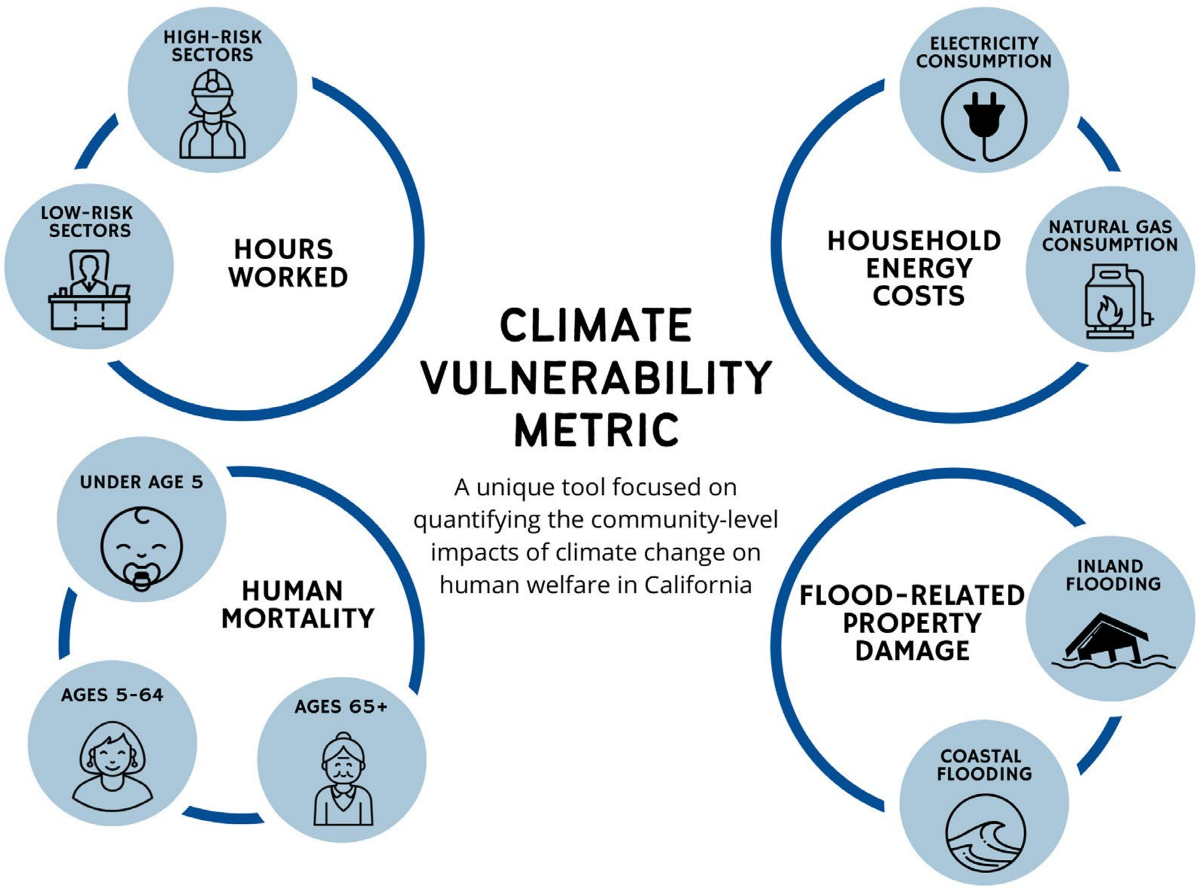
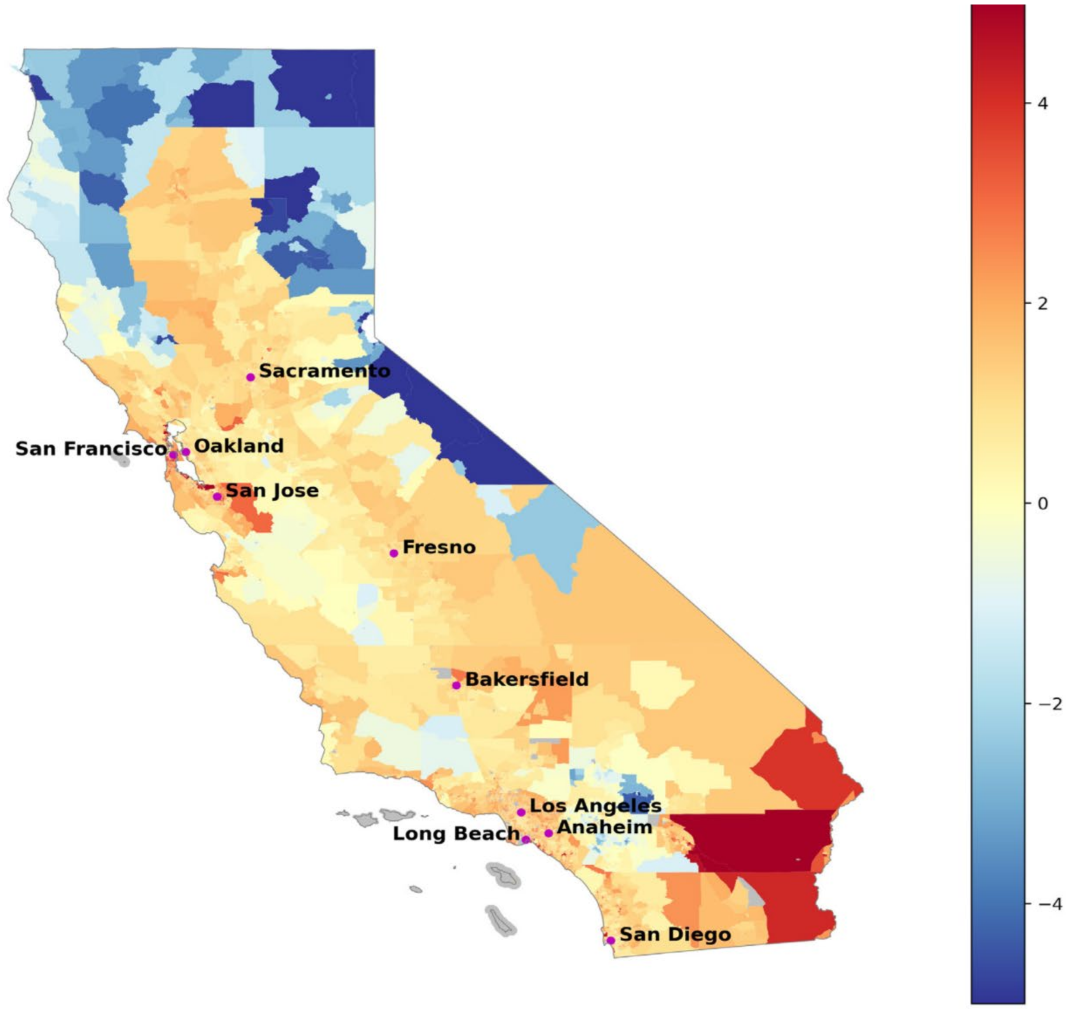
[243] Per capita income in 2019 for census tracts across California ranges from $633 to $176,388, with a median of $32,181 ($2019). Source: American Community Survey.

Figure 3-9: Categories of climate change impacts on human welfare included in the Climate Vulnerability Metric.



The CVM shows that climate change will have highly unequal impacts across California. While some southeastern regions of California are estimated to suffer damages that exceed 5% of annual income, other high-elevation northeastern regions of California are estimated to see benefits of up to 10%. Some low-lying urban areas, such as the San Francisco Bay Area, are estimated to be particularly vulnerable, while much of the Central Valley is estimated to suffer at least moderate economic damages relative to the rest of the state. It is important to note that the CVM does not set a threshold for vulnerability. Instead, it shows relative impacts across census tracts. The CVM is limited to the impacts that can currently be quantified at the census tract level.

Figure 3-10: Combined impacts of climate change in 2050 under a moderate emissions scenario; damages as share of 2019 tract income (%)



The map shows combined impacts of climate change in 2050 under a moderate emissions scenario (RCP 4.5), reported as a share of 2019 census tract income. For example, a CVM value of 3 implies that by 2050, a census tract is projected to experience human welfare impacts of climate change that amount to 3% of annual income. Impacts are combined across the categories shown in Figure 3-9. The higher the CVM for a given census tract, the more damaging the projected impacts of climate change on human welfare. Census tracts with high CVMs are represented by positive percentages in orange and red. A lower CVM is associated with lower projected impacts of climate change, shown in yellow, while a negative CVM value represents a projected beneficial impact of climate change (e.g., through reductions in deaths caused by extremely cold winter weather). Negative CVMs are represented by negative percentages in blue.

By providing information about how climate vulnerability varies across California (Figure 3-10), the CVM results can be used to direct resources to enhance resiliency in the state's most vulnerable communities based on the specific impacts, such as heat or flooding, they are experiencing. The CVM may be used in combination with existing screening tools, such as CalEnviroScreen 4.0, to identify communities that face environmental and health hazards that contribute to disproportionate economic impacts in addition to climate vulnerability. The CVM can become an essential source of information to implement this Scoping Plan and build a more resilient, just, and equitable future for all communities.

Public Health

Health Analysis Overview

This section focuses on a broader evaluation of public health and climate change. Science demonstrates that taking action to address climate change presents one of the most significant opportunities to improve public health outcomes.[244] Transitioning to clean energy and technology and improving land and ecosystem management will lead to a much healthier future. Many actions to reduce GHG emissions also have health co-benefits that can improve the health and well-being of populations across the state, as well as address climate change. This section and the accompanying Appendix G (Public Health) provide a qualitative analysis of health benefits to accompany the quantitative health analysis included in this chapter, in Appendix C (AB 197 Measure Analysis), and in Appendix H (AB 32 GHG Inventory Sector Modeling). Together the qualitative and quantitative analyses of benefits are demonstrating the many ways that climate action and health improvements go hand in hand.

Climate change can lead to a wide range of direct health impacts such as increased heat-related illnesses (i.e., heat exhaustion and heat stroke), and injuries and deaths from extreme weather events or disasters (e.g., severe storms, flooding, wildfires). Indirect impacts include:

- more air pollution-related exacerbations of cardiovascular and respiratory diseases (e.g., due to increased smog, wildfire smoke)
- increased vector-borne and fungal diseases due to changes in the distribution and geographic range of disease-carrying species (e.g., mosquitoes, ticks, fungi in dust)
- negative nutritional consequences related to decreases in agricultural food yields
- stress and mental trauma due to extreme weather-related catastrophes
- anxiety, depression, and other mental health impacts associated with gradual changes in the climate (e.g., prolonged drought or temperature shifts affecting jobs and industries) that result in unemployment and income loss

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[244] Watts, N., W. N. Adger, P. Agnolucci, et al. 2015. "Health and climate change: Policy responses to protect public health." *Lancet* 386, 1861–1914.

- residential displacement and home loss (e.g., sea level rise impacting coastal communities)

Wildfires and wildfire smoke are one area where we have already seen and expect to see even further drastic impacts on the health of Californians. According to CalFire, since 1932 the top eight largest wildfires in California have occurred in the past five years (2017–2022), with 151 deaths due directly to fires during that period.[245] Researchers estimate that wildfire smoke during fall 2020 may have led to as many as 3,000 excess deaths, with at least 95% of Californians suffering unhealthy levels of particle pollution due to wildfires in 2020.[246] Continued climate change is projected to further increase smoke exposure from wildfires through the end of the century.[247] Wildfires also create a high-risk environment for outdoor workers, including agricultural workers. While the direct medical and physical health impacts are often most noticeable, the psychological impacts can develop and persist well after the event. Estimates indicate that 20%–65% of survivors of extreme weather events have mental health issues following the event.[248]

Extreme heat, drought, and associated worsened air quality impacts are among the most serious climate-related exposures affecting the health of Californians. Numerous studies find a wide range of adverse health effects accompanying extreme heat, including heat stroke and adverse birth outcomes, and find that extreme heat can harm most body systems. Climate change exacerbates air pollution problems that cause difficulty breathing and can lead to serious illness and death in many parts of California. Increasing temperatures cause increases in ozone and other pollution concentrations, including for California's most polluted regions, and heighten health risks for the vulnerable and marginalized populations living in these areas.[249] In 2020, there were 157 ozone polluted days across Los Angeles, Orange, Riverside, and San Bernardino Counties—the most days since 1997. In addition, particulate matter exposure is a heightened problem during

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[245] California Department of Forestry and Fire Protection (CAL FIRE). "Stats and Events." *Cal Fire Department of Forestry and Fire Protection*, https://www.fire.ca.gov/stats-events/.
[246] G-FEED. 2020. Indirect mortality from recent wildfires in CA. http://www.g-feed.com/2020/09/indirect-mortality-from-recent.html.
[247] M. D. Hurteau, A. L. Westerling, C. Wiedinmyer, and B. P. Bryant. 2014. "Projected effects of climate and development on California wildfire emissions through 2100." *Environ. Sci. Technol.* 48, 2298–2304.
[248] American Public Health Association. 2019. Addressing the Impacts of Climate Change on Mental Health and Well-Being. Policy No: 20196. https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2020/01/13/addressing-the-impacts-of-climate-change-on-mental-health-and-well-being.
[249] American Lung Association. State of the Air 2021. https://www.lung.org/research/sota.

droughts, which are expected to increase over this century.[250,251] Worse air quality leads to illnesses, emergency room visits, and hospitalizations for chronic health conditions, including chronic obstructive pulmonary disease (COPD), asthma, chronic bronchitis, and other respiratory and cardiovascular conditions, as well as increased risk for respiratory infections, which all result in greater health costs to the state.[252,253,254] These and other climate-related health impacts are discussed in more detail in Appendix G (Public Health).

Health Analysis Components

This Scoping Plan health analysis focuses on the contrast between a California that is still dependent on a fossil fuel-based economy and a California that is transitioned to a carbon-neutral, clean energy future. This qualitative analysis evaluates and demonstrates the broad range of benefits of a dramatic reduction in fossil fuels by 2045 combined with healthier ecosystem management, comparing health outcomes for a "no-action" scenario (Reference) to a "take-action" decarbonization scenario. As this is a qualitative analysis, it looks more broadly at the public health benefits of a drastic reduction in fossil fuel combustion. While this analysis provides scientific evidence for Scoping Plan benefits based on achieving carbon neutrality by 2045, it does not analyze a specific scenario.

The key areas of focus for the analysis are: heat impacts, children's health and development, economic security, food security, mobility and physical activity, urban greening, wildfires and smoke impacts, and housing affordability. For each area of focus, the analysis covers the scientific evidence and compares expected health effects between the Reference and decarbonization scenarios. This analysis looks at the major health outcomes, provides directional effects for each health outcome, and where possible provides information on the strength and scale of health impacts. Some areas include quantitative information where tools are available to measure health outcomes. While the analysis is focused on health outcomes statewide, it also includes discussion

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[250] Cvijanovic, I., B. D. Santer, C. Bonfils, et al. 2017. "Future Loss of Arctic Sea-ice Cover Could Drive a Substantial Decrease in California's Rainfall." 8 *Nat. Commun.* 1947. https://doi.org/10.1038/s41467-017-01907-4.

[251] Williams, A. P., R. Seager, J. T. Abatzoglou, B. I. Cook, J. E. Smerdon, and E. R. Cook. 2015. "Contribution of anthropogenic warming to California drought during 2012–2014." *Geophysical Research Letters* 42(16), 6819–6828.

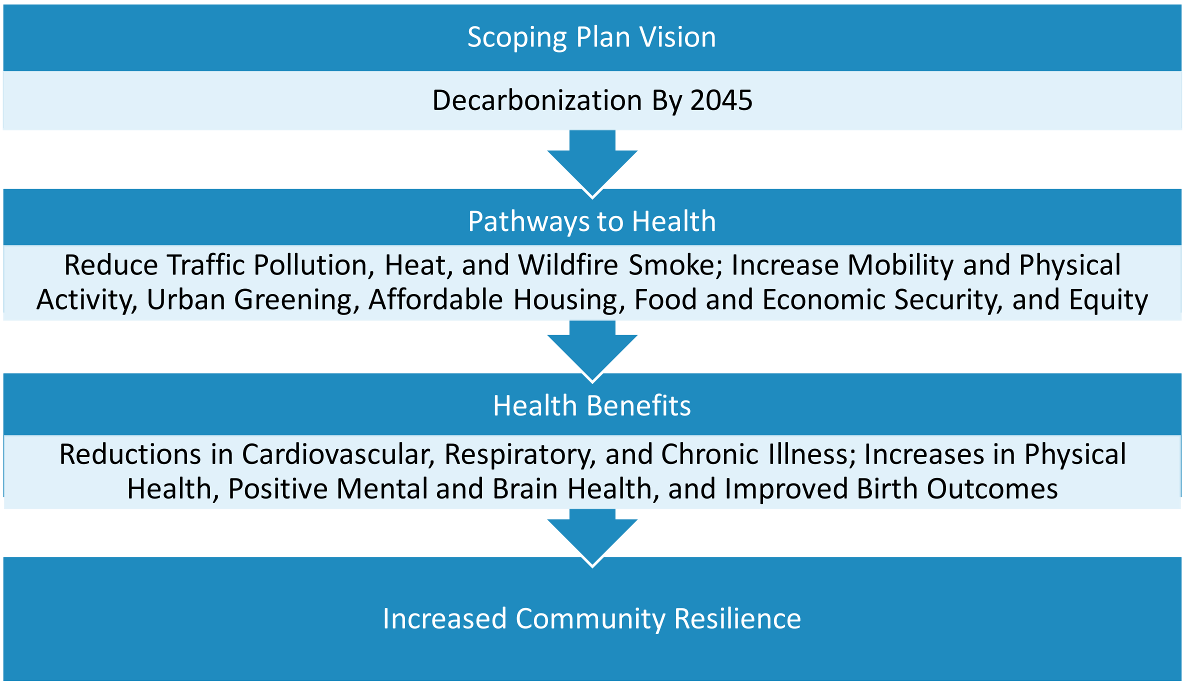
[252] Romley, J. A., A. Hackbarth, and D. P. Goldman. 2010. Cost and Health Consequences of Air Pollution in California. Santa Monica, California. RAND Corp. https://www.rand.org/pubs/research_briefs/RB9501.html.

[253] Wang, M., C. P. Aaron, J. Madrigano, E. A. Hoffman, E. Angelini, J. Yang, A. Laine, et al. 2019. "Association between long-term exposure to ambient air pollution and change in quantitatively assessed emphysema and lung function." *JAMA* 322(6), 546–556.

[254] Inserro, A. 2018. "Air Pollution Linked to Lung Infections, Especially in Young Children." *Am. J. Managed Care* (May 6). https://www.ajmc.com/view/air-pollution-linked-to-lung-infections-especially-in-young-children.

of benefits to community health and climate resilience, as well as potential inequities experienced at a community level. Figure 3-11 shows the co-benefit areas covered in this Scoping Plan and the path to health improvements and increased community resilience.

Figure 3-11: Scoping Plan outcome and the path to health improvements



Social and Environmental Determinants of Health Inequities

Communities across the state do not experience exposure to pollution sources and the resulting effects equally. Low-income communities and communities of color (including Black, Latino and Indigenous communities) consistently experience significantly higher rates of pollution and adverse health conditions than others due to factors including historic marginalization rooted in systemic racism. As shown in Figure 3-12, the most impacted neighborhoods according to CalEnviroScreen (CES) are home to very high percentages of people of color while the least impacted neighborhoods are predominantly white. Recent findings show that Black Californians have 19% higher $PM_{2.5}$ exposure from vehicle emissions than the state average, and the census tracts with the highest $PM_{2.5}$ pollution burden from vehicle emissions have a high proportion of people of color.[255] Air pollutant emissions from mobile sources have disproportionate impacts on low-income communities and communities of color due to their proximity.[256] Diesel-fueled vehicles traveling on California's freeways and major roads expose nearby residents to pollution that is linked to lung cancer, hospitalizations and emergency department visits for chronic heart and lung disease, and premature death.[257,258] A combination of historical and social inequities are evident in communities of color disproportionately living close to freeways and other major sources of vehicle pollution. Environmental exposures and contaminants are one component of a broader set of social, economic, and environmental factors that can amplify health conditions, and the combination of all these factors can compound the health effects of individual exposures. This broader set of community factors can be referred to as "cumulative impacts." In addition, specific populations are more sensitive to pollution and face greater susceptibility. This includes young children, older adults, and individuals with existing health conditions.

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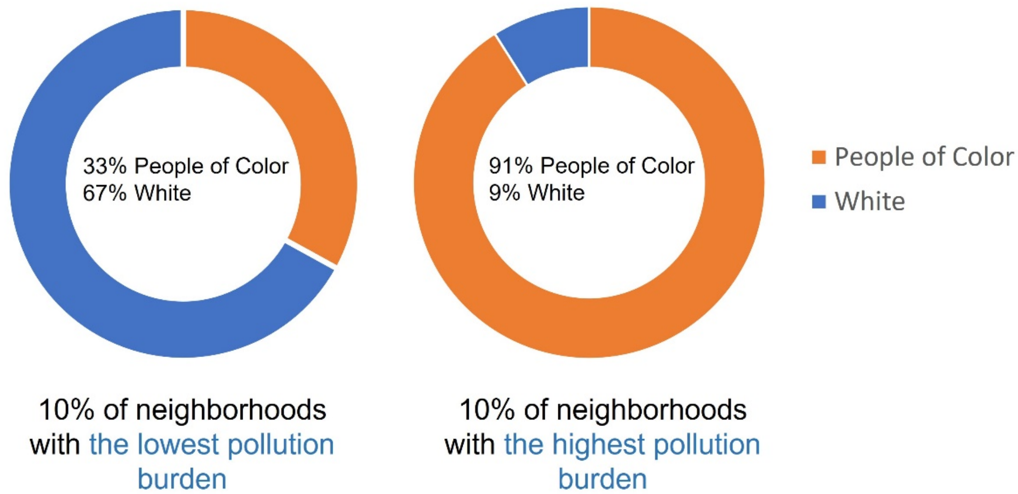
[255] Reichmuth, D. 2019. *Inequitable exposure to air pollution from vehicles in California.* https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles-california-2019.
[256] CARB. 2017. *California's 2017 climate change scoping plan.* https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.
[257] CARB. 2020. Overview: Diesel exhaust & health. https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health.
[258] Kagawa, J. 2002. "Health effects of diesel exhaust emissions—a mixture of air pollutants of worldwide concern." *Toxicology* 181–182:349–353.

Figure 3-12: Least and most impacted neighborhoods from CalEnviroScreen[259]



Social Determinants of Health Inequities

The physical and mental health of individuals and communities is shaped, to a great extent, by the social, economic, and environmental circumstances in which people live, work, play, and learn. According to the World Health Organization, these same circumstances—or social determinants of health—are "mostly responsible for health inequities: the unfair and avoidable differences in health status seen within and between countries." In fact, a strong body of research demonstrates that more than 50 percent of long-term health outcomes are the result of social determinants affecting an individual.[260] Race/ethnicity and socioeconomic status, for example, have been found to amplify impacts from long- and short-term environmental exposures for several health outcomes,

[259] The figure represents the top and bottom decile scoring of CalEnviroScreen census tracts for pollution burden. This chart is modified from Figure 2. Race in the Least and Most Impacted Census Tracts of CalEnviroScreen 4.0 in the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Analysis of Race/Ethnicity and CalEnviroScreen 4.0 Scores. 2021. https://oehha.ca.gov/media/downloads/calenviroscreen/document/calenviroscreen40raceanalysisf2021.pdf.

[260] California Department of Public Health (CDPH). 2015. *The Portrait of Promise: The California Statewide Plan to Promote Health and Mental Health Equity.* A Report to the Legislature and the People of California by the Office of Health Equity. Sacramento, California. California Department of Public Health, Office of Health Equity.

such as mortality and birth outcomes.[261,262,263,264] Social factors combine in low-income communities and communities of color to create levels of toxic chronic stress and limit opportunities for healthy food and healthy lifestyles. Social factors also can cause health disparities through psychosocial pathways such as discrimination and social exclusion.[265] While the importance of social determinants is well known, measuring the specific and cumulative impacts of social determinants is challenging.

There are several important tools to evaluate and map cumulative impacts and factors contributing to the results of historical practices such as redlining, and these tools have been used for air quality and climate planning, community protection, and investments. CalEnviroScreen is a tool that maps cumulative pollution burdens and vulnerabilities on a statewide basis and ranks census tracts based on environmental, exposure, population, and socioeconomic indicators. An analysis using CES shows a direct, persistent relationship between exposure to environmental burdens and socioeconomic and health vulnerabilities affecting communities of color and historical redlining practices. OEHHA has evaluated health impacts of certain climate change policies on disadvantaged communities and communities of color utilizing CES rankings.[266] The Healthy Places Index (HPI) maps indicators that affect life expectancy on a statewide basis. In the future, these and other tools can be helpful to prioritizing investments and informing implementation efforts for GHG emission reductions policies.

Environmental Determinants of Health Inequities

Communities with large percentages of Black and other socially vulnerable and marginalized groups are disproportionately located near pollution sources, such as traffic

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[261] O'Neill, M. S., M. Jerrett, I. Kawachi, J. I. Levy, A. J. Cohen, N. Gouveia, et al. 2003. "Health, wealth, and air pollution: Advancing theory and methods." *Environ Health Perspect.* 111 (16): 1861–70.
[262] Ponce, N. A., K. J. Hoggatt, M. Wilhelm, and B. Ritz. 2005. "Preterm birth: The interaction of traffic-related air pollution with economic hardship in Los Angeles neighborhoods." *Am J Epidemiol.* 162 (2): 140–8.
[263] Morello-Frosch, R., B. Jesdale, J. Sadd, and M. Pastor. 2010. "Ambient air pollution exposure and full-term birth weight in California." *Environ Health.* 9: 44.
[264] Finkelstein, M. M., M. Jerrett, P. DeLuca, N. Finkelstein, D. K. Verma, K. Chapman, et al. 2003. "Relation between income, air pollution, and mortality: A cohort study." *CMAJ.* 169 (5): 397–402.
[265] Clougherty, J., and L. Kubzansky. 2009. "A framework for examining social stress and susceptibility in air pollution and respiratory health." *Environ Health Perspect.* 117 (9): 1351–8.
[266] OEHHA. 2022. *Impacts of Greenhouse Gas Emission Limits Within Disadvantaged Communities.* https://oehha.ca.gov/media/downloads/environmental-justice//impactsofghgpoliciesreport020322.pdf.

and freight facilities, industrial facilities, and hazardous waste sites.[267,268,269,270] Research shows large disparities in exposure to pollution between white and non-white populations in California, and between low-income and communities of color (Figure 3-13). The research also shows Black and Latino populations experience significantly greater air pollution impacts than white populations in California.[271] Additionally, Native Americans are disproportionately impacted by air pollution with high rates of exposure to industrial, diesel, and residential pollution sources and higher rates of diseases linked to air pollution.[272, 273]

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[267] Mohai. P., P. M. Lanz, J. Morenoff, J. S. House, and R. P. Mero. 2009. "Racial and socioeconomic disparities in residential proximity to polluting industrial facilities: Evidence from the Americans' Changing Lives Study." *Am J Public Health.* 99 (Suppl 3): S649–56.

[268] Mohai, P., and R. Saha. 2007. "Racial inequality in the distribution of hazardous waste: A national-level reassessment." *Soc Probl.* 54 (3): 343–70.

[269] Morello-Frosch, R., M. Pastor, C. Porras, and J. Sadd. 2002. "Environmental justice and regional inequality in southern California: Implications for future research." *Environ Health Perspect.* 110 (Suppl 2): 149–54.

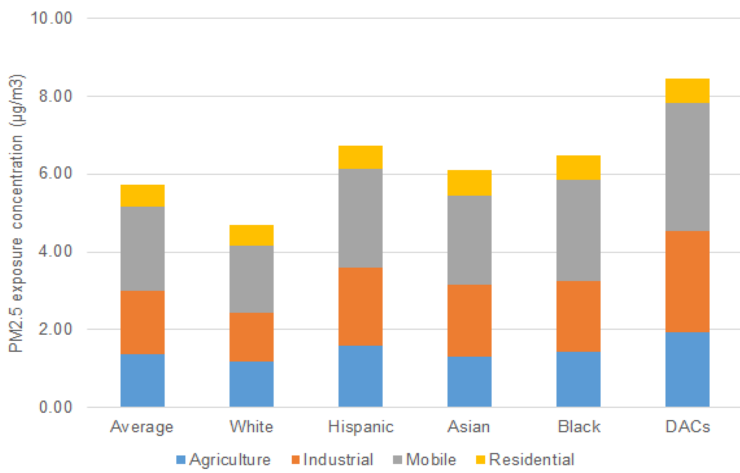
[270] Gunier, R. B., A. Hertz, J. von Behren, and P. Reynolds. 2003. "Traffic density in California: Socioeconomic and ethnic differences among potentially exposed children. *J Expo Anal Environ Epidemiol.* 13 (3): 240–6.

[271] Apte, J. S., S. E. Chambliss, C. W. Tessum, and J. D. Marshall. 2019. *A Method to Prioritize Sources for Reducing High $PM_{2.5}$ Exposures in Environmental Justice Communities in California.* CARB Research Contract Number 17RD006.

[272] Indigenous People and Air Pollution in the United States. A Report from the National Tribal Air Association and Moms Clean Air Force. 2021. https://7vv611.a2cdn1.secureserver.net/wp-content/uploads/2021/04/indigenousairpollution_041421.pdf

[273] National Tribal Air Association. 2022. Status of Tribal Air Report. Pg. 66. https://7vv611.a2cdn1.secureserver.net/wp-content/uploads/2022/10/2022-NTAA-Status-of-Tribal-Air-Report.pdf.

Figure 3-13: Top sources of $PM_{2.5}$ and their contribution to $PM_{2.5}$ exposures by race and in disadvantaged communities



These disparities in exposure to pollution sources generate health inequities. Communities located near major roadways are at increased risk of asthma attacks and other respiratory and cardiac effects. Studies consistently show that mobile source pollution exposure near major roadways or freight sources contributes to and exacerbates asthma, impairs lung function, and increases cardiovascular mortality.[274] The exposure to mixtures of gaseous and particulate pollutants in mobile sources (including PM, NO_x, and benzene) is associated with higher rates of heart attacks, strokes, lung cancer, autism, and dementia.[275]

Environmental hazards found in communities also can include exposures to toxic substances and emissions, as well as occupational exposures. Due to historical inequities, under-resourced communities and communities of color are often located close to sources of toxic pollution, including chrome platers; metal recycling facilities; oil and gas operations; agricultural burning; railyards; facilities transporting, managing, or disposing of hazardous waste; and areas impacted by pesticides, among others. Some populations may be at increased risk of exposure to pollutants, both at work and home.

Children are more susceptible to environmental pollutants for many reasons, including the ongoing development of their nervous, immune, digestive, and other bodily systems. Moreover, children eat more food, drink more fluids, and breathe more air relative to their

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[274] U.S. Environmental Protection Agency website. How Mobile Source Pollution Effects Your Health. https://www.epa.gov/mobile-source-pollution/how-mobile-source-pollution-affects-your-health.
[275] USC Environmental Health Centers. 2018. Living Near Busy Roads or Traffic Pollution. https://envhealthcenters.usc.edu/wp-content/uploads/2016/10/living-near-bus_19696172.pdf.

body weight, as compared to adults.[276] Exposure to high levels of air pollutants, including indoor air pollutants, increases the risk of respiratory infections, heart disease, and asthma.[277] Children living in low-income communities near industrial operations, rail yards, and heavily trafficked freeways and streets in urban areas are at especially high risk of chronic respiratory conditions. Black children are four times more likely to be hospitalized for asthma compared with white children, and urban Black and Latino children are two to six times more likely to die from asthma than white children.[278] Native American children also experience more impacts from asthma and Native American children, along with Black children, have the highest prevalence of asthma.[279]

For older adults, increased vulnerability is linked to respiratory, cardiovascular, and immune systems weakened by aging.[280] Preexisting health conditions interact with environmental pollutants to enhance risks of adverse health outcomes.[281,282] The recent COVID-19 pandemic has highlighted the heightened vulnerability of older adults as well as communities of color to respiratory disease, as hospital admissions and mortality data linked to COVID-19 cases for these groups have been higher than other groups. Research has also underscored the important link between COVID-19 mortality and morbidity and air pollution, demonstrating significantly higher mortality and morbidity for COVID-19 in areas of elevated $PM_{2.5}$ pollution.

Climate Vulnerabilities

Climate change is expected to exacerbate the existing disparities of health conditions and worsen climate vulnerability, which is the degree to which natural systems and people or

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[276] Blaisdell, R. J. Air Toxics Hot Spots Program Risk Assessment Guidelines. 2012. Technical Support Document for Exposure Assessment and Stochastic Analysis. Oakland, California: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. August.
[277] Woodruff, T. J., D. A. Axelrad, A. D. Kyle, O. Nweke, and G. G. Miller. 2003. *America's Children and the Environment: Measures of Contaminants, Body Burdens, and Illness.* 2nd ed. Washington, D.C.: United States Environmental Protection Agency. February.
[278] California Department of Public Health. Asthma Inequities in California Children. 2021. https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/CPE/CDPH%20Document%20Library/CA_Asthma_Inequities_Children_2021-Infographic.pdf.
[279] Meng, Y., S. H. Babey, T. A. Hastert, and E. Brown. 2007. California's Racial and Ethnic Minorities More Adversely Affected by Asthma. UCLA: Center for Health Policy Research. Retrieved from https://escholarship.org/uc/item/4k45v3xt.
[280] Sandström, T., A. J. Frew, M. Svartengren, and G. Viegi. 2003. "The need for a focus on air pollution research in the elderly." *Eur Respir J Suppl.* 40: 92s–5s.
[281] Zanobetti, A., and J. Schwartz. 2001. "Are diabetics more susceptible to the health effects of airborne particles?" *Am J Respir Crit Care Med.* 164 (5): 831–3. https://www.atsjournals.org/doi/pdf/10.1164/ajrccm.164.5.2012039.
[282] Zanobetti, A., J. Schwartz, and D. Gold. 2000. "Are there sensitive subgroups for the effects of airborne particles?" *Environ Health Perspect.* 108 (9): 841–5.

communities are at risk of experiencing the negative impacts of climate change.[283] A report from the California Climate Change Center warned that the impacts of climate change will likely create especially heavy burdens on low-income and other vulnerable populations: "*Without proactive policies to address these equity concerns, climate change will likely reinforce and amplify current as well as future socioeconomic disparities, leaving low-income, minority, and politically marginalized groups with fewer economic opportunities and more environmental and health burdens*."[284]

In the U.S. Environmental Protection Agency's "Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts,"[285] investigators analyzed risks of six primary climate change impacts disproportionately affecting communities across income, educational attainment, race/ethnicity, and age groups. Four socially vulnerable populations—low income, communities of color, no high school diploma, and age 65 and older—were identified as having a higher likelihood of experiencing the greatest impacts of a changing climate (according to the projected 2°C of global warming or 50 centimeters of global sea level rise). Disproportionate impacts were projected for climate events, including air quality, extreme temperature, coastal flooding, and other impacts, leading to increased risk of health and other adverse outcomes. The study projected significant health impacts for low-income communities, certain racial and ethnic subgroups, and those with lower educational attainment.

Several climate vulnerability tools have been developed or are under development to better understand and map areas at higher risk of climate impacts. The Climate Change and Health Vulnerability Indicators (CCHVIs) for California helps state and local health officials prepare for and reduce adverse health impacts due to a changing climate.[286] For example, Los Angeles County shows higher than state average climate vulnerability overall, particularly for those who are linguistically isolated (more than twice the state average).

In summary, there are many environmental, social, individual, and economic factors affecting health and equity in California and contributing to worsening health outcomes from climate change impacts. This section and Appendix G (Public Health) reference a substantial and growing body of research documenting the different social and

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[283] OPR. 2018. Defining Vulnerable Communities in the Context of Climate Adaptation. *https://opr.ca.gov/docs/20180723-Vulnerable_Communities.pdf*.

[284] Shonkoff, S., R. Morello-Frosch, M. Pastor, and J. Sadd. 2011. "The climate gap: environmental health and equity implications of climate change and mitigation policies in California—A review of the literature." *Climatic Change* 109 (Suppl 1): S485–S503.

[285] U.S. EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency. EPA 430-R-21-003.

[286] CDPH. 2022. Climate Change and Health Vulnerability Indicators for California. California Department of Public Health. *https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx*.

environmental factors affecting health outcomes and the many groups that are vulnerable to increased effects or that experience health inequities in California (see Table 3-13).

Table 3-13: Examples of vulnerable groups due to socioeconomic, environmental, developmental, and climate change factors

Examples of Vulnerable Groups Due to Socioeconomic, Environmental, Developmental, and Climate Change Factors		
Older People	People with Existing Chronic Illness	People Impacted Due to Working Conditions
Tribal Groups	Infants and Children	Low-Income People
People with Disabilities	People Experiencing Homelessness	Pregnant People
Communities of Color	Marginalized People	Immigrants/Refugees
People with Less Educational Options	Linguistically Isolated Households	People Impacted Due to Poor Housing Conditions

Summary of the Qualitative Health Analysis

CARB has developed a detailed health analysis that covers eight social and environmental co-benefit areas that impact public health (listed below). These co-benefit areas were selected due to ongoing research in these areas as well as discussion in a public workshop on climate change and health impacts held in summer 2018. For each social and environmental area, the analysis includes:

- a discussion of health impacts and disparities,
- key health metrics or epidemiological research on this topic,
- a discussion of how these areas would be affected by “no-action” (i.e., Reference) scenario compared to a “take-action” (i.e., Scoping Plan) scenario
- a discussion of where there are actions to consider for further success, and
- the types of mitigation actions that can help reduce or eliminate disparities and promote greater health equity and resilience.

All co-benefit areas are interconnected, and pursuing benefits in all areas has the potential to multiply positive results and further support building community resilience. *Community resilience* is the ability of a community to reduce harm and maintain an acceptable quality of life in the face of climate-induced stresses, which vary depending on that community’s circumstances and location. Below is a brief description of the areas evaluated for public health co-benefits. The specific health outcomes impacted by each area, as well as the directional health benefits, are included in the Summary of Health Benefits section of the chapter and covered in more detail in Appendix G (Public Health).

Heat Impacts

Globally, increased GHG concentrations in the atmosphere are causing a continuing increase of the planet's average temperature. California temperatures have risen since records began in 1895, and the rate of increase is accelerating. Recent heat waves have broken heat records and caused serious illness across the state, and these events are becoming more frequent. Heat waves have a particularly high impact in Southern California, where they have become more intense and longer lasting. In the past two years, Los Angeles recorded 121°F, and the Coachella Valley had its hottest year ever, with temperatures reaching 123°F. Heat island effects in urbanized areas can elevate heat effects and disproportionately affect low-income communities and communities of color. Heat events exacerbate respiratory and cardiac illness and cause emergency room visits to soar. Strategies that reduce the impacts of heat exposure promote improved health outcomes.

Wildfires and Smoke

California's NWL cover more than 90 percent of California and include rangeland, forests, woodlands, grasslands, and urban green space. They provide biodiversity and ecosystem benefits, including their ability to sequester carbon from the atmosphere. Protecting and managing California's forests and other natural lands and maintaining their ecosystem health are key practices for maximizing GHG benefits and minimizing negative climate change impacts. Vegetation plays an important role in storing carbon; however, it can also release CO_2 back into the atmosphere when it dies or is burned by fires. California's wildfires are getting worse with increased fire risks, higher frequency of occurrence, larger burn areas, more costly damage, and a longer fire season due to climate change. Strategies that promote healthy ecosystem management of natural and working lands and increased urban greening promote improved health outcomes. Healthy ecosystems provide many health and environmental benefits and can maximize carbon sequestration.

Children's Health and Development

There are a wide range of interconnected environmental, social, biological, and community factors associated with climate change that are adversely affecting children's health. This section focuses on air pollution and near-roadway or traffic pollution as environmental impacts that have a profound effect on children's health. Children's bodies and lungs are still developing, and they take in more air per body weight than adults do. Many low-income communities and communities of color in California experience disproportionately high levels of air pollution, as well as high levels of traffic and freight that impact children. This excess exposure harms children's development and predisposes them to increased risk of illness throughout their lives. Strategies that reduce air pollution and traffic emissions promote improved health outcomes for children.

Economic Security

Climate change is expected to result in serious adverse socioeconomic effects across many sectors. Economic factors, such as income inequality (among geographic regions), poverty, wealth, debt, unemployment rate, and job security are among the strongest determinants of health. Along the entire income spectrum, higher income is associated with increased life expectancy and improved health outcomes in the United States. Additionally, economic insecurity and negative health impacts are more pronounced in low-income communities and communities of color. Economic strategies, such as the promotion of clean energy and other green jobs and investments in low-income communities and communities of color, and promoting a transition to high road jobs in economic sectors tied to the current fossil fuel economy, can promote improved health outcomes.[287]

Food Security

The food system is under pressure from numerous factors, and climate change is a key concern. Climate change can affect food production and agricultural yield, impact culturally significant plants and animals for Native American tribes, and exacerbate factors that limit food availability, such as supply chain disruption. Food security is defined as stable access to affordable, sufficient food for an active, healthy life. Many Californians routinely experience food insecurity, and while that impacts Californians of all races and groups, low-income communities and communities of color and children are disproportionately affected by food insecurity. Many Native Americans depend on resources from the land, such as animals and plants for consumption and cultural practices. Strategies that promote sustainable agriculture, access to healthy foods, and reduced organic food waste promote improved health outcomes.

Mobility and Physical Activity

Physical activity is one of the most important factors for a healthy lifestyle, and lack of activity increases the risk of chronic illness and premature death. Research shows that regular physical activity improves health in people of all ages by improving heart and lung

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[287] According to the California Labor and Workforce Development Agency's High Road Training Partnership program, high road jobs are considered "Quality jobs [that] provide family-sustaining wages, health benefits, a pension, worker advancement opportunities, and collective worker input and are stable, predictable, safe and free of discrimination." *https://cwdb.ca.gov/wp-content/uploads/sites/43/2020/08/OneSheet_Job-Quality_ACCESSIBLE.pdf*.

function, muscle fitness, mental health and brain function, and sleep quality. A sedentary lifestyle contributes to chronic illnesses, including obesity, heart disease, and Type 2 diabetes among other chronic illnesses. Promoting community design that supports sustainable patterns of land use and transportation enables active transportation choices like walking, biking, and public transit over driving, and can significantly increase physical activity, leading to many valuable health benefits.

Affordable Housing

Housing is an important social determinant of health. The stability of housing, housing quality, conditions inside and outside the home, the cost of housing, and the environmental and social characteristics of the places people live all affect health (including energy efficiency and insulation, cooler building material, tree canopy, home size). Housing affordability is a key factor, and this section highlights how housing affordability supports not only improved health but also more sustainable land use and transportation patterns. A lack of affordable housing is increasing commute distances for low-income renters and creating health burdens. Strategies that support sustainable transportation and housing patterns, together with increased housing affordability, promote improved health outcomes.

Urban Greening

Urban Greening is well recognized as an important amenity, but the inherent health benefits are not always well understood. Under-resourced and vulnerable areas consistently show a lack of urban greening and higher percentages of concrete, asphalt, and impervious surfaces. Under-resourced communities have a greater proportion of concrete and heat-trapping surfaces and a lower amount of tree cover in the neighborhoods in which they live. Areas with reduced urban greening have the potential to create areas of higher temperatures as heat is reflected from pavements and buildings. By contrast, increasing urban greening can provide air pollution buffers and promote physical activity. Strategies that preserve and create urban parks, green space, natural infrastructure, and sustainable agricultural practices support improved physical and mental health outcomes.

No Action Scenario (Reference)

In a no-action scenario, California would remain dependent on fossil fuels and other GHG emitting technologies. Fossil-fuel powered mobile sources including cars, trucks, trains, tractors, and a myriad of other on-road and off-road vehicles and equipment are the largest source of criteria pollutants and toxic air contaminants that directly affect community health and contribute the largest portion of GHG emissions.[288] Other key GHG emission sources include buildings, natural and working lands, and power production and industry. The no-action scenario reflects a continued reliance on fossil fuels in mobile and stationary sectors, including buildings. The continued production and use of fossil fuels; ongoing dependence on gasoline and diesel cars, trucks, buses, and equipment; continued releases of short-lived climate pollutants; and decreased emphasis on forest and ecosystem health will impact communities by reducing climate resilience and health benefits. Green space will likely remain at the same levels or degrade, and urban heat islands will likely increase. With continued growth of vehicle miles traveled, physical activity and the accompanying health benefits will not increase.

Exposure to wildfire smoke will increase, and air quality is expected to worsen as rising temperatures will increase levels of harmful air pollution. Jobs and economic security will be affected by the continuing potential for price spikes in fossil fuels, impacts to the economy from climate change, and fewer job opportunities in green technologies such as solar and electric vehicles. Food security in California will decrease due to the effects of accelerating climate impacts to agriculture; and without increased recovery of organic waste, including food products, food security will continue to decline under a no action scenario. All these impacts can be linked to worse health outcomes. Adverse health impacts are often most felt by Black, Latino, Native American, and other people of color and in low-income communities. These groups are affected more intensely by the physical stress of environmental pollution, social inequities, and the psychological stress of extreme weather events and food and economic insecurity.

Take Action Scenario

In the Take Action scenario, California will drastically reduce reliance on fossil fuels for motor vehicles, freight, buildings, electricity, or other sectors. This scenario is not a specific scenario within this Scoping Plan but examines the broad outcomes of actions to achieve carbon neutrality in 2045. Implementation of this Scoping Plan would achieve a transition to ZEVs, with 100% sales of light-duty ZEVs by 2035 and 100% sales of zero emission trucks by 2040, along with 30% VMT reductions below 2019 levels by 2045. State and local action that supports sustainable land use and transportation patterns and enables more transit and active transportation will lead to substantial health benefits from physical activity, including reduced illness and deaths.

[288] CARB. 2022. *California Greenhouse Gas Emissions for 2000 to 2020.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf.

The economic benefits of improved health through active transportation can be modeled using the Healthy Mobility Options Tool (HMOT).[289] In order to demonstrate the important health and economic benefits of VMT reduction, CARB and CDPH used the HMOT to analyze an illustrative trip reduction scenario for 2050 from the California Transportation Plan (CTP). The CTP has a goal of increasing active modes of travel and transit from the current level of 13 percent to a level of 23 percent of all travel trips. While the CTP goal of 23 percent for active modes of travel is not a VMT reduction target, the scenario increases active transportation through a mix of changes in land use planning for increased transportation options, including increases in biking, walking, and transit use, and it helps to show the health benefits of increased active transportation. By achieving the CTP 2050 goals, nearly 8,000 deaths would be avoided in 2050 alone (see Figure 3-14), along with significant reductions in chronic diseases. Achieving this would rank among the top public health accomplishments (see Appendix G [Public Health] for additional modeling results and detailed discussion).

The dramatic reduction in fossil fuel combustion, combined with reductions in VMT and freight and traffic emissions projected in this Scoping Plan will significantly reduce air pollution and its associated health impacts on a statewide basis and in communities near freight sources. Coordinated action strategies will emphasize natural and working lands management changes, including healthy forests, increased vegetative cover, and increased organic farming. Wildfire smoke exposure will reduce significantly with healthy ecosystem management strategies. Since many communities in California are disproportionately impacted by high levels of traffic pollution, the reduction in petroleum fueled vehicles will reduce the additional impacts of living or going to school near historically highly polluting sources. Indoor air quality is also likely to improve through a shift to non-fossil fuel appliances. Concerted state and local action to support sustainable land use and transportation patterns can enable more active transportation with health benefits from physical activity.

[289] ITHIM California. 2020. Transportation Planning for Health, Equity, and Climate Change. https://skylab.cdph.ca.gov/HealthyMobilityOptionTool-ITHIM/.

Figure 3-14: Quantified health benefits of active transportation from increased physical activity

8,000 avoided deaths

from increasing Active Transportation*

*Calculated by the Healthy Mobility Options Tool, active transportation (including walking, rolling, cycling, and taking public transit) from the California Transportation Plan 2050 compared to business as usual for 2050.

Overall community resilience is expected to increase as physical activity and green space increases—potentially decreasing urban heat islands. Efforts to support VMT reduction will include coordination across state agencies on affordable housing measures. Reduced fossil fuel dependence will reduce economic pressure from wildfires, droughts, and price spikes in fossil fuels, especially as more jurisdictions implement plans with similar actions. Investment in sustainable agriculture, healthy forests, urban greening, and clean energy technologies will add sustainable jobs and further promote economic security. More sustainable agriculture and food recovery efforts will add to food security. All these impacts can be linked to wide ranging health benefits, including positive respiratory and cardiovascular effects, healthier birth and brain outcomes, improved mental health indicators, improved life expectancy, reductions in chronic illness and cancers, improved children's health and development, reduced depression, and other benefits. The magnitude of the possible co-benefits is extremely large, especially in areas that are currently the most affected.

Summary of Health Benefits

Below, Tables 3-14 and 3-15 show overall summaries of the directional benefits by co-benefit area estimated for this Scoping Plan. The supporting epidemiological studies used for qualitative or quantitative analysis of each co-benefit area are included in Appendix G (Public Health). Another section of Chapter 3, together with Appendix C (AB 197 Measure Analysis) and Appendix H (AB 32 GHG Inventory Sector Modeling), also includes the quantitative analysis of air pollution related health impacts, including recently added health endpoints for CARB's ongoing analysis.

Table 3-14: Scoping Plan directional benefits for health co-benefit areas (heat, affordable housing, food security, economic security, and urban greening)

	Health Co-benefit Areas*				
Quantitative vs. Qualitative	**Reduced Heat Impacts**	**Increased Affordable Housing**	**Increased Food Security**	**Increased Economic Security**	**Increased Urban Greening**
Research was used for Qualitative Analysis	↓ Mortality ↓ Emergency Room Visits for cardiovascular and respiratory causes and intestinal infections ↓Hospitalization for cardiovascular, respiratory causes ↓ Preterm Birth ↓ Mental Illness	↓ Infectious Disease ↓ Chronic Illness ↓ Asthma ↓ Injuries ↓ Mental Illness ↑ Children's Performance in Schools ↑ Children's Health ↓ Children's Behavioral Problems	↓ Mental Illness ↓ Iron Deficiency ↓ Chronic Diseases ↑ Life Expectancy ↓ Children's Mental Illness ↓ Children's Cognitive Problems ↓ Children's Behavioral Health Problems ↓ Children's Iron Deficiency ↓ Children's Oral Health Problems	↑ Life Expectancy ↑ Health Status ↑ Mental Health	↓ Mortality ↓ Asthma Prevalence ↓ Depression ↓ Adverse Birth Outcomes including low birth weight and small for gestational age ↑ Life Expectancy

*See Appendix G (Public Health) for a table with references to research for each health outcome listed.

Table 3-15: Scoping Plan directional benefits for health co-benefit areas (traffic pollution, wildfire, and active transportation)

Health Co-benefit Areas*			
Quantitative vs. Qualitative	**Reduced Traffic Pollution**	**Reduced Wildfire Smoke**	**Increased Active Transportation**
Research was used for Quantitative Analysis	↓ Children's Respiratory Outcomes, Hospital Admissions ↓ Children's Respiratory Outcomes, Emergency Room Visits ↓ Children's Asthma Onset ↓ Children's Asthma Symptoms	↓ All-Cause Mortality ↓ Asthma, Hospital Admissions ↓ COPD, Hospital Admissions ↓ All Respiratory Outcomes, Hospital Admissions ↓ Asthma, Emergency Room Visits ↓ All Respiratory Outcomes, Emergency Room Visits ↓ All Cardiac Outcomes, Emergency Room Visits	↓ Cardiovascular Diseases ↓ Colon Cancer ↓ Breast Cancer ↓ Diabetes ↓ Dementia ↓ Lung Cancer ↓ Respiratory Disease ↓ Depression ↑ Traffic Accidents
Research was used for Qualitative Analysis	↑ Children's Lung Function Growth ↓ Children's Bronchitic Symptoms ↓ Children's Impaired Cognitive Development ↓ Children's Adverse Birth Outcomes, including low birth weight and preterm birth		

*See Appendix G (Public Health) for a table with references to research for each health outcome listed.

In summary, the qualitative health analysis of the No-Action versus Take-Action scenarios for this Scoping Plan shows an overwhelming benefit for the state by taking action to move forward to carbon neutrality while continuing efforts to increase health equity and resilience in individual communities. Taking action can improve physical and mental health for adults and children, reduce a range of chronic illnesses, and promote improvements in life expectancy. Development and implementation of actions to achieve the outcomes called for in this Scoping Plan should consider how to engage affected communities in implementation, address the existing health and opportunity gaps, and pursue equitable implementation statewide and locally. This Scoping Plan deployment of clean technology and fuels, together with improved land management, will reduce GHGs and air pollution and create more resilient communities that are better able to prepare for and recover from extreme climate events.

Environmental Analysis

In May 2022, CARB, as the lead agency for the Scoping Plan, released for public review the Draft Environmental Analysis (Draft EA) for this Scoping Plan; it assessed the potential environmental impacts of implementing the Scoping Plan. CARB circulated the Draft EA for public review and comment for a period of 45 days that began on May 10, 2022, and ended on June 24, 2022. CARB held a public hearing on June 23, 2022 to provide the opportunity for public comment. During the review period, written and oral comments were received on the Draft EA. CARB reviewed the comments to identify environmental topics and began preparation of responses to those comments.

After the end of the Draft EA public review period, CARB identified potential revisions to certain aspects of this Scoping Plan that merit revisions to the project description. This new information results from, among other things, revisions to the project description regarding energy sector goals (including offshore wind), revised carbon removal targets, and additional strategies for natural and working lands. CARB released a Recirculated Draft EA for a written public comment period that started September 9, 2022, and ended on October 24, 2022. See Chapter 2 of the Recirculated Draft EA[290] for further information regarding the changes. The Recirculated Draft EA assesses the potential for significant adverse and beneficial environmental impacts associated with all proposed actions in this Scoping Plan, and provides a programmatic environmental analysis of the reasonably foreseeable compliance responses that could result from implementation of the Scoping

[290] CARB. 2022. Recirculated Draft EA. *https://ww2.arb.ca.gov/sites/default/files/2022-09/2022-draft-sp-appendix-b-draft-ea-recirc.pdf*.

Plan.[291] The Recirculated Draft EA concluded implementation of this Scoping Plan could result in the following:

- Beneficial impacts to: air quality (long-term operational-related) and GHG emissions (short-term construction-related and long-term operational-related)
- Less than significant impacts to: energy demand, mineral resources, population and housing, public services, recreation (short-term construction-related), and wildfire (short-term construction-related)
- Potentially significant and unavoidable adverse impacts to: aesthetics, agriculture and forest resources, air quality (construction-related and operational odors), biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, recreation (long-term operational-related), transportation and traffic, tribal cultural resources, utilities and service systems, and wildfire (long-term operational-related

Before the public meeting at which the Board will consider this Scoping Plan Update, CARB will publish the Final EA as Appendix B (Final Environmental Analysis) to this Scoping Plan, along with written responses to timely submitted comments raising significant environmental issues received on the Draft EA and the Recirculated Draft EA, which will be presented to the Board for consideration.

[291] The Recirculated Draft EA is available at *https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents*.

Chapter 4: Key Sectors

Chapter 4 provides an overview of the major energy sources and technology in use today, and of alternative clean technology and fuels to support decarbonization based on the latest information available. Every sector of the economy will need to begin to transition in this decade to meet our GHG reduction goals and achieve carbon neutrality no later than 2045. AB 32 requires climate change mitigation policies to be considered in the context of the sector's contribution to the state's total GHG emissions. The transportation, electricity (in-state and imported), and industrial sectors are the largest contributors of GHGs in the state and present the largest opportunities for GHG reductions. Actions to reduce fossil fuel combustion in these sectors also can provide critical air pollution reductions in low-income communities and communities of color, which are often located adjacent to these sources. A carbon neutrality framework also elevates the role of CO_2 removal through natural and working lands and mechanical capture and storage. Actions that support energy efficiency, reduced VMT, alternative fuels, and renewable power also can provide benefits by reducing both criteria and toxic air pollutants.

What sets this plan apart from previous Scoping Plans is the focus on the accelerated rate of deployment of clean technology and energy within every sector. As a result, specific actions, including accelerated rates of deployment of clean technology and fuels identified within this Scoping Plan, will need to be translated into both new and amended regulations, policies, and incentive programs. State agencies will need to evaluate current authority to align existing policies or develop new ones to achieve outcomes called for in this Scoping Plan. Legislative support may be needed in some cases to ensure authority and funding is sufficient to ensure this Scoping Plan is translatable to action on the ground. Most regulations, or change to existing regulations, ultimately considered by the Board or other state agencies for adoption will be subject to administrative procedure requirements. Accordingly, they must rely on specific subsequent supporting analysis and extensive public processes and consultations with interested tribes to develop and identify appropriate proposals for effective implementation. For example, any proposal to strengthen the LCFS regulations through amendments increasing the stringency of the carbon intensity (CI) targets would be considered on the basis of a public process, including workshops, and focused environmental, economic, and public health analyses.

Policies that ensure economy-wide investment or program decisions that incorporate consideration of GHG emissions are particularly important. As we pursue GHG reduction targets, we must acknowledge the manner in which built and natural environments are connected, how changes in one may impact the other, and how policy choices in one sector can and do impact other sectors. For example, fostering more compact, transportation-efficient development in infill areas and increasing transportation choices with the goal of reducing VMT not only reduces demand for transportation fuel but also requires less energy for buildings and helps to conserve natural and working lands that sequester carbon. Therefore, the multiple and often interwoven actions that reduce VMT both reduce emissions from the transportation sector and support reductions needed in other sectors.

Legislation, such as SB 350[292] (De León and Leno, Chapter 457, Statutes of 2015), has recognized the need for CARB, the CEC, and the CPUC to work together to ensure the state's energy and climate goals are integrated in procurement decisions by load serving entities as part of Integrated Resource Plans. Moving forward, it is especially critical that similar approaches are adopted to break down silos across state agencies to ensure policies and programs are aligned with multiple state priorities outlined in this plan. Finally, supportive legislative direction, such as SB 905 that requires CARB to create the Carbon Capture, Removal, Utilization, and Storage Program, may also benefit emerging areas of policy to provide express agency authority and roles for these nascent efforts, including streamlining of permitting, while ensuring that protections for communities are in place.

Unlike previous Scoping Plans that separated out individual economic sectors, this Scoping Plan approaches decarbonization from two perspectives: (1) managing a phasedown of existing energy sources and technology and (2) ramping up, developing, and deploying alternative clean energy sources and technology over time. This approach supports a more comprehensive consideration of our energy infrastructure, the ability to repurpose existing assets, and the need to build new assets. It also provides multiple metrics beyond just the annual AB 32 GHG Inventory to better enable tracking progress. For example, it clearly demonstrates the production and distribution rates of specific types of clean energy, such as adding 4.3 GW of utility solar and 2.5 GW of storage year-over-year between now and 2035 to be on track to achieve carbon neutrality no later than 2045, and does the same for technology deployment, such as 11 million ZEVs in 2035.

The sections below include key actions to support success in the necessary transition away from fossil combustion, which is an overriding goal of this plan. The wide array of complementary and supporting actions being contemplated or to be undertaken across state government are detailed here. The broad view of actions described in this chapter thus provides context for the specific deployment of clean technology and fuels identified in the Scoping Plan Scenario described in Chapter 2. Actions identified in this Scoping Plan are based on currently known options and the latest science. As part of future Scoping Plan updates, additional clean technology and fuels may be identified and added to the mix of needed tools to continue to reduce the state's GHG emissions, support air quality co-benefits, and remove carbon from the atmosphere.

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[292] California Air Resources Board. SB 350 Electricity Sector Greenhouse Gas Planning Targets. https://ww2.arb.ca.gov/our-work/programs/sb350.

Transportation Sustainability

The transportation sector has long relied on liquid petroleum fuels as the primary energy source for internal combustion engine (ICE) vehicles, including cars, trucks, locomotives, marine equipment, and aircraft. Combustion of fossil fuels in vehicles emits significant amounts of GHGs, criteria pollutants, and toxic air contaminants. In 2019,[293] the transportation sector accounted for approximately 50 percent of statewide GHG emissions[294] and thus was by far the single largest source of carbon pollution in the state. In addition, the transportation sector accounted for over 80 percent of statewide NOx emissions and 30% of fine particulate matter emissions, including toxic diesel particulate matter.[295]

Communities adjacent to congested roadways, including ports and distribution centers, are exposed to the highest concentration of toxic pollutants from vehicles and equipment consuming fossil fuels, leading to a number of demonstrated health impacts such as respiratory illnesses, higher likelihood of cancer development, and premature death. In addition, communities located near oil extraction operations or crude oil refineries often experience higher exposure to poor air quality. While CARB's programs, along with local action, have made substantial progress over the past few decades, it is clear that California must transition away from fossil fuels to zero-emission technologies with all possible speed and pursue policies that result in less driving, in order to meet our GHG and air quality targets.

The transportation sector can be divided into three general categories: Technology, Fuels, and Vehicle Miles Traveled.

- *Technology* refers to the vehicles themselves, as well as the associated refueling infrastructure for those vehicles.
- *Fuels* refers to the energy source used to power vehicles and the facilities that produce them.
- Vehicle travel is measured as *vehicle miles traveled* (VMT), and is a product of development patterns and available transportation options.

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[293] In 2020 the state experienced shelter-in-place orders in response to the COVID-19 pandemic. The orders, and the effects of the pandemic, led to a significant year-over-year decline in transportation emissions in 2020. This means 2019 is likely a more representative year for overall transportation emissions and 2020 a likely outlier in the historical transportation emissions trend data.
[294] CARB. 2022. *California Greenhouse Gas Emissions for 2000 to 2020.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf. This includes upstream oil extraction and refining emissions.
[295] CARB. California Greenhouse Gas Emission Inventory Program. https://ww2.arb.ca.gov/our-work/programs/ghg-inventory-program.

Sector Transition

Technology

Vehicles must transition to zero emission technology to decarbonize the transportation sector. Executive Order N-79-20[296] reflects the urgency of transitioning to zero emission vehicles (ZEVs) by establishing target dates for reaching 100 percent ZEV sales or fleet transitions to ZEV technology. The primary ZEV technologies available today are battery-electric and hydrogen fuel cell electric vehicles (FCEVs), both of which emit zero tailpipe GHGs, criteria pollutants, and toxic air contaminants, as they do not burn fuel. These vehicles are rapidly growing in performance, affordability, and popularity.[297] Plug-in hybrid electric vehicles also offer a limited but increasing range of zero emission operation and will play a role in the transition to ZEVs.

Light-duty passenger vehicles consume the majority of gasoline in the state—12.9 billion gallons in 2019[298]—and are well-suited for transitioning to ZEVs. EO N-79-20 calls for 100 percent ZEV sales of new light-duty vehicles by 2035, and this target is reflected in this Scoping Plan.[299] The Advanced Clean Cars II regulation fulfills the goal in the Executive Order and serves as the primary mechanism to help deploy ZEVs. A number of existing incentive programs also support this transition, including the Clean Cars 4 All Program.[300] Heavy-duty trucks are the largest source of diesel particulate matter, a toxic air contaminant that is directly linked to a number of adverse health impacts, and EO N-79-20 also sets targets for transitioning the medium- and heavy-duty fleet to zero emissions: by 2035 for drayage trucks and by 2045 for buses and heavy-duty long-haul trucks where feasible. Replacing heavy-duty vehicles with ZEV technology will significantly reduce GHG emissions and diesel PM emissions in low-income communities and communities of color adjacent to ports, distribution centers, and highways. The existing Advanced Clean Trucks regulation, paired with the proposed Advanced Clean Fleets regulation, are designed to transition a significant amount of the

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[296] Executive Department. State of California. Executive Order N-79-20. https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.

[297] CARB. 2021. Public Workshop for Advanced Clean Cars II. May 6. https://ww2.arb.ca.gov/sites/default/files/2021-05/acc2_workshop_slides_may062021_ac.pdf.

[298] CARB. 2022. *Fuel Activity for California's Greenhouse Gas Inventory by Sector and Activity.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/fuel_activity_inventory_by_sector_all_00-20.xlsx.

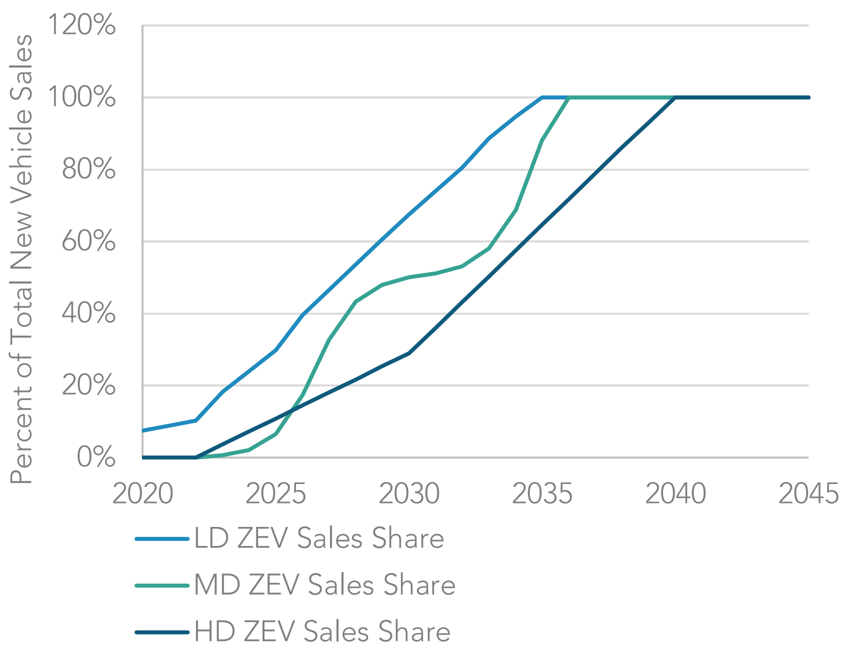
[299] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1A, with reference to the date at which all new vehicle sales are ZEVs. finalejacrecs.pdf (arb.ca.gov).

[300] CARB. Clean Cars 4 All. https://ww2.arb.ca.gov/our-work/programs/clean-cars-4-all. The Clean Vehicle Rebate Project (CVRP) also supports the transition to ZEVs. https://cleanvehiclerebate.org/en.

California truck fleet to ZEV technology. As with the LDV sector, a number of incentive programs support this transition, such as the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP).[301]

Figure 4-1 below illustrates the pace of transition in vehicle technology needed to drastically reduce GHG emissions from vehicles. All vehicle classes reach 100 percent ZEV sales before 2045, with some achieving this well before. The ZEV technology across the vehicle classes is assumed to be primarily battery electric and hydrogen fuel cell (reflecting the primary ZEV technologies available today).[302]

Figure 4-1: Transition of on-road vehicle sales to ZEV technology in the Scoping Plan Scenario



Today, off-road vehicles also rely heavily on ICE technology. Executive Order N-79-20 sets an off-road equipment target of transitioning the entire fleet to ZEV technology by 2035, where feasible. There is a great need for both investment and innovation in the off-road space in order to develop and commercialize zero emission equipment types that meet or exceed the performance of existing equipment. A number of funding sources currently support this transition, including programs such as FARMER, Carl Moyer, and

[301] California HVIP. Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project. https://californiahvip.org/?msclkid=efaf65f2c26f11eca6bdd08ecc323864.

[302] The light-duty fleet includes more than 11 million battery electric and hydrogen fuel cell vehicles in 2035 and over 23 million battery electric and hydrogen fuel cell vehicles in 2045.

the Community Air Protection Incentives—as well as Low Carbon Transportation Incentives, including the Clean Off-Road Equipment (CORE) program. In addition, the 2021–22 California budget provided record-high allocations for funding ZEVs, including off-road equipment, and the 2022–23 budget is similarly ambitious.[303] Several regulations focused on transitioning to zero emission off-road equipment have recently been adopted or are in the works, and apply to locomotives,[304] forklifts, ocean-going vessels at berth,[305] commercial harbor craft,[306] small off-road engines,[307] and more.

Intrastate aviation relies on ICE technology today, but battery-electric and hydrogen fuel cell aviation applications are in development, along with sustainable aviation fuel. The Scoping Plan Scenario includes a transition of 20% of aviation fuel demand to ZEV technologies by 2045 and sustainable aviation fuel for the rest.

Refueling infrastructure is a crucial component of transforming transportation technology. Electric vehicle chargers and hydrogen refueling stations must become easily accessible for all drivers to support a wholesale transition to ZEV technology. Deployment of ZEV refueling infrastructure is currently supported by a number of existing local and state public funding mechanisms, the new National Electric Vehicle Infrastructure (NEVI) federal funding mechanism, California's electric utilities, the Electrify America initiative that was established in response the Volkswagen ZEV commitment, and by numerous companies, such as EVgo, ChargePoint, Tesla, Ford, FirstElement Fuel, Chevron, Shell, and Iwatani, who are investing substantial private resources into developing these networks. Private investment in reliable, affordable and ubiquitous refueling infrastructure must drive the transition as the business case for ZEVs continues to strengthen.

Strategies for Achieving Success

- Achieve 100 percent ZEV sales of light-duty vehicles by 2035[308] and medium-heavy-duty vehicles by 2040.
- Achieve a 20% zero emission target for the aviation sector.

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[303] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1C. CARB and the Administration are committed to increasing focus on transportation equity investment as was reflected in the governor's 2022–23 budget. *finalejacrecs.pdf (arb.ca.gov)*.

[304] CARB. Reducing Rail Emissions in California. *https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california.*

[305] CARB. Ocean-Going Vessels At Berth Regulation. *https://ww2.arb.ca.gov/our-work/programs/ocean-going-vessels-berth-regulation*.

[306] CARB. CARB passes amendments to commercial harbor craft regulation. *https://ww2.arb.ca.gov/news/carb-passes-amendments-commercial-harbor-craft-regulation*.

[307] CARB. Small Off-Road Engines (SORE). *https://ww2.arb.ca.gov/our-work/programs/small-off-road-engines-sore*.

[308] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1A. *finalejacrecs.pdf (arb.ca.gov)*.

- Develop a rapid and robust network of ZEV refueling infrastructure to support the needed transition to ZEVs.
- Ensure that the transition to ZEV technology is affordable for low-income households and communities of color, and meets the needs of communities and small businesses.[309]
- Prioritize incentive funding for heavy-duty ZEV technology deployment in regions of the state with the highest concentrations of harmful criteria and toxic air contaminant emissions.[310]
- Promote private investment in the transition to ZEV technology, undergirded by regulatory certainty such as infrastructure credits in the Low Carbon Fuel Standard for hydrogen and electricity[311] and hydrogen station grants from the CEC's Clean Transportation Program[312] pursuant to Executive Order B-48-18.[313]
- Evaluate and continue to offer incentives similar to those through FARMER,[314] Carl Moyer,[315] the Clean Fuel Reward Program,[316] the Community Air Protection Program,[317] and Low Carbon Transportation,[318] including CORE.[319] Where feasible, prioritize and increase funding for clean transportation equity programs.[320]
- Continue and accelerate funding support for zero emission vehicles and refueling infrastructure through 2030 to ensure the rapid transformation of the transportation sector.

[309] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF6, in the context of communities. finalejacrecs.pdf (arb.ca.gov).

[310] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF7. finalejacrecs.pdf (arb.ca.gov).

[311] CARB. LCFS ZEV Infrastructure Crediting. https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting.

[312] CEC. Clean Transportation Program. https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program.

[313] EO B-48-18 calls for 200 hydrogen refueling stations by 2025. https://www.library.ca.gov/wp-content/uploads/GovernmentPublications/executive-order-proclamation/39-B-48-18.pdf.

[314] CARB. FARMER program. https://ww2.arb.ca.gov/our-work/programs/farmer-program.

[315] CARB. Carl Moyer program. https://ww2.arb.ca.gov/our-work/programs/carl-moyer-memorial-air-quality-standards-attainment-program.

[316] California Clean Fuel Reward Program. https://cleanfuelreward.com/.

[317] CARB. Community Air Protection Program. https://ww2.arb.ca.gov/capp.

[318] CARB. Low Carbon Transportation Investments and Air Quality Improvement Program. https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program.

[319] Clean Off-Road Equipment (CORE) Voucher Incentive Program. https://californiacore.org/.

[320] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1C. finalejacrecs.pdf (arb.ca.gov).

- Evaluate and align with this Scoping Plan relevant CARB policies such as Advanced Clean Cars II,[321] Innovative Clean Transit,[322] Zero Emission Airport Shuttle,[323] California Phase 2 GHG Standards,[324] Advanced Clean Trucks, Advanced Clean Fleets, Zero Emission Forklifts,[325] In-use Locomotives,[326] the Off-Road Zero-Emission Targeted Manufacturer rule, Clean Off-Road Fleet Recognition Program, In-use Off-Road Diesel-Fueled Fleets Regulation,[327] Commercial Harbor Craft,[328] Off-Road Zero-Emission Targeted Manufacturer rule, Clean Off-Road Fleet Recognition Program, Amendments to the In-use Off-Road Diesel-Fueled Fleets Regulation,[329] carbon pricing through the Cap-and-Trade Program,[330] and the Low Carbon Fuel Standard.[331]
- Identify and address permitting and market barriers to successful rapid ZEV technology deployment while protecting public health and the environment.

Fuels

Transitioning away from conventional ICE vehicles is part of the solution, but we must ensure that an adequate supply of zero-carbon alternative fuel and distribution is available to power these vehicles. Electricity and hydrogen are currently the primary fuels for ZEVs,

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321 CARB. Advanced Clean Cars Program. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program. Cal. Code Regs., tit. 13, §§ 1900, 1961.2, 1961.3, 1961.4, 1962.2, 1962.3, 1962.4, 1962.5, 1962.6, 1962.7, 1962.8, 1965, 1968.2, 1969, 1976, 1978, 2037, 2038, 2112, 2139, 2140, 2147, 2317, 2903.

322 CARB. Innovative Clean Transit. https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit. Cal. Code Regs., tit. 13, §§ 2023—2023.11.

323 CARB. Zero-Emission Airport Shuttle. https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle. Cal. Code Regs., tit. 17, §§ 95690.1—95690.8.

324 CARB. California Phase 2 Greenhouse Gas Standards. https://ww2.arb.ca.gov/our-work/programs/greenhouse-gas-standards-medium-and-heavy-duty-engines-and-vehicles/phase2. Cal. Code Regs., tit. 13, §§ 1956.8 and 2036; and Cal. Code Regs., tit. 17, §§ 95301, 95302, 95303, and 95663.

325 CARB. Zero-Emission Forklifts. https://ww2.arb.ca.gov/our-work/programs/zero-emission-forklifts. Cal. Code Regs., tit. 17, §§ 95690.1—95690.8.

326 CARB. Reducing Rail Emissions. https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california. Proposed Cal. Code Regs., tit. 13, §§ 2478—2478.16.

327 CARB. In-use Off-Road Diesel-Fueled Fleets Regulation. https://ww2.arb.ca.gov/our-work/programs/use-road-diesel-fueled-fleets-regulation. Cal. Code Regs., tit. 13, §§ 2449, 2449.1, 2449.2.

328 CARB. Commercial Harbor Craft. https://ww2.arb.ca.gov/our-work/programs/commercial-harbor-craft. Cal. Code Regs., tit. 13, § 2299.5.

329 CARB. In-use Off-Road Diesel-Fueled Fleets Regulation. https://ww2.arb.ca.gov/our-work/programs/use-road-diesel-fueled-fleets-regulation.

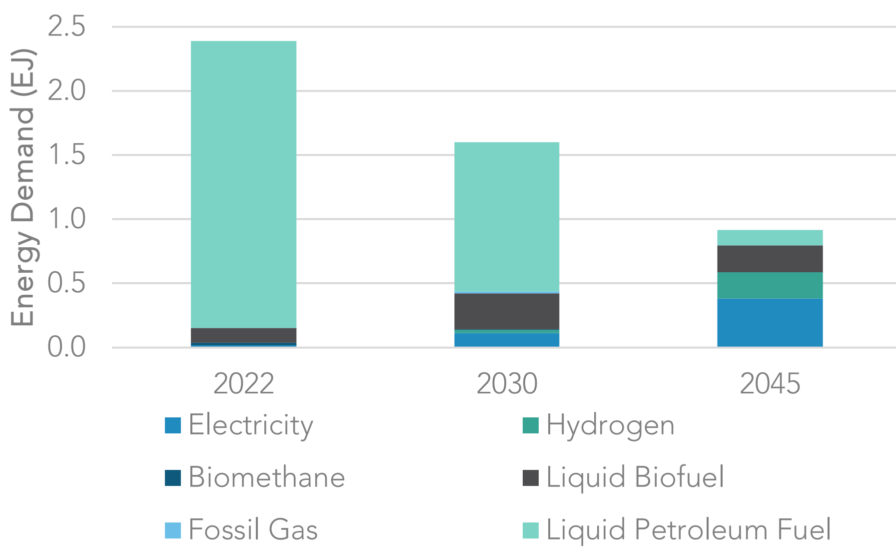
330 CARB. Cap-and-Trade Program. https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program. Cal. Code Regs., tit. 17, §§ 95801 et seq.

331 CARB. Low Carbon Fuel Standard. https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard. Cal. Code Regs., tit. 17, §§ 95480 et seq.

and both fuels must be produced using low-carbon technology and feedstocks to minimize upstream emissions.

The transition to complete ZEV technology will not happen overnight. Conventional ICE vehicles from legacy fleets will remain on the road for some time, even after all new vehicle sales have transitioned to ZEV technology. In addition, some equipment types are only now in the initial stages of development of ZEV technology for propulsion, such as commercial aircraft or ocean-going vessels. In addition to building the production and distribution infrastructure for zero-carbon fuels, the state must continue to support low-carbon liquid fuels during this period of transition and for much harder sectors for ZEV technology such as aviation, locomotives, and marine applications. Biomethane currently displaces fossil fuels in transportation and will largely be needed for hard-to-decarbonize sectors but will likely continue to play a targeted role in some fleets while the transportation sector transitions to ZEVs. Figure 4-2 provides the detail on fuels used in 2020 and the fuel mix under the Scoping Plan Scenario for 2035 and 2045.

Figure 4-2: Transportation fuel mix in 2022, 2030, and 2045 in the Scoping Plan Scenario[332]



Private investment in alternative fuels will play a key role in diversifying the transportation fuel supply away from fossil fuels. The Low Carbon Fuel Standard is the primary mechanism for transforming California's transportation fuel pool with low-carbon

[332] See https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx for transportation fuels by year.

alternatives and has fostered a growing alternative fuel market. Partially as a result of the powerful market signals from the LCFS, fuels like renewable diesel, sustainable aviation fuel, biomethane, and electricity have all gained significant market shares and continue to displace gasoline and diesel in both on- and off-road vehicles. In addition, Executive Order N-79-20 calls on state agencies to support the transition of existing fuel production facilities away from fossil fuels and directs that this transition also protect and support workers, public health, safety, and the environment. In line with this direction, existing refineries could be repurposed to produce sustainable aviation fuel, renewable diesel, and hydrogen. This trend has already begun, and continuing to develop fuel production capacity in-state to support the energy transition while making the most efficient use of existing assets is critical to avoiding emissions leakage. If fuel demand persists after fuel production facilities have ceased operations, fuel demand will have to be met through imports.

As we transition or build new energy production facilities and infrastructure, it will be important to ensure low-income communities, tribes, and communities of color do not experience increases in existing air pollution disparities and continue to experience a reduction in the air pollution disparities that exist today. California must use the best available science to ensure that raw materials used to produce transportation fuels do not incentivize feedstocks with little to no GHG reductions from a life cycle perspective. A dramatic increase in alternative fuel production must not come at the expense of global deforestation, unsustainable land conversion, or adverse food supply impacts, to name a few examples. CARB will continue to monitor scientific findings on these topics to ensure that California policies, such as the LCFS, send the appropriate market signals and do not result in unintended consequences.[333]

Strategies for Achieving Success

- Accelerate the reduction and replacement of fossil fuel production and consumption in California.[334]
- Incentivize private investment in new zero-carbon fuel production in California.
- Incentivize the transition of existing fuel production and distribution assets to support deployment of low- and zero-carbon fuels while protecting public health and the environment.
- Invest in the infrastructure to support reliable refueling for transportation such as electricity and hydrogen refueling.

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[333] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1E. finalejacrecs.pdf (arb.ca.gov).

[334] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F3. finalejacrecs.pdf (arb.ca.gov).

- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Initiate a public process focused on options to increase the stringency and scope of the LCFS:
    - Evaluate and propose accelerated carbon intensity targets pre-2030 for LCFS.
    - Evaluate and propose further declines in LCFS post-2030 carbon intensity targets to align with this 2022 Scoping Plan.
    - Consider integrating opt-in sectors into the program.
    - Provide capacity credits for hydrogen and electricity for heavy-duty fueling.
- Monitor for and ensure that raw materials used to produce low-carbon fuels or technologies do not result in unintended consequences.[335]

Vehicle Miles Traveled

Transforming the transportation sector goes beyond phasing out combustion technology and producing cleaner fuels. Managing total demand for transportation energy by reducing the miles people need to drive on a daily basis is also critical as the state aims for a sustainable transportation sector in a carbon neutral economy. Though GHG emissions are declining due to cleaner vehicles and fuels, rising VMT can offset the effective benefits of adopted regulations.

Even under full implementation of Executive Order N-79-20 and CARB's Advanced Clean Cars II Regulations, with 100 percent ZEV sales in the light-duty vehicle sector by 2035, a significant portion of passenger vehicles will still rely on ICE technology, as demonstrated in Figure 4-2 above. Accordingly, VMT reductions will play an indispensable role in reducing overall transportation energy demand and achieving the state's climate, air quality, and equity goals. After a significant pandemic-induced reduction in VMT during 2020, passenger VMT has steadily climbed back up and is now closing in on pre-pandemic levels.[336] Driving alone with no passengers remains the primary mode of travel in California, amounting to 75 percent of the mode share for daily commute trips. Conversely, the transit industry, which was significantly impacted during

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[335] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1E. finalejacrecs.pdf (arb.ca.gov).

[336] U.S. Department of Transportation. 2021. December 2021 Traffic Volume Trends. Figure 3 - Seasonally Adjusted Vehicle Miles Traveled by Month. https://www.fhwa.dot.gov/policyinformation/travel_monitoring/21dectvt/figure3.cfm.

the lockdown months, and has struggled to recover; ridership only averages two-thirds of pre-pandemic levels,[337] [338] and service levels also lag behind.

Sustained VMT reductions have been difficult to achieve for much of the past decade, in large part due to entrenched transportation, land use, and housing policies and practices. Specifically, historic decision-making favoring single-occupancy vehicle travel has shaped development patterns and transportation policy, generating further growth in driving (and making transit, biking and walking less viable alternatives). These policies have also reinforced long-standing racial and economic injustices that leave people with little choice but to spend significant time and money commuting long distances, placing a disproportionate burden on low-income Californians, who pay the highest proportion of their wages on housing and transportation. While CARB has included VMT reduction targets and strategies in the Scoping Plan and appendices, these targets are not regulatory requirements, but would inform future planning processes. CARB is not setting regulatory limits on VMT in the 2022 Scoping Plan; the authority to reduce VMT largely lies with state, regional, and local transportation, land use, and housing agencies, along with the Legislature and its budgeting choices.

Appendix E (Sustainable and Equitable Communities) elaborates on reasons for reducing VMT and identifies a series of policies that, if implemented by various responsible authorities, could help to achieve the recommended VMT reduction trajectory included in this Scoping Plan (and related mode share increases for transit and active transportation). These policies aim to advance four strategic objectives:

1. Align current and future funding for transportation infrastructure with the state's climate goals, preventing new state-funded projects from inducing significant VMT growth and supporting an ambitious expansion of transit service and other multimodal alternatives.
2. Move funding for transportation beyond the gasoline and diesel taxes and implement fuel-agnostic pricing strategies that accomplish more productive uses of the roadway network and generate revenues to further improve transit and other multimodal alternatives.
3. Deploy autonomous vehicles, ride-hailing services, and other new mobility options toward high passenger-occupancy and low VMT-impact service models that complement transit and ensure equitable access for priority populations.
4. Encourage future housing production and multi-use development in infill locations and other areas in ways that make future trip origins and destinations

[337] U.S. Government Accountability Office. January 25, 2022. During COVID-19, Road Fatalities Increased and Transit Ridership Dipped. https://www.gao.gov/blog/during-covid-19-road-fatalities-increased-and-transit-ridership-dipped.
[338] American Public Transportation Association. APTA - Ridership Trends. https://transitapp.com/APTA.

closer together and create more viable environments for transit, walking, and biking.

The pace of change to reduce VMT must be accelerated. Certainly, structural reform will be challenging, but California has demonstrated time and again that it possesses the collective leadership and commitment to break away from ideas that no longer represent Californians' values and their aspirations for the many generations to come.

Strategies for Achieving Success

- Achieve a per capita VMT reduction of at least 25 percent below 2019 levels by 2030 and 30 percent below 2019 levels by 2045. [339]
- Reimagine new roadway projects that decrease VMT in a way that meets community needs and reduces the need to drive.
- Invest in making public transit a viable alternative to driving by increasing affordability, reliability, coverage, service frequency, and consumer experience.[340]
- Implement equitable roadway pricing strategies based on local context and need, reallocating revenues to improve transit, bicycling, and other sustainable transportation choices.[341]
- Expand and complete planned networks of high-quality active transportation infrastructure.[342]
- Channel the deployment of autonomous vehicles, ride-hailing services, and other new mobility options toward high passenger-occupancy and low VMT-impact service models that complement transit and ensure equitable access for priority populations.
- Streamline access to public transportation through programs such as the California Integrated Travel Project.
- Ensure alignment of land use, housing, transportation, and conservation planning in adopted regional plans, such as regional transportation plans (RTP)/ sustainable communities strategies (SCS), regional housing needs assessments (RHNA), and local plans (e.g., general plans, zoning, and local transportation plans), and develop tools to support implementation of these plans.

[339] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1D. *finalejacrecs.pdf (arb.ca.gov)*.
[340] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1D. *finalejacrecs.pdf (arb.ca.gov)*.
[341] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1D. *finalejacrecs.pdf (arb.ca.gov)*.
[342] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1F. *finalejacrecs.pdf (arb.ca.gov)*.

- Accelerate infill development and housing production at all affordability levels in transportation-efficient places, with a focus on housing for lower-income residents.

Clean Electricity Grid

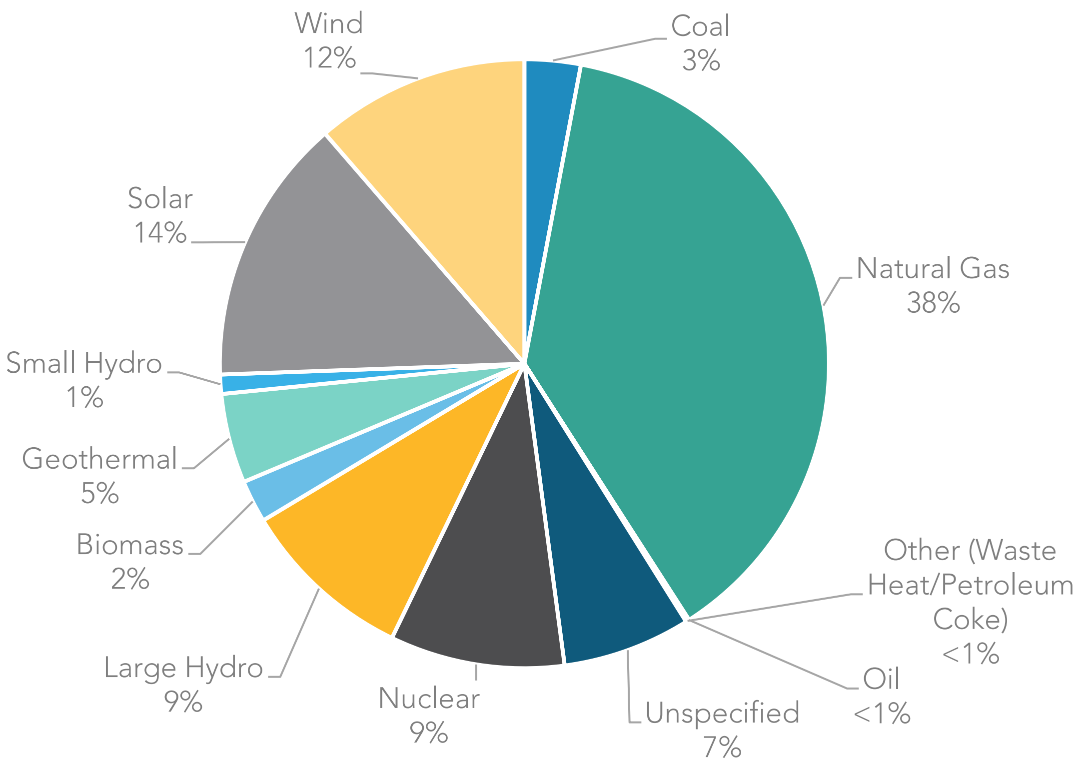
Much of the state's success to date in reducing GHGs is due to decarbonization of the electricity sector as a result of the RPS, SB 100 implementation, and the Cap-and-Trade Program. Moving forward, a clean, affordable, and reliable electricity grid will serve as a backbone to support deep decarbonization across California's economy. Under this Scoping Plan, the role of electricity in powering the economy will grow in almost every sector.

In 2021, 70 percent of California electricity demand was served by in-state power plants totaling about 82 GW, with the rest coming from out-of-state imports.[343] Additionally, approximately 8 GW of customer solar photovoltaic capacity has been installed to date to help with in-state demand.[344] Figure 4-3 shows the breakdown of in-state and imported sources of electricity.

[343] CEC. 2021. Electric Generation Capacity and Energy. Data available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/electric-generation-capacity-and-energy and CEC. 2021. Total System Electric Generation. Data available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation. Capacity values are nameplate capacity from sources 1 MW and larger.

[344] CEC. 2021. *SB 100 Joint Agency Report Summary: Achieving 100% Clean Electricity in California, An Initial Assessment.* 10. https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity.

Figure 4-3: 2021 total system electric generation (based on GWh)[345]



Note: Imports contributing to total system generation are comprised of 58% zero-carbon energy and 42% non-renewable and unspecified energy. Percentages do not add to exactly 100 due to rounding.

In 2021, about 48 percent of electricity generation serving California came from non-renewable and unspecified[346] resources, while 52 percent came from renewable and zero-carbon resources. The state's Strategic Reliability Reserve, established in AB 205 to provide additional reliability insurance during extreme events, may make three of the fossil gas-fired OTC plants planned for retirement available to support the grid on a limited basis after 2023. The state also adopted legislation to facilitate extension of the Diablo Canyon Nuclear Power Plant for five years beyond its 2025 planned closure.[347] At the

[345] *Total system generation* is the sum of all utility-scale, in-state generation, plus net electricity imports. CEC. 2021 Total System Electricity Generation. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation.
[346] *Unspecified power* refers to electricity that is not traceable to a specific generating facility, such as electricity traded through open market transactions. It typically consists of a mix of resources and may include renewables.
[347] In accordance with SB 846 (Dodd, Chapter 239, Statutes of 2022).

same time, the state continues to rapidly expand deployment of clean energy generation and storage resources and plan for increased electrification.[348] This is critical to reducing GHG emissions and addressing the long-term impacts of climate change.

Climate change is causing unprecedented stress on California's energy system—driving high demand and constraining supply. Heat, drought, and wildfires can both reduce electricity supply from reductions in hydropower generation and impacts on generation and transmission performance, and increase demand, especially in the evening hours when solar generation is declining.

California has experienced three straight years of energy reliability challenges, including a multi-day extreme heat event across the western United States with temperatures up to 20 degrees above normal in California, resulting in rotating outages in August 2020. In 2021, heat waves in June prompted a Grid Warning and the onset of emergency conditions, and the Bootleg Fire caused the loss of one transmission line, reducing import capability by 3,000 megawatts into the California Independent System Operator (CAISO) balancing authority area. And from August 31–September 9, 2022, a 10-day extreme heat event resulted in an unprecedented, sustained period of high peak loads in the CAISO system, averaging 47,000 MW and maxing at an all-time record of over 52,000 MW on September 6. The Western region also hit its record peak load on September 6, at 167.5 GW.

Reliable electricity service was maintained throughout the 10-day September 2022 heat wave in spite of the record breaking load levels. Factors that contributed to this outcome include the installation of over 3,500 MW of lithium-ion battery storage since summer 2020, enhanced coordination and communication within and outside of California, engagement with customer groups and other stakeholders, state actions to reduce load during critical times, and the additional capacity provided through the Strategic Reliability Reserve and other new state programs authorized in the 2022 Budget to provide load reduction and support the grid in extreme events. CEC, CPUC, CAISO, and the California Department of Water Resources will continue to build out strategies to enhance reliability in light of the increasing and compounding impacts of climate change on the electricity system.

[348] In June 2021, the CPUC adopted D.21-06-035 directing procurement of 11,500 MW of new capacity between 2023 and 2026 to ensure systemwide electric reliability as Diablo Canyon and several OTC facilities retire. It requires that, out of the 11,500 MW, 2,500 MW must be from zero-emission resources. Additionally, 2,000 MW must be long lead-time resources, with at least 1,000 MW of long-duration storage and 1,000 MW of firm capacity with zero on-site emissions or that qualifies under the RPS eligibility requirements.

While the electricity sector is using less fossil fuel due to increasing amounts of renewables,[349] existing fossil gas generation will continue to play a critical role in grid reliability until other clean, dispatchable alternatives can be deployed at scale. The integration of greater amounts of variable renewable generation resources[350] is changing power system planning and operations, and system operators need resources with flexible attributes to balance shifting supply and demand.

High levels of solar generation can lead to instances of oversupply during the middle of the day, when the sun is brightest.[351] In the evening hours, as the sun is setting, solar generation declines to zero and customers with solar generation shift back to the electric grid. In hot weather, customer demand remains high well into the summer evening period to power air conditioning, which can lead to reliability challenges.[352]

Figure 4-4 shows the energy sources used throughout one summer day in July. Renewable energy is consistent during the middle of the day, but it cannot meet all of the evening demand in the gray area. As illustrated in the figure, fossil gas generation is currently a resource that is typically ramped up to meet this evening demand as solar production begins to drop and electrical loads increase To help address this challenge, resource installations that pair solar with batteries, as well as a greater amount of battery build-out, are coming online currently and over the next five years. Nevertheless, the state's electricity grid is expected to be stressed further in the coming years by heat waves, drought, wildfires, and the growing intermittent power supply from renewables. California must accelerate deployment of diverse clean energy resources to maintain reliability and affordability in the face of climate change.

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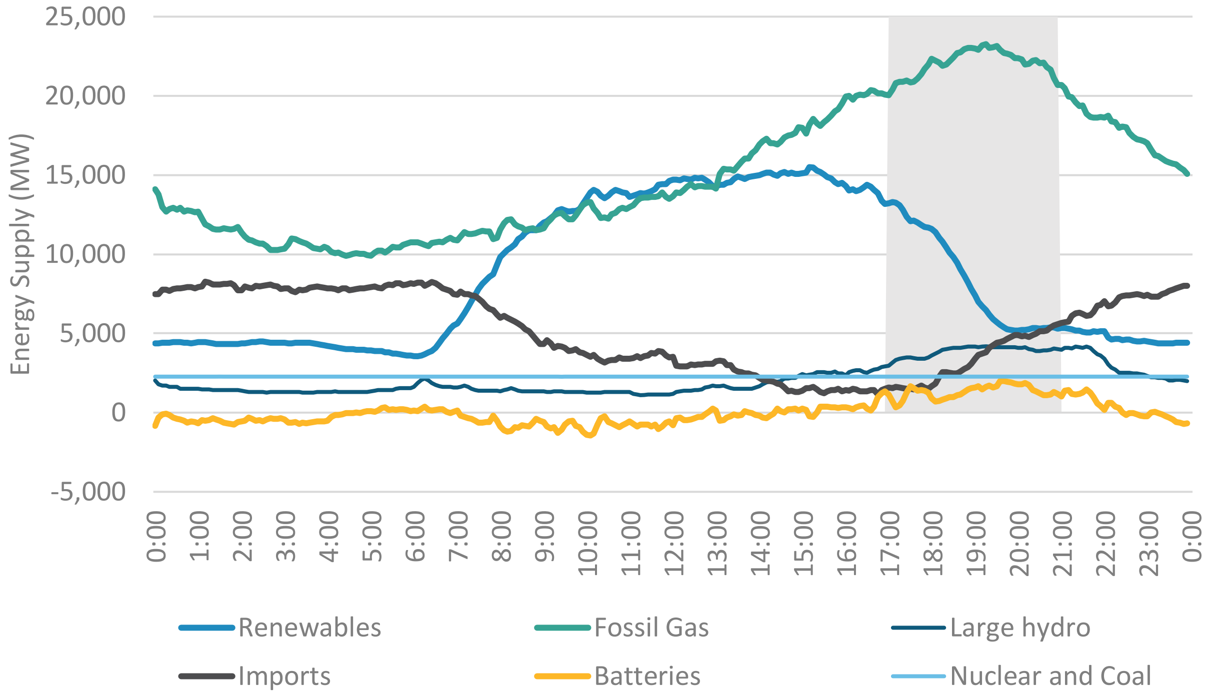
[349] CARB. 2022. *California Greenhouse Gas Emissions for 2000 to 2020.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf.

[350] A *variable renewable generation resource* is a renewable source of electricity that is non-dispatchable due to its fluctuating nature and only produces electricity when weather conditions are right, such as when the sun is shining or the wind is blowing. Renewable resources that can be controlled and are dispatchable include geothermal, biomass, and dam-based hydroelectric power.

[351] *Brightness* is used colloquially here; solar energy depends on insolation (e.g., sun-hours), which is the measurement of cumulative solar energy that reaches an area over a period of time.

[352] CAISO, CPUC, and CEC. 2021. *Final Root Cause Analysis: Mid-August 2020 Extreme Heat Wave.* http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf.

Figure 4-4: Electricity supply trend by resource for a California summer day, July 2022



Sector Transition

Decarbonizing the electricity sector is a crucial pillar of this Scoping Plan. It depends on both using energy more efficiently and replacing fossil-fueled generation with renewable and zero carbon resources, including solar, wind, energy storage,[353] geothermal, biomass, and hydroelectric power. The RPS Program[354] and the Cap-and-Trade Program continue to incentivize dispatch of renewables over fossil generation to serve state demand. SB 100 increased RPS stringency to require 60 percent renewables by 2030 and for California to provide 100 percent of its retail sales[355] of electricity from renewable and zero-carbon resources by 2045. Furthermore, SB 1020 has added interim targets to

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[353] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF1, NF2. finalejacrecs.pdf (arb.ca.gov).

[354] The CEC estimates that 36 percent of California's 2019 retail electricity sales was served by RPS-eligible renewable resources (see CPUC. 2021. CPUC Perspectives on Electric Sector Decarbonization. https://ww2.arb.ca.gov/sites/default/files/2021-11/CPUC-sp22-electricity-ws-11-02-21.pdf).

[355] SB 100 speaks only to retail sales and state agency procurement of electricity. The *2021 SB 100 Joint Agency Report* interprets this to mean that other loads—wholesale or non-retail sales and losses from storage and transmission and distribution lines—are not subject to the law.

SB 100's policy framework to require renewable and zero-carbon resources to supply 90 percent of all retail electricity sales by 2035 and 95 percent of all electricity retail sales by 2040; the governor has asked the CEC to establish a planning goal of at least 20 GW of offshore wind by 2045; and the governor directed that state agencies plan for an energy transition that avoids the need for new fossil gas capacity to meet California's long-term energy goals.[356] In addition to grid-level resources, state efforts have supported rapid growth of the distributed solar industry through key actions like the California Solar Initiative (SB 1, Murray, Chapter 132, Statues of 2006).[357] Steps to commercialize microgrids powered by clean resources[358] are also being examined as part of SB 1339 (Stern, Chapter 566, Statutes of 2018).[359]

California also continues to advance its appliance and building energy efficiency standards to reduce growth in electricity consumption and meet the SB 350 goal to double statewide energy efficiency savings in electricity and fossil gas end uses[360] by 2030. In 2018, the CEC adopted a building energy efficiency code requiring most new homes to have solar photovoltaic systems[361] (or be powered by a solar array nearby) starting January 1, 2020. In 2019, California reached the milestone of 1 million solar rooftop installations.

Increased transportation and building electrification and continued policy commitment to behind-the-meter solar and storage will continue to drive growth of microgrids and other distributed energy resources (DER).[362] The CPUC's High-DER proceeding is examining how to prepare the electric grid for a high DER future by determining how to integrate

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[356] Newsom, Gavin. July 22, 2022. Letter from Governor Newsom to CARB Chair Liane Randolph. *https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf*.

[357] More information on the program, which closed in 2016, can be found on the CPUC website, including annual program assessment reports, at: *https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/california-solar-initiative*.

[358] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, In part (NF2, NF13). *finalejacrecs.pdf (arb.ca.gov)*.

[359] CPUC. Resiliency and Microgrids. *https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/resiliency-and-microgrids*.

[360] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF1, ES1. *finalejacrecs.pdf (arb.ca.gov)*.

[361] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF2. *finalejacrecs.pdf (arb.ca.gov)*.

[362] Distributed energy resources include rooftop solar and other distributed renewable generation resources, energy storage, electric vehicles, time variant and dynamic electric rates, flexible load management, demand response, and energy efficiency technologies.

millions of DERs within the distribution grid to maximize societal and ratepayer benefits from DERs while ensuring grid reliability and affordable rates.[363]

SB 350 also aims to connect long-term planning for electricity needs with the state's climate targets. This is primarily accomplished through CARB's establishment of 2030 GHG emissions targets for the electricity sector in general and for each electricity provider, which inform the CPUC and publicly owned utilities' integrated resource planning. A GHG planning target range of 30 to 53 $MMTCO_2e$—informed by the 2017 Scoping Plan—was originally developed and adopted by CARB in 2018. In its 2021 IRP planning cycle, the CPUC adopted a 38 MMT GHG target for the electricity sector in 2030, which drops to 35 MMT in 2032.[364]

The Scoping Plan Scenario incorporates SB 350's energy efficiency doubling goal, aligns with the CPUC's IRP 2030 GHG target and latest GHG emissions benchmarks through 2035,[365] the governor's 20 GW offshore wind and no new gas generation[366] goals, and SB 100's 2030 RPS and 2045 zero-carbon retail sales targets to reduce dependence on fossil fuels in the electricity sector by transitioning substantial energy demand to renewable and zero-carbon resources.[367] As described in Chapter 2, CCS is applied in limited sectors, including on 16.7 MMT of CO_2 from existing fossil gas electricity generation in 2045, to ensure the state achieves the 85 percent reduction in anthropogenic emissions required by AB 1279. Continued transition to renewable and

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[363] The High-DER proceeding is one of four "anchor" proceedings in the CPUC's DER Action Plan 2.0 and is within the Action Plan's infrastructure track. Information on the High-DER proceeding is available at: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/distribution-planning. The Action Plan can be accessed at: https://www.cpuc.ca.gov/about-cpuc/divisions/energy-division/der-action-plan.

[364] The February 10, 2022, Decision 22-02-004 by the CPUC adopts the 2021 Preferred System Plan, completing the 2019–21 IRP cycle. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K412/451412947.PDF. The Decision requires load serving entities to submit plans in the next IRP cycle detailing how they will meet their proportionate share of a 30 MMT electric sector target, as well as a 38 MMT GHG target.

[365] June 15, 2022, Administrative Law Judge's Ruling for 2022 integrated resource plan filings specifies the need for GHG targets to plan for in 2035 to continue progress toward the 2045 goal. The ruling proposes a straight-line projection from the GHG planning target for 2030. Corresponding to the adopted Preferred System Plan in D.22-02-004, 38 MMT in 2030 leads to a target of 30 MMT in 2035. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M485/K625/485625915.PDF.

[366] The governor's July 22, 2022, letter specifies no new gas generation but does not place any constraints on existing gas resources. Therefore, for purposes of RESOLVE electricity sector modeling, existing gas capacity is an available resource that is able to be reduced over time based on announced retirements or if selected for retirement by the model.

[367] CARB. 2021. PATHWAYS Scenario Modeling: 2022 Scoping Plan Update – Attachment B: Generation Technologies to be included in Modeling. https://ww2.arb.ca.gov/sites/default/files/2021-12/Revised_2022SP_ScenarioAssumptions_15Dec.pdf.

zero-carbon electricity resources will enable electricity to become a zero-carbon substitute for fossil fuels across the economy.

Figure 4-5 shows the modeled resource capacity to meet the SB 100 retail sales target.[368] Energy efficiency moderates some of the need for additional electricity generation. However, that is quickly surpassed by growing electricity demand of 26 percent by 2030 and 76 percent by 2045 compared to today (2022) from increased population and electrification of other sectors, as shown in Figure 4-6. The estimated resource build needed to meet this level of demand amounts to approximately 72 GW of utility solar[369] and 37 GW of battery storage by 2045. Annual build rates (over the 2022–2035 period) for the Scoping Plan Scenario will need to increase by about 60 percent and over 700 percent for utility solar and battery storage, respectively, compared to historic maximum rates.[370] To reach the 2045 target, the state will need to quadruple its current level of wind and solar capacity. This does not include capacity associated with hydrogen production nor mechanical CDR, which was modeled off-grid; assuming hydrogen production via electrolysis, this would roughly be equivalent to an additional 10 GW[371] of solar generation needed in 2045, and an additional 64 GW of solar generation for direct air capture in 2045. The scale of solar and battery build rates needed could be reduced through the commercialization of new zero-carbon technologies.

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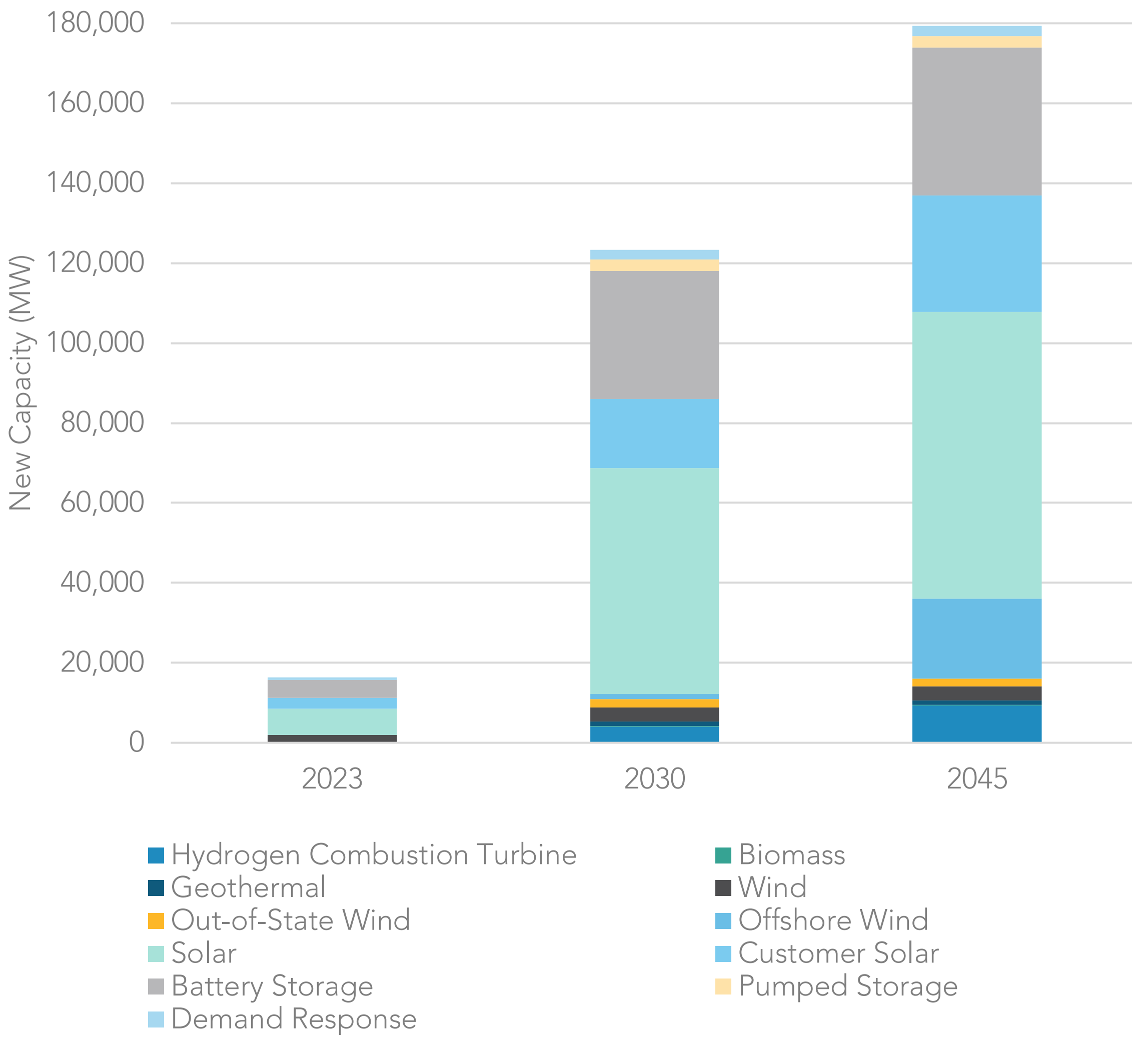
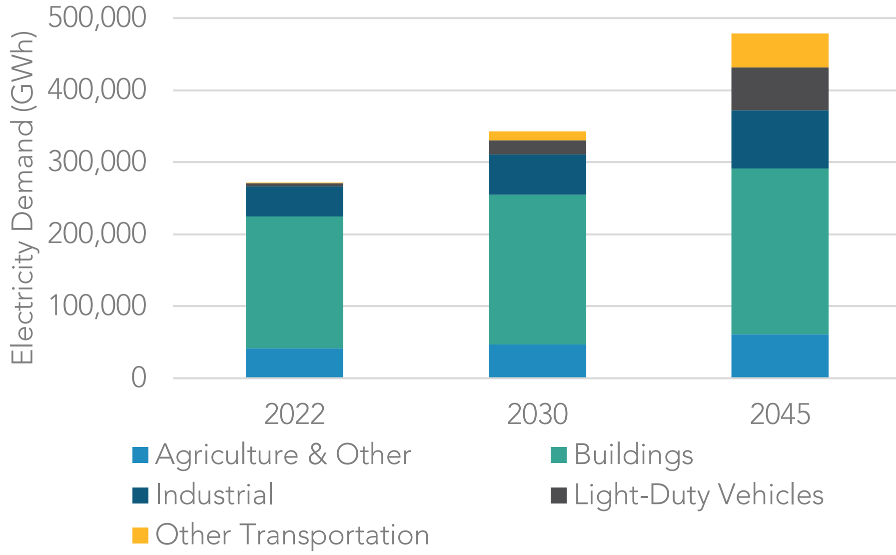
[368] SB 846 requires that load-serving entities exclude energy, capacity, or any attribute from the Diablo Canyon power plant in their resource plans. The Scoping Plan Scenario excludes energy, capacity, or any attribute from the Diablo Canyon power plant after the prior planned retirement date of 2025.
[369] The amount of additional customer solar included in the Scoping Plan Scenario is 29,208 MW by 2045.
[370] E3. 2022. CARB Scoping Plan: AB32 Source Emissions Final Modeling Results. PowerPoint. *https://ww2.arb.ca.gov/sites/default/files/2022-11/SP22-MODELING-RESULTS-E3-PPT.pdf*. Build rates are from EIA data historical builds in the 2011–2021 time frame.
[371] The estimate does not include hydrogen production assumed to be produced with bioenergy with carbon capture and storage (BECCS) and steam methane reforming (SMR).

Figure 4-5: Projected new electricity resources needed by 2045 in the Scoping Plan Scenario[372]



[372] See https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx for the capacity build-out by resource type.

Figure 4-6: Electric loads in 2022, 2030 and 2045 for the Scoping Plan Scenario[373]



This transformation will drive investments in a large fleet of generation and storage resources but will also require significant transmission to accommodate these new capacity additions. Transmission needs include high-voltage lines to access out-of-state resources and major in-state generation pockets. In consideration of typical 8- to 10-year lead times for many projects, the CAISO published its first 20-Year Transmission Outlook to inform transmission planning focused on meeting the needs identified through the 2021 SB 100 Joint Agency Report process. The outlook calls for significant transmission development to access offshore wind and out-of-state wind and reinforce the existing CAISO footprint at an estimated cost of $30.5 billion.[374]

Presently, fossil gas power plants provide about 75 percent of the flexible capacity for grid reliability as more renewable power enters the system. Moving forward, other resources such as storage and demand-side management are essential to maintain reliability with high concentrations of renewables. Hydrogen produced from renewable resources and renewable feedstocks can serve a dual role as a low-carbon fuel for existing combustion turbines or fuel cells, and as energy storage for later use. Reliability

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[373] *Other Transportation* includes all non-light-duty vehicles and reflects electrification of modes like passenger and freight rail, aviation, and ocean-going vessels.

[374] CAISO. 2022. *20 Year Transmission Outlook.* http://www.caiso.com/InitiativeDocuments/20-YearTransmissionOutlook-May2022.pdf.

also can be supported through increased coordination and markets in the interconnected western power grid; this is already helping to better integrate renewables.[375]

Strategies for Achieving Success

- Use long-term planning processes (Integrated Energy Policy Report, IRP, CAISO Transmission Planning Process, AB 32 Climate Change Scoping Plan) to support grid reliability and expansion of renewable and zero-carbon resource and infrastructure deployment.
- Complete systemwide and local reliability assessments across CAISO and other balancing authority areas, using realistic assumptions for land use, build rates, statewide and distribution system level constraints, and energy needs. Such assessments should be completed before state agencies update their electricity sector GHG targets.
- Prioritize actions to mitigate impacts to electricity reliability and affordability and provide sufficient flexibility in the state's decarbonization roadmap for adjustments as may be needed.
- Facilitate long lead-time resource development through the IRP and the SB 100 interagency process and through technology development and demonstration funding[376] that includes resources such as long-duration energy storage and hydrogen production.
- Continue coordination between energy agencies and energy proceedings to maximize opportunities for demand response.
- Continue to explore the benefits of regional markets to enhance decarbonization, reliability, and affordability.
- Address resource build-out challenges, including permitting, interconnection, and transmission network upgrades.
- Explore new financing mechanisms and rate designs to address affordability.[377]
- Per SB 350, double statewide energy efficiency savings in electricity and fossil gas end uses by 2030, through a combination of energy efficiency and fuel substitution actions.[378]
- Per SB 100 and SB 1020, achieve 90 percent, 95 percent, and 100 percent

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[375] CEC. 2021. *2021 SB 100 Joint Agency Report – Achieving 100 Percent Clean Electricity in California: An Initial Assessment.* Publication Number: CEC-200-2021-001.
[376] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, ES2. The committee recommendation speaks specifically to offshore wind production. *finalejacrecs.pdf (arb.ca.gov)*.
[377] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF30. *finalejacrecs.pdf (arb.ca.gov)*.
[378] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF1, NF2. *finalejacrecs.pdf (arb.ca.gov)*.

renewable and zero-carbon retail sales by 2035, 2040, and 2045, respectively.

- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Target programs and incentives to support and improve access to renewable and zero-carbon energy projects (e.g., rooftop solar, community owned or controlled solar or wind, battery storage, and microgrids) for communities most at need, including frontline, low-income, rural, and indigenous communities.[379]
- Prioritize public investments in zero-carbon energy projects to first benefit the most overly burdened communities affected by pollution, climate impacts, and poverty.[380]

Sustainable Manufacturing and Buildings

Fossil gas is the primary gaseous fossil fuel used to produce heat at industrial facilities, as well as in residential and commercial buildings. In buildings, space and water heating, cooking, and clothes drying all rely on gaseous fuels today. Industrial processes that require heat for conventional boilers and other processes also rely on gaseous fuels. Refineries rely on fossil gas and other gaseous fossil fuels, like liquefied petroleum gas and refinery fuel gas, and fossil gas is also used to generate electricity, as discussed earlier.

Gaseous fossil fuel use can be displaced by four primary alternatives: zero-carbon electricity, solar thermal heat, hydrogen, and biogas/biomethane. Displacing gaseous fossil fuel use can yield indoor air quality benefits, protect public health and property from unexpected fossil gas leaks, and reduce short-lived climate pollutants, which are many times more potent in affecting climate change than CO_2. The Scoping Plan Scenario reduces dependence on fossil gas in the industrial and building sectors by transitioning substantial energy demand to alternative fuels. Reducing fossil gas combustion also will help toward achieving our air quality and equity goals by reducing pollution in neighboring areas and communities. In addition, reduced dependence on gasoline and diesel in the transportation sector diminishes the need for gaseous fossil fuels to support oil and gas production and petroleum refining operations as those are phased down relative to the demand.

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[379] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF2, NF9, NF11, NF12, NF13. finalejacrecs.pdf (arb.ca.gov).

[380] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF14. finalejacrecs.pdf (arb.ca.gov).

Sector Transition

Industry

California's industrial sector contributes significantly to the state's economy, with a total output from manufacturing in 2019 of $324 billion (10.4 percent of the state total)[381] and employment of 1,222,000 manufacturing jobs (7.6 percent of the total state workforce).[382] California industry includes a diverse range of facilities, including cement plants, refineries, glass manufacturers, oil and gas producers, paper manufacturers, mining operations, metal processors, and food processors. Combustion of fossil gas, other gaseous fossil fuels, and solid fossil fuels provide energy to meet three broad industry needs: electricity, steam, and process heat. Non-combustion emissions result from fugitive emissions and from the chemical transformations inherent to some manufacturing processes. About 20 percent of the GHG emissions from the industrial sector are non-combustion emissions.

Decarbonizing industrial facilities depends upon displacing fossil fuel use with a mix of electrification, solar thermal heat, biomethane, low- or zero-carbon hydrogen, and other low-carbon fuels to provide energy for heat and reduce combustion emissions. Emissions also can be reduced by implementing energy efficiency measures and using substitute raw materials that can reduce energy demand and some process emissions. Some remaining combustion emissions and some non-combustion CO_2 emissions can be captured and sequestered. The strategy employed will depend on the industrial subsector and the specific processes utilized in production. The left side of Figure 4-7 illustrates the fuels used to meet industrial manufacturing energy demand in 2020. Industrial manufacturing energy demand needs to transition to the fuel mix shown for 2035 and 2045. The right side of Figure 4-7 illustrates the fuel mix needed to meet the energy demand of oil and gas extraction and petroleum refining operations for the same years. Energy demand in this portion of the industrial sector declines along with decreased demand for gasoline and diesel in the transportation sector. In both figures there is a continuing demand for fossil gas due to lack of non-combustion technologically feasible or cost-effective alternatives for certain industrial sectors. Policies that support decarbonization strategies like electrification, use of renewable energy, and transition to alternative fuels are needed.

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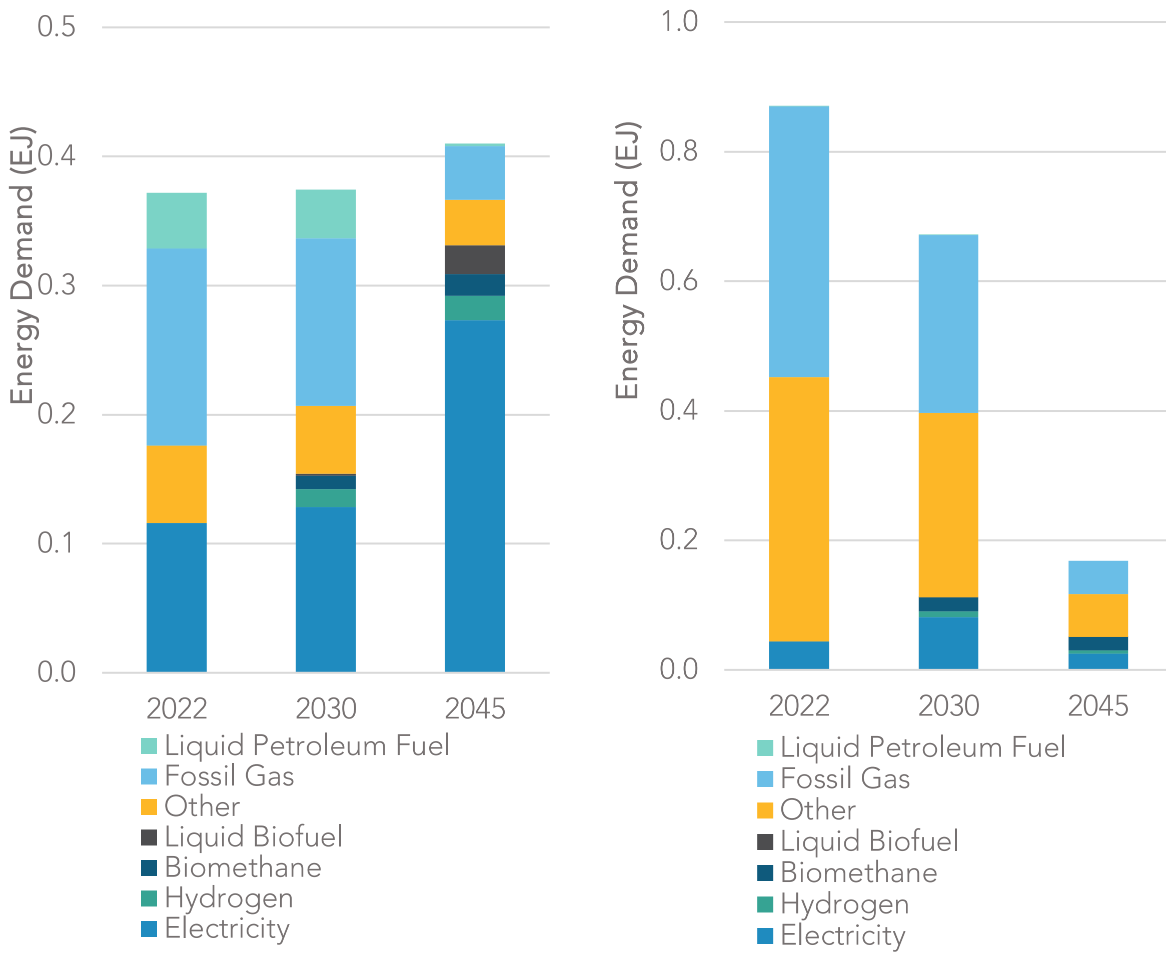
[381] National Association of Manufacturers (NAM). 2021 California Manufacturing Facts. https://www.nam.org/state-manufacturing-data/2021-california-manufacturing-facts/.
[382] NAM. 2021 California Manufacturing Facts. https://www.nam.org/state-manufacturing-data/2021-california-manufacturing-facts/.

Figure 4-7: Final energy demand in industrial manufacturing (left) and in oil and gas extraction and petroleum refining (right) in 2022, 2030, and 2045 in the Scoping Plan Scenario[383]



Electrification and solar thermal heat are best-suited to industrial processes that have relatively low heat requirements, such as food processors, paper mills, and industries that use low-pressure steam in their processes. Approaches could include replacing fossil gas boilers with electric boilers, process heaters with industrial electric heat pumps, steel forging furnaces with induction heaters, and implementing other sector-specific process electrification. Under current rate structures for industrial electricity and fossil gas in

[383] *Other* fuel in the industrial manufacturing sector is primarily coke and coal for cement production. *Other* fuel in the petroleum refining sector is primarily fossil gas associated with refining petroleum products.

California, most projects to electrify a fossil gas-powered industrial process will face operating cost barriers and potential reliability concerns. Microgrids powered by renewable resources and with battery storage are emerging as a key enabler of electrification and decarbonization at industrial facilities.

There are fewer commercially available and economically viable electrification options to replace industrial processes that require higher-temperature heat. For these processes, onsite combustion may continue to be needed, and decarbonization will require fuel substitution to hydrogen,[384] biomethane, or other low-carbon fuels. Fuel substitution and continued combustion will require monitoring and mitigation of any potential air quality impacts, especially in low-income and communities of color which already face disproportionate air pollution burdens. Industries in California with high heat needs include steel forging, glass manufacturing, and industries with calcination processes, such as manufacturing lime and cement.

Onsite emissions from cement manufacturing derive from two main sources: (1) fuel combustion to heat the kiln to a very high temperature and (2) process CO_2 emissions from the chemical transformation of limestone. Over 60 percent of emissions from the sector are process emissions unrelated to fuel use, and most emissions related to fuel use are from coal and petroleum coke combustion. Process emissions from cement manufacturing are significant and will continue even if the sector were to operate using only zero-carbon fuels; thus carbon capture and use/sequestration will be a likely component of any strategy to fully decarbonize cement manufacturing. There are additional opportunities to reduce GHG emissions from cement manufacturing via the combination of fuel-switching to low-carbon fuels (e.g., biomethane, municipal solid waste, biochar), increased blending of non-clinker materials, and efficiency improvements. High technological and economic barriers exist to electrifying kiln process heat at cement plants, as clinker production requires temperatures in excess of 1,500°C. There are potential decarbonization opportunities throughout the value chain of cement use, including in cement manufacturing, concrete mixing, and construction practices.[385] SB 596 (Becker, Chapter 246, Statutes of 2021), which was signed by Governor Newsom in September 2021, requires CARB to develop a comprehensive strategy for cement use in California to achieve a GHG intensity 40 percent below 2019 levels by 2035, and net-zero emissions by 2045.

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[384] Griffiths, Steve, Benjamin K. Sovacool, Jinsoo Kim, Morgan Bazilian, and Joao M. Uratani. 2021. “Industrial decarbonization via hydrogen: A critical and systematic review of developments, socio-technical systems and policy options.” *Energy Research & Social Science* 80. 102208, ISSN 2214-6296. https://doi.org/10.1016/j.erss.2021.102208.

[385] California Nevada Cement Association. Achieving Carbon Neutrality in the California Cement Industry. https://cncement.org/attaining-carbon-neutrality.

Oil and gas extraction and refining make up over half of California's industrial GHG emissions. Reduced demand for transportation fossil fuels corresponds to reduced supply of fossil gas and other gaseous fossil fuels for refineries to produce these fuels. Some refining operations will continue to operate to produce fossil fuel for the remaining transportation energy demands, along with renewable diesel and sustainable aviation fuel, as discussed in the Transportation Sustainability section of this chapter.

Across industrial subsectors and processes, California facilities also could realize significant reductions in GHG emissions and energy-related costs by implementing advanced energy efficiency projects and tools.[386] While enhanced operation and maintenance practices are typical at industrial facilities, additional strategic energy management practices offer greater efficiency gains by focusing on setting goals, tracking progress, and reporting results.

Strategies for Achieving Success

- Maximize air quality benefits using the best available control technologies for stationary sources in communities most in need, including frontline, low-income, disadvantaged, rural, and tribal communities.[387]
- Prioritize alternative fuel transitions first in communities most in need, including frontline, low-income, disadvantaged, rural, and tribal communities.[388]
- Invest in research and development and pilot projects to identify options to reduce materials and process emissions along with energy emissions in California's industrial manufacturing facilities, leveraging programs like the CEC's Electric Program Investment Charge (EPIC).[389]
- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Support electrification with changes to industrial rate structures.
- Develop infrastructure for CCS and hydrogen production to reduce GHG emissions where cost-effective and technologically feasible non-combustion alternatives are not available.
- Implement SB 905.

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[386] Therkelsen, Peter, Aimee McKane, Ridah Sabouini, and Tracy Evans. 2013. *Assessing the Costs and Benefits of the Superior Energy Performance Program.* U.S Department of Energy. https://www.osti.gov/servlets/purl/1165470.

[387] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, JT14. *finalejacrecs.pdf (arb.ca.gov)*.

[388] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, JT15. *finalejacrecs.pdf (arb.ca.gov)*.

[389] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, M20. *finalejacrecs.pdf (arb.ca.gov)*.

- Establish markets for low-carbon products and recycled materials using Buy Clean California Act and other mechanisms relying on robust data
- Develop a net-zero cement strategy to meet SB 596 targets for the GHG intensity of cement use in California.
- Continue to leverage energy-efficiency programs, including the U.S. DOE's ENERGY STAR program,[390] U.S. DOE's Superior Energy Performance program,[391] and ISO 50001.[392]
- Evaluate and continue to offer incentives to install energy efficiency and renewable energy technologies through programs such as CPUC decisions as part of rulemaking R.19-09-009[393] and the CEC's Food Production Investment Program (FPIP) and EPIC programs.[394]
- Leverage low-carbon hydrogen programs, including the Bipartisan Infrastructure Law, for regional hydrogen hubs, hydrogen electrolysis, and hydrogen manufacturing and recycling.
- Evaluate the role of hydrogen in meeting GHG emission reductions, including policy recommendations regarding the use of hydrogen in California as required by SB 1075.
- Address cost barriers to promote low-carbon fuels for hard-to-electrify industrial applications.

Buildings

Buildings have cross-sector interactions that influence our public health and well-being and affect land use and transportation patterns, energy use, water use, and indoor and outdoor environments.[395] There are about 14 million existing homes and over 7.5 billion square feet of existing commercial buildings[396] in California. Fossil gas supplies about half of the energy consumed by end uses in these buildings. In addition to GHG emissions, fossil gas usage in buildings also produces CO_2, NOx, $PM_{2.5}$, and

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[390] ENERGY STAR. ENERGY STAR Guidelines for Energy Management. https://www.energystar.gov/buildings/tools-and-resources/energy-star-guidelines-energy-management.

[391] Energy.gov. Superior Energy Performance 50001. https://www.energy.gov/eere/amo/superior-energy-performance.

[392] ISO. ISO 50001 Energy Management. https://www.iso.org/iso-50001-energy-management.html.

[393] CPUC. January 14, 2021. CPUC Adopts Strategies to Help Facilitate Commercialization of Microgrids Statewide. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M360/K370/360370887.PDF.

[394] Bailey, Stephanie, David Erne, and Michael Gravely. 2021. *Final 2020 Integrated Energy Policy Report Update, Volume II: The Role of Microgrids in California's Clean and Resilient Energy Future, Lessons Learned From the California Energy Commission's Research.* California Energy Commission. Publication Number: CEC-100-2020-001-V2-CMF.

[395] See Appendix F (Building Decarbonization).

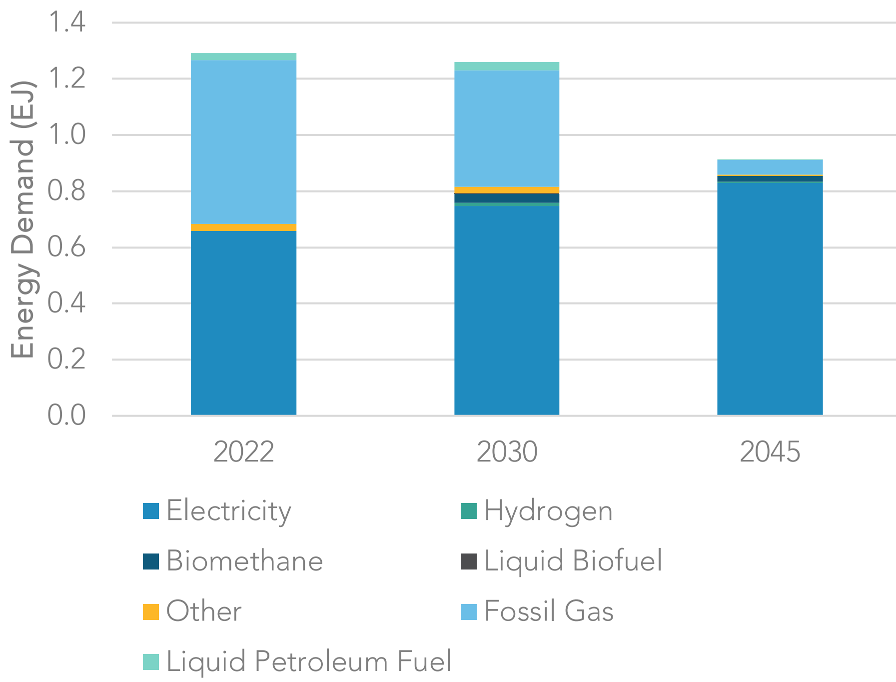
[396] CEC. 2021. California Building Decarbonization Assessment. https://efiling.energy.ca.gov/GetDocument.aspx?tn=239311&DocumentContentId=72767.

formaldehyde.[397] Each year, about 120,000 new homes[398] and more than 100 million-square feet[399] of commercial buildings are newly constructed across California. These new buildings will represent between a third to half of the total building stock by mid-century.

Achieving carbon neutrality must include transitioning away from fossil gas in residential and commercial buildings, and will rely primarily on advancing energy efficiency while replacing gas appliances with non-combustion alternatives. This transition must include the goal of trimming back the existing gas infrastructure so pockets of gas-fueled residential and commercial buildings do not require ongoing maintenance of the entire limb for gas delivery. Blending low-carbon fuels such as hydrogen and biomethane into the pipeline further displaces fossil gas. Pipeline safety and reliability must be evaluated to accommodate low-carbon fuels. Figure 4-8 illustrates the energy Californians use in buildings at present compared with the Scoping Plan Scenario, which introduces alternatives to fossil gas. In that scenario almost 90 percent of energy demand is electrified by 2045, and the remaining energy demand is met with combustion of hydrogen, biomethane, and fossil gas.

[397] Zhu, Yifang, et al. 2020. *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California.* UCLA Fielding School of Public Health Department of Environmental Health Sciences.
[398] Construction Industry Research Board. 2018. Annual Building Permit Summary. http://www.cirbreport.org.
[399] Delforge, Pierre. August 11, 2021. California Forging Ahead on Zero Emission Buildings. Blog. NRDC. https://www.nrdc.org/experts/pierre-delforge/california-forging-ahead-zero-emission-buildings.

Figure 4-8: Final energy demand in buildings in 2022, 2030, and 2045 in the Scoping Plan Scenario[400]



This transition is achieved when all new buildings constructed include non-combustion appliances, and appliances in existing buildings are replaced at the end of their useful life with non-combustion alternatives. Currently, electric alternatives, combined with the decarbonizing of California's grid, are the most effective alternatives, and the Scoping Plan Scenario modeled these alternatives. The Scoping Plan Scenario assumes three million all-electric and electric-ready homes by 2030 and seven million by 2035. Figure 4-9 illustrates the pace at which electric space heating appliance sales increase and gas space heating appliance sales decrease in residences in the Scoping Plan Scenario, such that by 2035 100 percent of residential home appliance sales are electric. By 2030 over six million electric heat pumps are installed statewide. The residential electric space heating appliance sales increases rapidly in the near term as new all-electric buildings are constructed and as existing buildings are renovated to utilize electric appliances. A similar transition is envisioned for other home appliances. Commercial buildings also will undergo a transition away from gas appliances to electric appliances, achieving 80 percent sales of all-electric appliances by 2035 and 100 percent by 2045. Appendix F (Building Decarbonization) describes a holistic policy approach to rapidly grow the

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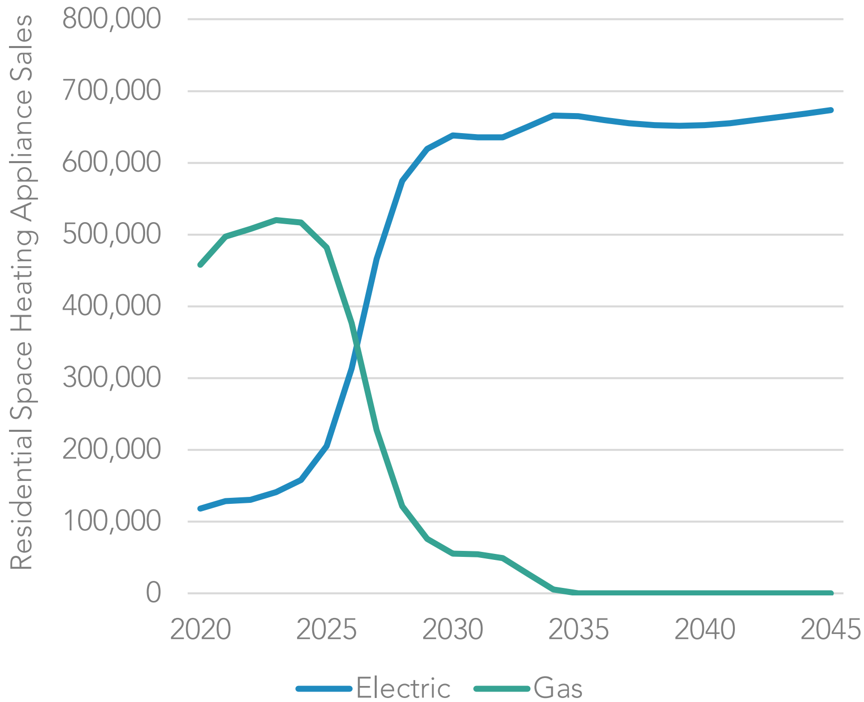
400 *Other* fuel in the buildings sector is primarily liquid petroleum gas and waste heat.

number of zero emission appliances and buildings, to surmount the market barriers, and to prioritize an equitable transition for vulnerable communities.

Figure 4-9: Residential space heating appliance sales in the Scoping Plan Scenario



Strategies for Achieving Success

- Prioritize California's most vulnerable residents with the majority of funds in the new $922 million Equitable Building Decarbonization program, created through the 2022–2023 state budget. This would include residents in frontline, low-income, disadvantaged, rural, and tribal communities. This program is dedicated to a statewide direct-install building retrofit program for low-income households to replace fossil fuel appliances with electric appliances, energy-efficient lighting, and building insulation and sealing while also coordinating reductions in gas infrastructure in specific geographic areas.
- Achieve three million all-electric and electric-ready homes by 2030 and seven million by 2035 with six million heat pumps installed statewide by 2030.
- Expand incentive programs to support the holistic retrofit of existing buildings, especially for vulnerable communities.
- Ensure that incentive programs prioritize energy affordability and tenant protections, promote affordable and low-income household retrofits that improve habitability and reduce expenses, protect and empower small landlords and homeowners, address overlooked consumer groups, and pair decarbonization

with other critically needed renovation efforts to ensure that buildings support human health and are climate- and weather-resistant.[401]

- End fossil gas infrastructure expansion for newly constructed buildings.[402]
- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Strengthen California's building standards to support zero-emission new construction.
- Develop building performance standards for existing buildings.
- Adopt a zero-emission standard for new space and water heaters sold in California beginning in 2030, as specified in the 2022 State Strategy for the State Implementation Plan.
- Expand use of low-GWP refrigerants within buildings.
- Support electrification with changes to utility rate structures and by promoting load management programs.
- Increase funding for incentive programs and expand financing assistance programs focused on existing buildings and appliance replacements.
- Expand consumer education efforts to raise awareness and stimulate the adoption of decarbonized buildings and appliances, especially in vulnerable communities.
- Implement biomethane procurement targets for investor-owned utilities as specified in SB 1440 (Hueso, Chapter 739, Statutes of 2018) to reduce GHG emissions in remaining pipeline gas and reduce methane emissions from organic waste.

[401] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF23, NF24, NF25, NF26, NF28. *finalejacrecs.pdf (arb.ca.gov)*.

[402] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF22. *finalejacrecs.pdf (arb.ca.gov)*.

Carbon Dioxide Removal and Capture

Climate Change 2022: Mitigation of Climate Change,[403] a report by the IPCC released in early 2022, states "The deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved. The scale and timing of deployment will depend on the trajectories of gross emission reductions in different sectors. Upscaling the deployment of CDR depends on developing effective approaches to address feasibility and sustainability constraints especially at large scales." In line with that report, this Scoping Plan considers CDR as a complement to technologically feasible and cost-effective GHG emissions mitigation, and the size of its role will depend on the degree of success in reducing GHG emissions at the source across the economy. [404] The modeling shows that emissions from the AB 32 GHG Inventory sources will continue to persist even if all fossil related combustion emissions are phased out. These residual emissions must be compensated for to achieve carbon neutrality. Options for CDR include both sequestration in natural and working lands and mechanical approaches like direct air capture. Chapter 2 provides estimates on how much CO_2 removal is possible by our natural and working lands and how much must be removed by mechanical CDR.

CCS, which is carbon capture from anthropogenic point sources, is described in Chapter 2 and involves capturing carbon from a smokestack of an emitting facility. Direct air capture, on the other hand, captures carbon directly from the atmosphere. Direct air capture technologies, unlike CCS, are not associated with any particular point source.

For this section, *carbon management* refers to the capture, movement, and sequestration of CO_2 through mechanical solutions for both capture at point sources and direct removal from the atmosphere through direct air capture.[405] Enabling policies and regulations across each of these steps are necessary for individual projects, and on a broader scale, for delivering reductions in support of the state's carbon neutrality and long-term carbon-negative goals. Figure 4-10 provides a graphic of the typical carbon management infrastructure.

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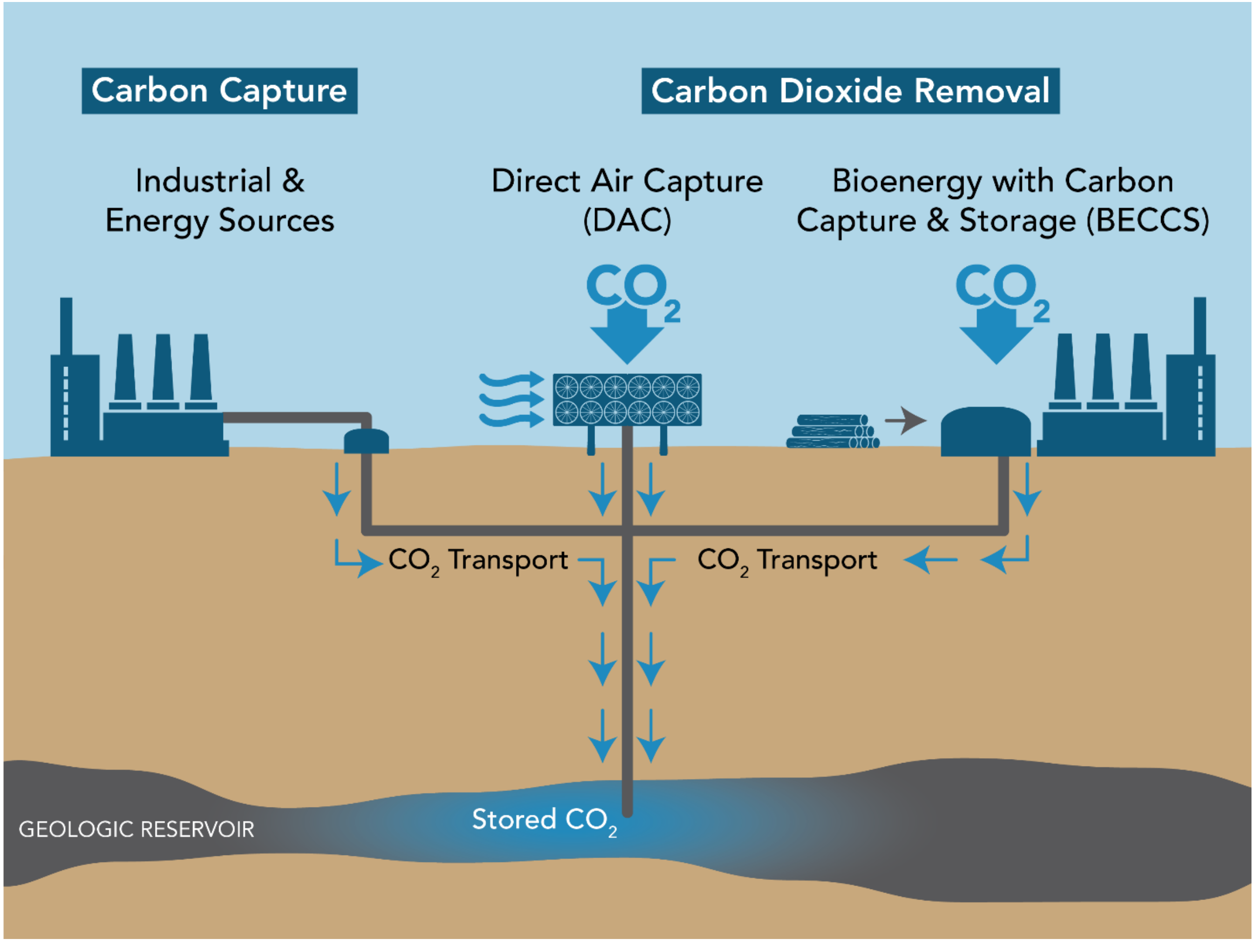
[403] IPCC. 2022. *Climate Change 2022: Mitigation of Climate Change.* https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/.
[404] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F4.7. finalejacrecs.pdf (arb.ca.gov).
[405] CDR through natural and working lands is discussed in Chapter 2 and later in this chapter.

Figure 4-10: Carbon management infrastructure



Carbon dioxide removal directly from the atmosphere itself refers to a suite of carbon negative technologies that can be used to draw down ongoing and historical carbon emissions already in the atmosphere. Some CO_2 removal technologies leverage the abilities of both natural photosynthesis and mechanical removal by using biomass wastes as inputs to make low- or zero-carbon energy or fuels, all while capturing and storing produced CO_2.

Captured CO_2 from point sources or from the atmosphere is permanently stored in specialized geologic formations, typically half a mile or more underground. A recent Stanford University study estimated the state's commercial storage potential is nearly 70,000 million metric tons of CO_2, even when excluding oil and gas reservoirs.[406] California is well-positioned because few other places on the West Coast are suitable for

[406] Stanford Center for Carbon Storage. Opportunities and Challenges for CCS in California. https://sccs.stanford.edu/california-projects/opportunities-and-challenges-for-CCS-in-California.

geologic storage at scale. To inform discussion around CO_2 removal, CARB held two full-day workshops exploring the types of options for carbon capture and geologic storage and utilization in products.[407,408,409]

The modeling results provided in Chapter 2 demonstrate the targeted need for CCS on large facilities such as refineries and cement. The CCS numbers do not include the potential additional applications for producing hydrogen with biomethane, other manufacturing, electricity, or other bioenergy. If CCS is not deployed, those emissions would be released directly into the atmosphere and instead need to be addressed through CDR to achieve carbon neutrality. Although a study finds California has 76 existing electricity and industrial facilities that are suitable candidates for CCS retrofit,[410] this Scoping Plan proposes a targeted role for this technology such that it would only be used to address sectors where non-combustion options are not technologically feasible or cost-effective at this time, to the extent needed to achieve the 85 percent reduction in anthropogenic emissions as called for in AB 1279. In future updates to the Scoping Plan, there may be additional options for technologically feasible or cost-effective technologies that may be deployed, which would further reduce the need for CCS and CDR except in situations to address historical GHG emissions.

Recognizing the need for carbon capture and utilization sequestration and removal, the Legislature passed, and the governor signed, SB 905. It includes several key requirements in the development of the state's Carbon Capture Removal, Utilization, and Storage Program. The following is a summary of the work to be completed to establish and administer this program. Many of these steps will address the need to evaluate the safety and efficacy of actions to support carbon removal, sequestration, and transfer via pipelines. Note that not all of these actions are under CARB's authority.

- Review technology to evaluate efficacy, safety, viability of CCUS/CDR methodologies.
- Develop monitoring and reporting requirements and schedules.
- Develop a unified permit application.
- Develop financial responsibility requirements.
- Develop a centralized public database for project status.

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[407] CARB. December 11, 2019. Carbon Neutrality Meetings & Workshops. *https://ww2.arb.ca.gov/our-work/programs/carbon-neutrality/carbon-neutrality-meetings-workshops*.
[408] CARB. August 2, 2021 Scoping Plan Meetings & Workshops. *https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/scoping-plan-meetings-workshops*.
[409] *Carbon utilization* refers to the use of captured carbon to produce products such as plastics and concrete.
[410] Glenwright, Kara. 2020. *Roadmap for carbon capture and storage in California.* Precourt Institute for Energy. *https://earth.stanford.edu/news/roadmap-carbon-capture-and-storage-california#gs.ysj78q.*

- Consult with CNRA on pore space requirements as CNRA develops a framework for pore space governing agreements.
- Establish a Geologic Carbon Sequestration Group to identify suitable injection well locations, subsurface monitoring, and potential hazards that may require suspension of injection.

SB 905 also has requirements for project developers such as to develop monitoring plans and to avoid any adverse health and environmental impacts at the carbon capture location—or mitigation of unavoidable impacts as required under existing requirements. For the site of injection, there are requirements for site stability, monitoring, and reporting plans. SB 905 also bans CCS with enhanced oil recovery in California and prohibits the transfer of CO_2 via pipeline until the U.S. Department of Transportation's Pipelines and Hazardous Materials Safety Administration (PHMSA) completes its current rulemaking to update existing CO_2 pipeline safety requirements.

An often-cited example of pipeline concerns involves a CO_2 pipeline in Mississippi. On February 22, 2020, a CO_2 pipeline operated by Denbury Gulf Coast Pipelines LLC (Denbury) ruptured in proximity to the community of Satartia, Mississippi. The rupture followed heavy rains that resulted in a landslide, creating excessive axial strain on a pipeline weld (DOT 2022). The combination of weather and topography resulted in a slower dissipation of the gas. The pipeline was also carrying hydrogen sulfide, a flammable and toxic gas. The pipeline failed on a steep embankment, which had recently subsided. Heavy rains are believed to have led to a landslide, which created axial strain on the pipeline and resulted in a full circumferential girth weld failure. The PHMSA investigation also revealed several contributing factors to the accident, including but not limited to: Denbury not addressing the risks of geohazards in its plans and procedures, underestimating the potential affected areas that could be impacted by a release in its CO_2 dispersion model, and not notifying local responders to advise them of a potential failure.

As the Satartia example highlights, appropriate pipeline safety and environmental standards in California are critical to minimize any risks from CO_2 transport in the future. As such, SB 905 also tasks CNRA, in consultation with the Public Utilities Commission, to, no later than February 1, 2023, provide a proposal to the Legislature to establish a state framework and standards for the design, operation, siting, and maintenance of intrastate pipelines carrying CO_2 fluids of varying composition and phase to minimize the risk posed to public and environmental health and safety. The recommended framework shall be designed to minimize risk to public health and environmental health and safety, to the extent feasible. Because SB 905 prohibits the transfer of CO_2 via pipeline until the PHMSA completes its current rulemaking to update existing CO_2 pipeline safety requirements, CCS or CDR projects that would require a pipeline to transfer CO_2 are not feasible at this time within California.

Ultimately, and in accordance with SB 905, the merits of each CCS or CDR project must be evaluated on a case-by-case basis.[411] Deployment of CCS and CDR could support skilled jobs and workforces, including those in traditional fossil energy communities. Other co-benefits could include criteria air pollutant reductions and water production. It will be important to design projects that do not exacerbate community health impacts, include early and ongoing community engagement, and are in compliance with local, state, and federal public health and environmental protection laws. It also should be noted that, as these types of projects are an emerging area of governance, additional coordination and discussion will be needed among the various levels of authorities involved. SB 905 has already initiated this process by assigning specific agencies with tasks related to their expertise and authority.

Chapter 2 includes a more detailed discussion about the proposed role of CO_2 removal in this Scoping Plan.

Sector Transition

State,[412] national,[413,414] and global decarbonization analyses[415] indicate a significant role for carbon management infrastructure, yet relatively few projects are operational. Around the world, about two dozen large CCS projects are capturing tens of millions of metric tons of CO_2 each year, with about a dozen operating in the United States.[416] The vast majority of capacity is at industrial facilities, such as ethanol and fertilizer plants, that would otherwise vent nearly pure CO_2 into the atmosphere as a by-product of normal, non-combustion processes. Future research, development, and demonstration projects must refine and commercialize capture systems for more complex applications, especially

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[411] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F4.5. finalejacrecs.pdf (arb.ca.gov).

[412] E3. October 2020. Achieving Carbon Neutrality in California Report: Final Presentation. https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_presentation_oct2020_2.pdf.

[413] World Resources Institute. January 31, 2020. CarbonShot: Federal Policy Options for Carbon Removal in the United States. Working paper. https://www.wri.org/research/carbonshot-federal-policy-options-carbon-removal-united-states.

[414] C2ES. No date. Getting to Zero: A U.S. Climate Agenda — Center for Climate and Energy Solutions. https://www.c2es.org/getting-to-zero-a-u-s-climate-agenda-report/.

[415] IPCC. Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. Chapter 2. https://www.ipcc.ch/sr15/chapter/chapter-2/. All analyzed pathways limiting warming to 1.5°C with no or limited overshoot use CDR to some extent to neutralize emissions from sources for which no mitigation measures have been identified and, in most cases, also to achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence). The longer the delay in reducing CO_2 emissions toward zero, the larger the likelihood of exceeding 1.5°C, and the heavier the implied reliance on net negative emissions after mid-century to return warming to 1.5°C (high confidence).

[416] Congressional Research Service. 2021. Carbon Capture and Sequestration (CCS) in the United States. R44902. https://crsreports.congress.gov/product/pdf/R/R44902?msclkid=e45e0012c25911ec8085ca575cb61e82.

for those with limited decarbonization options. It has only been in the last few years that attention has seriously turned to mechanical CDR. As new information and modeling on climate change have been made available, the science has become clearer that avoiding the most catastrophic impacts of climate change requires both reducing emissions and deploying mechanical CDR.

California is paving a path forward on a science-based carbon management infrastructure policy that can serve as an example for other jurisdictions. The LCFS, which reduces the carbon intensity of transportation fuels, includes a protocol for select carbon management projects to become certified and generate LCFS credits.[417] CCS is not a new concept or technology. Twenty years of CCS testing show it is a safe and reliable tool.[418] As mentioned in Chapter 2, while no new CCS projects have been implemented or generated any credits under the CARB CCS protocol, CCS projects have been implemented elsewhere since the 1970s. Moreover, there has been a U.S. Department of Energy CCS research program underway for more than two decades. These all form a foundation of information for future efforts. Certified projects must successfully demonstrate adherence to rigorous pre-construction, operational, and site closure standards designed to strengthen environmental performance, as described in CARB's CCS Protocol. The protocol is designed to layer on top of existing federal carbon sequestration regulations designed to protect the environment. The protocol would need to be reevaluated if CCS were to be more broadly applied across sectors beyond transportation fuel production.

Direct air capture and carbon mineralization have high potential capacity for removing carbon, but direct air capture is currently limited by high cost. Carbon mineralization may also have high potential for removing carbon from the atmosphere, but understanding of the technology is still limited.[419] Direct air capture could also be deployed at higher rates to remove legacy GHG emissions from the atmosphere. Chapter 2 contains additional information on the current status of CCS and mechanical CDR projects globally, as well as federal support of such technologies.

Strategies for Achieving Success

- Implement SB 905.

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[417] CARB. 2018. Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard. August 13. https://ww2.arb.ca.gov/sites/default/files/2020-03/CCS_Protocol_Under_LCFS_8-13-18_ada.pdf.

[418] National Energy Technology Laboratory. Permanence and Safety of CCS. https://netl.doe.gov/coal/carbon-storage/faqs/permanence-safety.

[419] Aines, Roger. No date. Options for Removing CO_2 from California's Air. Lawrence Livermore National Laboratory. https://ww2.arb.ca.gov/sites/default/files/2021-08/llnl_presentation_sp_engineeredcarbonremoval_august2021.pdf.

- Convene a multi-agency Carbon Capture and Sequestration Group comprised of federal, state, and local agencies to engage with environmental justice advocates, tribes, academics, researchers, and community representatives to identify the current status, concerns, and outstanding questions concerning CCS, and develop a process to engage with communities to understand specific concerns and consider guardrails to ensure safe and effective deployment of CCS.[420]
- Iteratively update the CARB CCS Protocol with the best available science and implementation experience.
- Incorporate CCS into other sectors and programs beyond transportation where cost-effective and technologically feasible options are not currently available and to achieve the 85 percent reduction in anthropogenic sources below 1990 levels as called for in AB 1279.
- Evaluate and propose, as appropriate, financing mechanisms and incentives to address market barriers for CCS and CDR.
- Evaluate and propose, as appropriate, the role for CCS in cement decarbonization (SB 596) and as part of hydrogen production pathways (SB 1075).
- Support carbon management infrastructure projects through core CEC research, development, and demonstration (RD&D) programs.
- Continue to explore carbon capture applications for producing or leveraging zero-carbon power for reliability needs as part of SB 100.
- Consider carbon capture infrastructure when developing hydrogen roadmaps and strategy, especially for non-electrolysis hydrogen production.
- Evaluate and streamline permitting barriers to project implementation while protecting public health and the environment.
- Explore options for how local air quality benefits can be achieved when CCS is deployed.
- Explore opportunities for CCS and CDR developers to leverage existing infrastructure, including subsurface infrastructure.
- Explore permitting options to allow for scaling the number of sources at carbon sequestration hubs.

Short-Lived Climate Pollutants (Non-Combustion Gases)

Short-lived climate pollutants (SLCPs) include black carbon (soot), methane (CH_4), and fluorinated gases (F-gases, including hydrofluorocarbons [HFCs]). They are powerful climate forcers and harmful air pollutants that have an outsized impact on climate change

[420] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F4.9. finalejacrecs.pdf (arb.ca.gov).

in the near term, compared to longer-lived GHGs, such as CO_2. According to the IPCC's *Climate Change 2021: The Physical Science Basis,* in the near-term (i.e., 10- to 20-year time scale) the warming influence of all SLCPs combined will be at least as large as that of CO_2.[421] The United Nations Environment Programme's Global Methane Assessment[422] advises that achieving the least-cost pathways to limit warming to 1.5°C requires global methane emission reductions of 40–45 percent by 2030 alongside substantial simultaneous reductions of all climate forcers, including CO_2 and SLCPs. Action to reduce these powerful emissions sources today will provide immediate benefits—both to human health locally and to reduce warming globally—as the effects of our policies to transition to low carbon energy systems and achieve carbon neutrality further unfold.

In 2017, the Board approved the comprehensive Short-Lived Climate Pollutant Reduction Strategy (Strategy).[423] This strategy explained how the state would meet the following SB 1383-established targets:

- 40 percent reduction in total methane emissions[424] (including a separate 40 percent reduction in dairy and livestock emissions)
- 40 percent reduction in hydrofluorocarbon gas emissions
- 50 percent reduction in anthropogenic black carbon emissions
- 50 percent reduction of organic waste disposal from 2014 levels by 2020, and 75 percent by 2025, including recovery of at least 20 percent of edible food for human consumption

The state is expected to achieve roughly half of the SB 1383 targeted emissions reductions by 2030 through strategies currently in place (See Figure 4-11). As directed by the Legislature under SB 1383, state agencies focused on voluntary, incentive-based mechanisms to reduce SLCP emissions in the early years of implementation to overcome technical and market barriers. Under this "carrot-then-stick" strategy, incentives are replaced with requirements as the solutions become increasingly feasible and cost-effective. To meet legislated targets, more aggressive action is needed.

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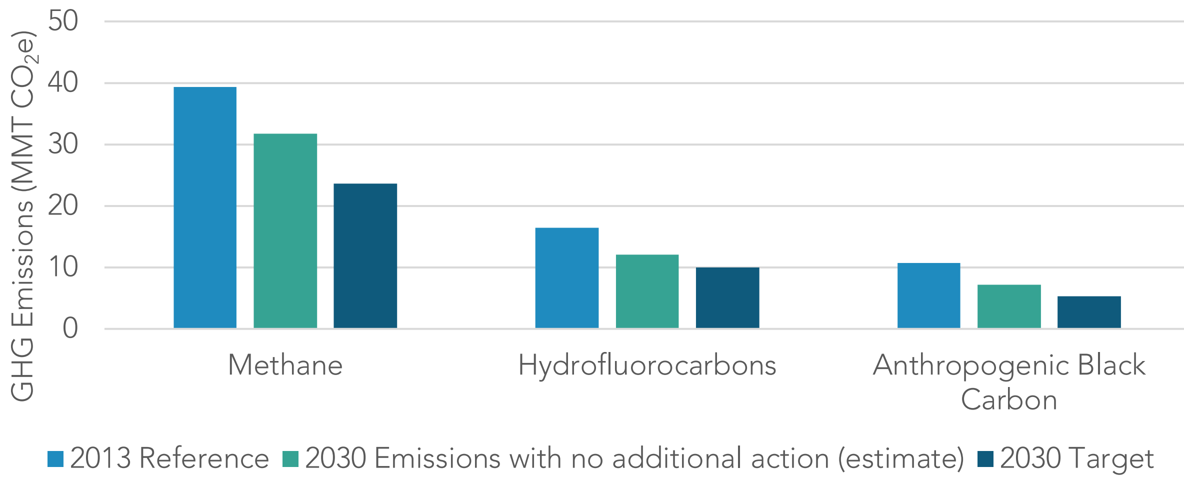
[421] IPCC. 2021. *Climate Change 2021:The Physical Science Basis.* https://www.ipcc.ch/report/ar6/wg1/.
[422] United Nations. Global Methane Assessment. Summary for Policymakers. https://wedocs.unep.org/bitstream/handle/20.500.11822/35917/GMA_ES.pdf.
[423] CARB. 2017. Short-Lived Climate Pollution Reduction Strategy. https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf.
[424] All SB 1383 emissions reductions are mandated to be realized by 2030 and are relative to 2013 levels.

Figure 4-11: Expected progress toward SB 1383 targeted emissions reductions by 2030 through strategies currently in place



While the state's overall GHG emissions have declined by 9 percent over the past decade, SLCP emissions reductions have not kept pace with broader progress toward decarbonization. After growing steadily in the preceding decade, methane emissions have remained relatively flat since 2013.

HFCs are the fastest growing source of GHG emissions, primarily driven by their use to replace ozone-depleting substances and an increased demand for cooling and refrigeration.[425] Since 2005, statewide HFC emissions have more than doubled. While the rate of increase has slowed in recent years due to the state's measures, HFC emissions are still on the rise in California, and have grown by over 50 percent since 2010.[426] Globally, as temperatures rise, adoption of cooling technologies (and refrigerants) is increasing rapidly. If no measures are taken, it is estimated that HFCs will account for 9 to 19 percent of the total global GHG emissions by 2050.[427]

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[425] CARB. 2022. *California Greenhouse Gas Emissions for 2000 to 2020: Trends of Emissions and Other Indicators.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf.

[426] CARB. 2022. *California Greenhouse Gas Emissions for 2000 to 2020.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf.

[427] Velders, G. J., D. W. Fahey, J. S. Daniel, M. McFarland, and S. O. Andersen. 2009. "The large contribution of projected HFC emissions to future climate forcing." *Proceedings of the National Academy of Sciences* 106(27), 10949–10954.

Methane

Human sources of methane emissions are estimated to be responsible for up to 25 percent of current warming.[428] Fortunately, methane's short atmospheric lifetime of ~12 years[429] means that emissions reductions will rapidly reduce concentrations in the atmosphere, slowing the pace of temperature rise in this decade. Further, a substantial portion of the targeted reductions can be achieved at low cost and will provide significant human health benefits. For example, the UN's *Global Methane Assessment* (2021)[430] found that over half of the available targeted measures have mitigation costs below $21/MTCO_2e$, and that each million metric tons of methane reduced would prevent 1,430 premature deaths annually due to ozone pollution caused by methane.

Following the Twenty Sixth Conference of Parties (COP26) (the United Nations Convention on Climate Change in 2021), over 110 nations have signed onto the Global Methane Pledge (Pledge)[431] to limit methane emissions by 30 percent relative to 2020 levels. The Pledge covers countries that emit nearly half of all methane and make up 70 percent of global GDP. The UN's Global Methane Assessment[432] shows that human-caused methane emissions can be reduced by up to 45 percent this decade, which would avoid nearly 0.3°C of global warming by 2045.

As shown in Figure 4-12, the three largest sources of California's methane emissions are the dairy and livestock industry, landfills, and oil and gas systems.

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[428] IPCC. 2021. *Climate Change 2021:The Physical Science Basis.* https://www.ipcc.ch/report/ar6/wg1/.

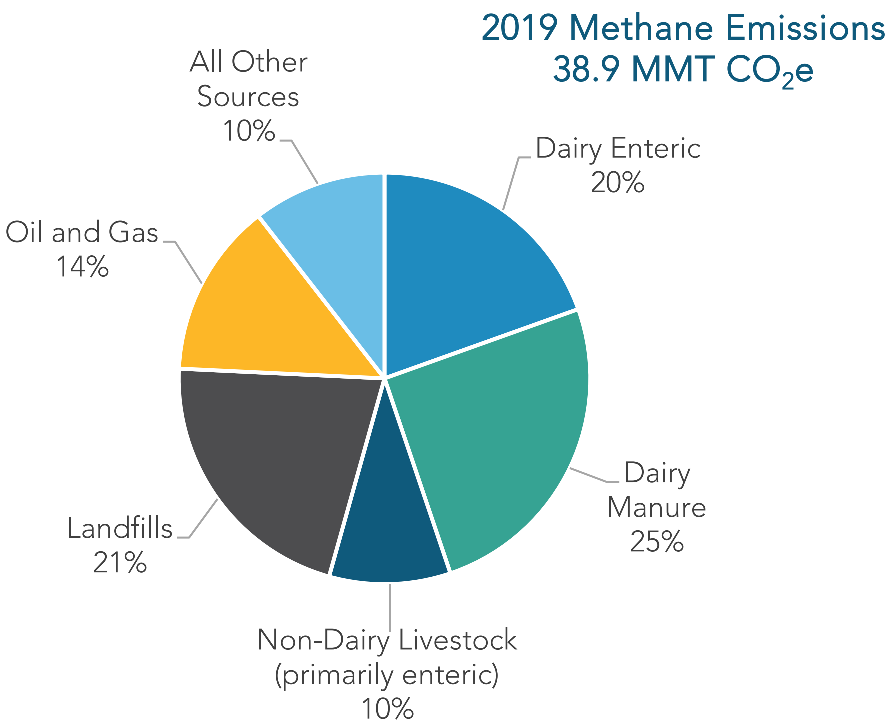
[429] In contrast, the lifetime of CO_2 is hundreds of years. The IPCC Third Assessment Report concluded that no single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes. According to IPCC Fourth Assessment Report, the majority of an increase in CO_2 will be removed from the atmosphere within decades to a few centuries, while the remaining 20 percent may stay in the atmosphere for many thousands of years.

[430] United Nations. 2021. Global Methane Assessment. https://wedocs.unep.org/bitstream/handle/20.500.11822/35917/GMA_ES.pdf.

[431] Global Methane Pledge. https://www.globalmethanepledge.org/.

[432] United Nations Environment Programme. 2021. Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions. https://www.unep.org/resources/report/global-methane-assessment-benefits-and-costs-mitigating-methane-emissions?msclkid=00661370c85811eca078eb8fdbd603d1.

Figure 4-12: Sources of California methane emissions (2019)



Emissions from dairy and livestock operations come from two main sources: (1) enteric fermentation and (2) manure management operations, especially at dairies that employ open anaerobic lagoons that allow methane to escape into the atmosphere. Landfills, the second largest source of methane emissions, produce methane from the decomposition of organic waste. Although approximately 95 percent of all the waste that has been disposed of in the state has been deposited in a landfill that is equipped with a gas collection and control system, as required by California's Landfill Methane Regulation,[433] a portion of the methane still escapes into the atmosphere. Fugitive methane emissions can be intermittent and highly variable, both seasonally and spatially, particularly at landfills. Research has shown that landfills are complex systems and a wide range of conditions (e.g., atmospheric, operational, biological, chemical, and physical) may contribute to variability in rates of organic waste degradation, methane generation, and capture efficiency, so reducing the amount of organics deposited in landfills is critical to reducing overall landfill methane emissions. And despite the variability in individual landfill emissions, landfill gas collection and control systems remain the most effective strategy

[433] CARB. Landfill Methane Regulation. https://ww2.arb.ca.gov/our-work/programs/landfill-methane-regulation.

for reducing methane emissions from waste once it is placed in a landfill. Non-combustion methane emissions from the oil and gas sector are the third largest source of methane emissions in California. Almost three-quarters of the methane emissions from this sector come from leaks and venting from fossil gas transmission and distribution pipelines and equipment.

Hydrofluorocarbons

HFCs are synthetic GHGs that are powerful climate forcers. They are used mainly as refrigerants or heat transfer fluids in refrigeration, space conditioning, and heat pump equipment. Refrigerants are ubiquitous and are used everywhere from supermarkets, convenience stores, cold storage warehouses and wineries, to vending machines and residential and motor vehicle air-conditioners. Additionally, HFCs are also used as foam-blowing agents, solvents, aerosol-propellants, and fire suppressants. While HFCs remain in the atmosphere for a much shorter time than CO_2, the relative global warming potential (GWP) values of HFCs can be hundreds to thousands of times greater than CO_2. The mix of HFCs currently in use in California, weighted by usage (tonnage), have an average 100-year GWP of 1,700.[434] The average atmospheric lifetime of the mix of HFCs in use is 15 years.[435] Given the short average lifetimes, rapid reductions in HFC emissions can translate into near-term reductions in climate change effects.

As the global temperatures increase, the demand for cooling and refrigerants will continue to grow, as will the use of electric heat pumps to replace conventional fossil gas heating options. Unless addressed, continued use of high-GWP HFCs will perpetuate a feedback loop, where the cooling agents themselves cause additional warming.

In 2016, representatives from 197 nations signed the Kigali Amendment, which amended the existing Montreal Protocol (to reduce ozone-depleting substance production and consumption) to include a global phasedown in the production and consumption of HFCs beginning in 2019.[436] As of September 2022, 137 nations have either accepted, approved, or ratified the Kigali Amendment. On September 21, 2022, the U.S. Senate approved ratification of the Kigali Amendment, and it is expected that the United States

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[434] CARB. 2020. *Initial Statement of Reasons: Public Hearing to Consider the Proposed Amendments to the Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols-Propellants, and Foam End-Uses Regulation.* October 20. https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/isor.pdf?_ga=2.164659835.592460318.1646664679-912670513.1542398285.

[435] Zhongming, Z., et al. 2011. *HFCs: A Critical Link in Protecting Climate and the Ozone Layer: A UNEP Synthesis Report.*

[436] United Nations Treaty Collection. Chapter XXVII, Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer. https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-2-f&chapter=27&clang=_en.

will soon join the 137 nations that have already ratified.[437] In the United States, Congress enacted the federal *American Innovation and Manufacturing (AIM) Act* in December 2020.[438] The AIM Act authorizes the U.S. EPA to address HFCs in several ways, including a national HFC phasedown that nearly mirrors the schedule of the global phasedown under the Kigali amendment.[439]

Nearly 90 percent of HFC emissions in California come from their use as refrigerants in the commercial, industrial, residential, and transportation sectors. The timescales over which the HFC emissions occur vary, depending on the type of application. Thus, strategies to reduce HFC emissions must be tailored by equipment type. CARB has several measures in place to tackle HFC emissions from the various sources shown in Figure 4-13 below. This includes the Refrigerant Management Program[440] that tracks and manages emissions from large commercial, industrial, and cold storage refrigeration facilities in the state. CARB has adopted regulations to reduce HFC emissions from consumer product aerosol propellants, semiconductor manufacturing, and small cans of automotive refrigerant.[441]

In 2018, California adopted HFC prohibitions via regulation and legislation for several sectors, including stationary refrigeration and foam end uses to backstop the partially vacated federal Significant New Alternatives Policy (SNAP) program.[442] Most recently, in 2020, CARB adopted additional measures that place GWP limits on refrigerants used in refrigeration and air conditioning equipment, which are the largest sources of HFC emissions, and are commonly used in residential, commercial, and industrial buildings. Additionally, CARB adopted a unique pilot program requiring the use of reclaimed refrigerant: the Refrigerant Recovery, Reclaim, and Reuse (R4) Program. The newly adopted HFC rules for the refrigeration and air conditioning sectors are the first of their kind in the nation.

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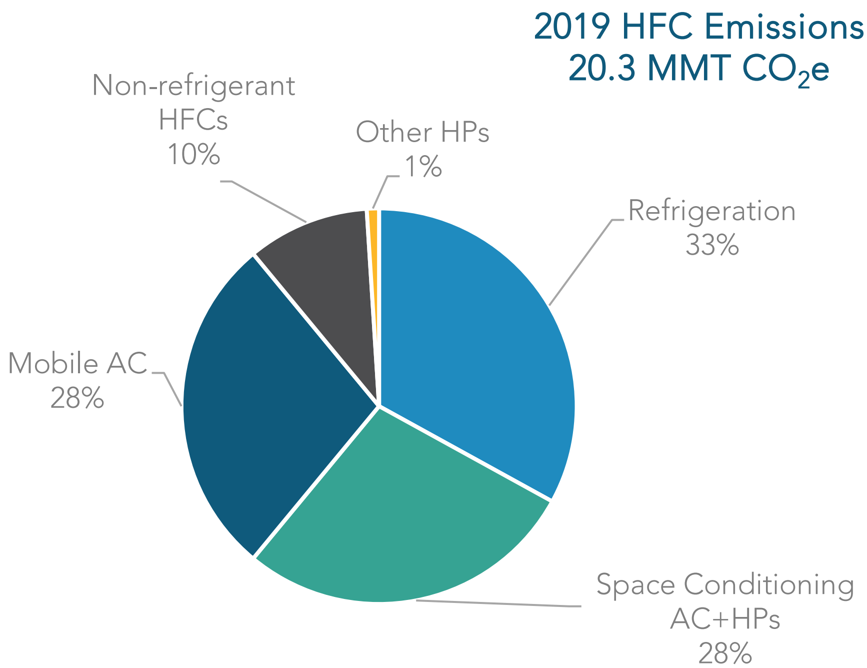
[437] U.S. Ratification of the Kigali Amendment - United States Department of State. https://www.state.gov/u-s-ratification-of-the-kigali-amendment/.
[438] 42 U.S.C § 7675, Pub. L. 116-260, § 103. https://www.epa.gov/sites/default/files/2021-03/documents/aim_act_section_103_of_h.r._133_consolidated_appropriations_act_2021.pdf.
[439] 42 U.S.C § 7675, Pub. L. 116-260, § 103.
[440] Cal. Code of Regs., tit. 17, §§ 95380, et seq.
[441] Contained in various sections, commencing with Cal. Code of Regs., tit. 13, §§ 1900 et seq.
[442] Cal. Code of Regs., tit. 17, §§ 95371, et seq.; California Cooling Act, Senate Bill 1013 (Lara, Stats. of 2018, Ch. 375, Health & Saf. Code § 39764).

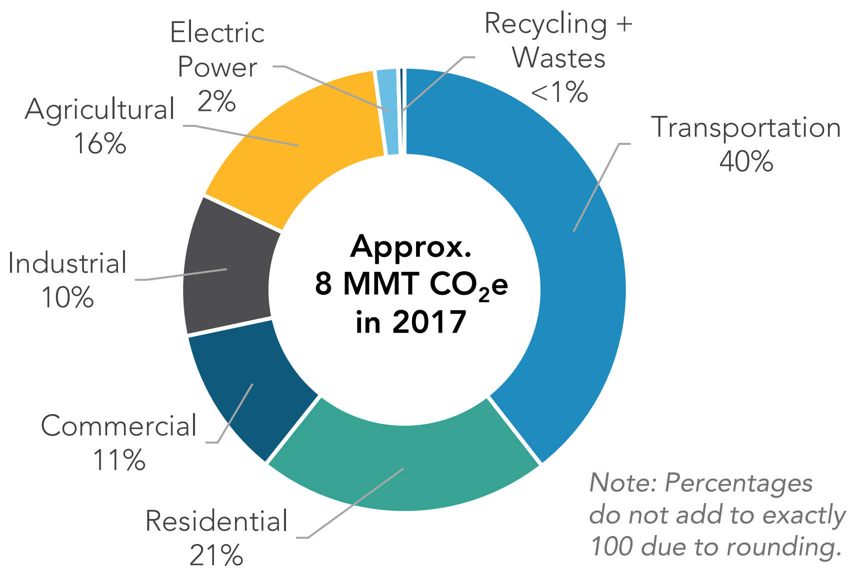
Figure 4-13: Sources of hydrofluorocarbon (HFC) emissions (2019)



Anthropogenic Black Carbon

Black carbon is not included in AB 32 or the state's AB 32 GHG inventory that tracks progress toward the state's climate targets; however, it has been identified as a powerful climate forcer and is included California's Short-Lived Climate Pollutant Reduction Strategy. The majority of anthropogenic black carbon emissions come from transportation, specifically heavy-duty vehicles, and they have decreased since 2013 due to engine certification standards and in-use rules for on-road and off-road fleets, along with clean fuel requirements and incentives, including California Climate Investments and LCFS credits. Additionally, fuel combustion for residential, commercial, and industrial applications contribute significantly to overall black carbon emissions. Approximately 95 percent of residential black carbon emissions are due to wood combustion; these emissions are being reduced through programs like the Woodsmoke Reduction Program established by SB 563 (Lara, Chapter 671, Statutes of 2017). Alternatives to agricultural burning and policies that phase out agricultural burning will also result in agricultural black carbon emissions reductions. In 2021 CARB provided a preliminary estimate of 2017 black carbon emissions (Figure 4-14).[443] This estimate will be finalized as part of a future update to the Short-Lived Climate Pollutant Inventory.

Figure 4-14: Sources of anthropogenic black carbon (preliminary 2017 estimates; AR5 100-yr GWP 900)



Sector Transition

California has long recognized the importance of mitigating non-combustion SLCPs and took several early action measures as part of a comprehensive, ongoing program to reduce in-state GHG emissions under AB 32. The early action measures included CARB's Landfill Methane Regulation,[444] Refrigerant Management Program,[445] and Oil and Gas Methane Regulation.[446]

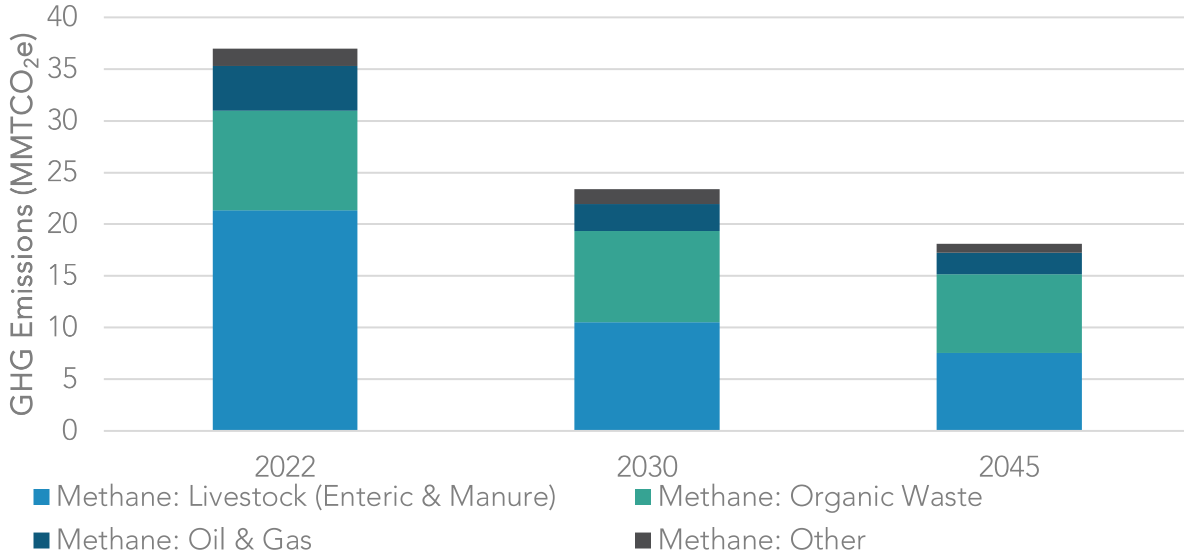
Methane

The methane abatement strategies currently in place are projected to achieve half of the methane emissions needed to meet the overall methane reduction target of SB 1383 (40 percent reduction by 2030). The reduction target translates to a limit of less than 24 $MMTCO_2e$ in 2030 (Figure 4-15). It is anticipated that, since some sectors have fewer

[443] CARB. 2021. 2022 Scoping Plan Update – Short-Lived Climate Pollutants Workshop Presentation, September 8. https://ww2.arb.ca.gov/sites/default/files/2021-09/carb_presentation_sp_slcp_september2021_1.pdf.
[444] Cal. Code of Regs., tit. 17, §§ 95460, et seq.
[445] Cal. Code of Regs., tit. 17, §§ 95380, et seq.
[446] Cal. Code of Regs., tit. 17, §§ 95665–77.

strategies that can be implemented to reduce methane in the near-term, other sectors will need to go beyond the 40 percent reduction to meet the target.

Figure 4-15: Methane emissions in 2022, 2030, and 2045 in the Scoping Plan Scenario[447]



Dairy and Livestock Methane

California is the largest dairy-producing state, home to one in five U.S. dairy cows. To date, methane emissions reductions from the dairy and livestock sector have mainly been driven by a decreasing animal population and the growing adoption of manure management strategies, including anaerobic digesters and conversion to dry manure systems and pasture systems. CARB recently completed a detailed analysis of the emission reductions expected by 2030 and the estimated additional investment needed to reach the dairy and livestock sector methane reduction target.[448]

Assuming no adoption of additional manure management and enteric mitigations strategies beyond the projects that have committed funding, and a continued annual animal population decrease of 0.5 percent per year through 2030, further reductions of approximately 4.4 $MMTCO_2e$ will be needed to achieve the 2030 methane emissions reduction target for the sector set by SB 1383. If the remaining reductions are met through

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[447] The *Organic Waste* category includes methane from landfills, wastewater treatment, and compost facilities.

[448] CARB. 2021. Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target. June. https://ww2.arb.ca.gov/sites/default/files/2021-06/draft-2030-dairy-livestock-ch4-analysis.pdf.

a mix of dairy projects in which half are dairy digesters and half are alternative manure management projects, then it is estimated that at least 420 additional projects will be necessary. Additional emissions reductions beyond this level will likely be necessary to ensure that the overall state methane emissions reduction targets are met.

Despite the considerable methane emissions mitigation potential of enteric strategies like feed additives, little progress has been made, as few products with proven mitigation potential have become commercially available, and unlike manure management strategies, there is a lack of financial incentives for their adoption.

Market conditions favoring farm consolidation and improved production efficiencies have driven reductions in the California and U.S. dairy population over the past decade. [449] These efficiency gains have allowed California to maintain production levels despite the decreasing population. If demand for dairy and beef products remains steady or increases, continued improvements in production efficiency and adoption of effective manure management and enteric mitigation strategies will be important to support dairy and livestock methane emission reductions.

Strategies for Achieving Success

- Install state of the art anaerobic digesters that maximize air and water quality protection, maximize biomethane capture, and direct biomethane to sectors that are hard to decarbonize or as a feedstock for energy.
- Increase alternative manure management projects, including but not limited to conversion to "solid," "dry," or "scrape" manure management; installation of a compost-bedded pack barn; an increase in the time animals spend on pasture; and implementation of solid-liquid separation technology into flush manure management systems.
- Implement enteric fermentation strategies that are cost-effective, scientifically proven, safe for animal and human health, and acceptable to consumers, and that do not impact animal productivity. Provide financial incentives for these strategies as needed.
- Accelerate demand for dairy and livestock product substitutes such as plant-based or cell-cultured dairy and livestock products to achieve reductions in animal populations.
- In consideration of pace of deployment of methane mitigation strategies and the scale of complimentary incentives, consider regulation development to ensure that the 2030 target is achieved, assuming the conditions outlined in SB 1383 are met.

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[449] MacDonald, James M., Jonathan Law, and Roberto Mosheim. 2020. *Consolidation in U.S. Dairy Farming.* ERR-274. July. https://www.ers.usda.gov/webdocs/publications/98901/err-274.pdf.

Landfill Methane

Achieving the 75 percent organic waste disposal reduction target[450] of SB 1383, and maintaining that level of disposal in subsequent years, would bring annual landfill emissions in 2030 to just below the 2013 baseline. Annual methane emissions will be higher through 2030 than originally anticipated by the SLCP Strategy because the state did not achieve the anticipated reductions in organic waste disposal of 50 percent below 2014 levels by 2020. SB 1383 prohibited the organic disposal regulations from taking effect until 2022,[451] and, as a result, emissions have continued to increase.

Due to the multidecadal time frame required to break down landfilled organic material, the emissions reductions from diverting organic material in one year are realized over the course of several decades. For example, one year of waste diversion in 2030 is expected to avoid 8 $MMTCO_2e$ of landfill emissions, cumulatively, over the lifetime of that waste's decomposition.[452] Near-term diversion efforts are critical to avoid locking in future landfill methane emissions.

CalRecycle's 2020 report, *Analysis of the Progress Toward the SB 1383 Waste Reduction Goals,*[453] estimated that 8 million short tons of composting and anerobic digestion capacity will be needed to manage organic wastes, above the existing and new capacity expected to be available by 2025. The 2019 report, *Co-Digestion Capacity in California,*[454] from the State Water Resources Control Board estimated that at least 2.4 million tons of digester capacity is available at urban wastewater treatment plants if sufficient incentives or funding for collection, receiving, and processing operations are provided to enable utilization of this capacity. The CPUC approved a decision in February 2022 implementing the biomethane procurement program, which will require investor-owned utilities by 2025 to procure 17.6 billion cubic feet (BCF) of biomethane produced from organic wastes to support the landfill disposal reduction and SLCP target and reduce fossil gas reliance for

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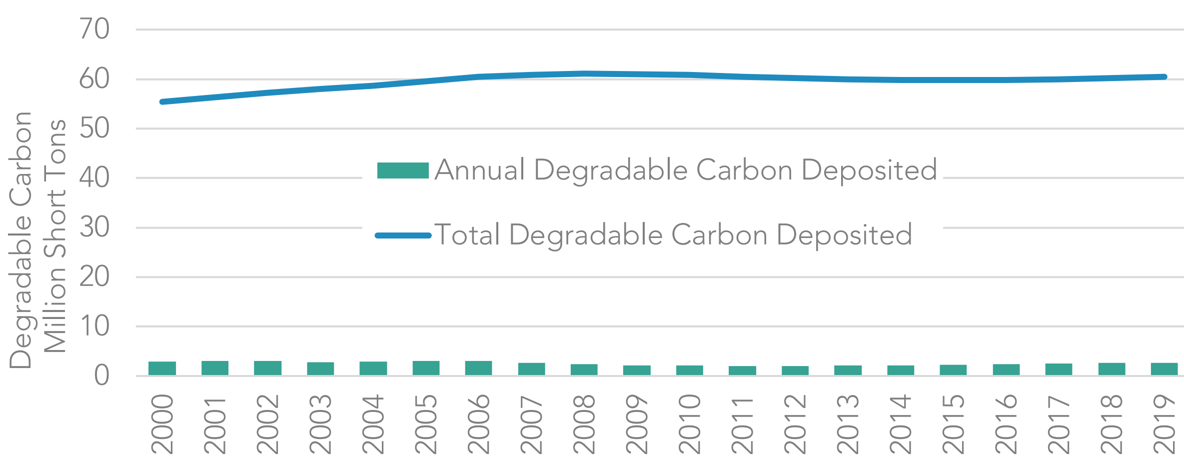
[450] The target is from 2014 levels by 2025.
Public Resources Code, § 42652.5. CalRecycle approved the SLCP: Organic Waste Reductions regulations (*https://calrecycle.ca.gov/organics/slcp/*) in 2020 and began implementing them in January 2022. These regulations are designed to achieve the 2025 disposal reduction and edible food recovery targets.
[452] The life cycle emissions reduction is based on anticipated diversion of 27 million short tons of organic waste from CalRecycle (2020) Analysis of the Progress Toward the SB 1383 Organic Waste Reduction Goals (*https://www2.calrecycle.ca.gov/Publications/Details/1693*). Under CalRecycle's SLCP regulations, an alternative to landfill disposal must achieve a life cycle GHG reduction of 0.3 $MTCO_2e$ per short ton of waste diverted.
[453] CalRecycle. 2020. *Analysis of the Progress Toward the SB 1383 Waste Reduction Goals.* *https://www2.calrecycle.ca.gov/Publications/Details/1693*.
[454] State Water Resources Control Board. 2019. *Co-Digestion Capacity in California.* *https://www.waterboards.ca.gov/water_issues/programs/climate/docs/co_digestion/final_co_digestion_capacity_in_california_report_only.pdf*.

residential and commercial customers.[455] Additionally, the organic waste stream includes more than one million tons of edible food that could be recovered before it enters the waste stream through food rescue programs that combat hunger in communities throughout California.

While reducing organic waste disposal is the most effective means of achieving reductions in waste sector methane, strategies to reduce emissions from waste already in place in landfills also will play a role in achieving near-term reductions. As Figure 4-16 shows, the total degradable carbon (a measure of the amount of waste with potential to generate methane) that is accumulated from waste deposited in previous years is over 20 times greater than the amount added each year. This illustrates that even if we were able to entirely phase out landfilling of organic waste today, the existing waste in place at landfills would continue to generate methane for decades into the future.

Through a combination of improvements in operational practices, use of lower permeability covers, advanced landfill gas collection systems, and increased monitoring to detect and repair leaks, it is estimated that a direct emission reduction of 10 percent is achievable across the state's landfills by 2030. Technologies to utilize landfill gas efficiently can contribute further emission reductions in the energy sector.

Figure 4-16: Degradable carbon deposited in landfills



Strategies for Achieving Success

- Maximize existing infrastructure and expand it to reduce landfill disposal, with strategies including composting, anaerobic digestion, co-digestion at wastewater treatment plants, and other non-combustion conversion technologies.

455 CPUC. 2022. Decision 22-02-025.

- Expand markets for products made from organic waste, including through recognition of the co-benefits of compost, biochar, and other products.[456]
- Recover edible food to combat food insecurity.
- Invest in the infrastructure needed to support growth in organic recycling capacity.
- Utilize existing digesters at wastewater treatment facilities to rapidly expand food waste digestion capacity.
- Direct biomethane captured from landfills and organic waste digesters to sectors that are hard to decarbonize.
- Implement improved technologies and best management practices at composting and digestion operations.
- Reduce emissions from landfills through improvements in operational practices, lower permeability covers, advanced collection systems, and technologies to utilize landfill gas.
- Leverage advances in remote sensing capabilities to quickly pinpoint large methane sources and mitigate leaks, improve understanding of the factors that lead to better capture efficiency, and explore new technologies and practices that can reliably improve methane control at landfills.

Upstream Oil and Gas Methane Reduction

For oil and gas production, processing, and storage, California is currently on track to achieve a 41 percent reduction in methane emissions by 2025 relative to 2013. The additional reductions needed to meet the 2030 target may be achieved by implementing additional regulatory requirements to further reduce intentional venting of fossil gas from equipment. If necessary, additional reductions from transmission and distribution facilities may be achieved by requiring the utilities to increase inspection and repair activities or further reduce emissions from pipeline blowdowns by implementing methods such as using portable compressors, using plugs to isolate sections of pipelines, flaring vented gas, routing gas to fuel gas systems, and installing static seals on compressor rods. Advances in methane detection technologies (e.g., satellites equipped to detect large methane sources) may also help to identify and mitigate methane emissions quickly across the oil and gas sector.

As California transitions away from fossil fuels, in-state oil and gas production will likely decline. This could result in an increase over time in the number of long-term idle and orphan wells (idle wells lacking a financially solvent, responsible owner) in the state. While California has regulations aimed at helping ensure operators manage their idle wells,

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[456] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F4.4. finalejacrecs.pdf (arb.ca.gov).

there could likely be an increase in California's orphan well population. Plugging all orphan wells, of which there are currently over 5,000, could take decades due to the limited resources California has for orphan well plugging. The benefits from plugging wells include methane emission reductions and job creation; employment gains from well plugging and site remediation activities could help temporarily offset job losses from the oil and gas industry. The California Council on Science and Technology's 2018 report on orphan wells, *Orphan Wells in California: An Initial Assessment of the State's Potential Liabilities to Plug and Decommission Orphan Oil and Gas Wells,*[457] found that the potential cost to the state of plugging current orphan wells could be approximately $500 million, and the cost of plugging all active and idle wells could total over $9.1 billion. As oil and gas production in California declines due to reduced demand for fossil fuels, additional funding will likely be needed to cover the costs of plugging wells that have no viable operator.

Strategies for Achieving Success

- Mitigate emissions from leaks by regular leak detection and repair (LDAR) surveys at all facilities.
- Replace high emitting equipment with zero emission alternatives wherever feasible.[458]
- Have CARB and CalGEM lead a Task Force to identify and address methane leaks from oil infrastructure near communities.
- Pursuant to SB 1137, develop leak detection and repair plans for facilities in health protection zones, implement emission detection system standards, and provide public access to emissions data.
- Minimize emissions from equipment that must vent fossil gas by design (e.g., fossil gas powered compressors).
- Install vapor collection systems on high emitting equipment.
- Phase out venting and routine flaring of associated gas (gas produced as a by-product during oil production).
- Continuous ambient monitoring at fossil gas underground storage facilities to quickly detect large methane sources.
- Reduce pipeline and compressor blowdown emissions.

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[457] The California Council on Science and Technology. 2018. *Orphan Wells in California: An Initial Assessment of the State's Potential Liabilities to Plug and Decommission Orphan Oil and Gas Wells.* https://ccst.us/wp-content/uploads/CCST-Orphan-Wells-in-California-An-Initial-Assessment.pdf.

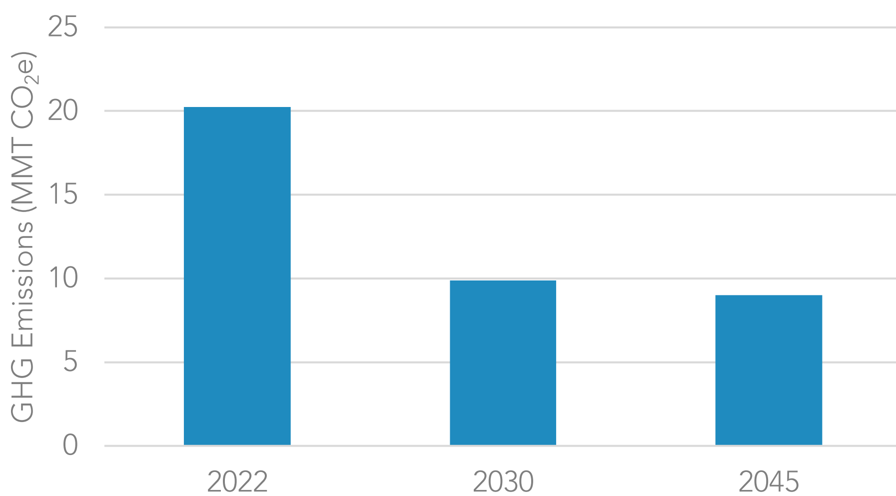
[458] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, P5. finalejacrecs.pdf (arb.ca.gov).

- Leverage advances in remote sensing capabilities to quickly pinpoint large methane sources and mitigate leaks.[459]

Hydrofluorocarbons

In California, all the HFC measures currently in place will help achieve more than 70 percent of the reductions needed to achieve the 2030 HFC goal and provide very significant emissions reductions by 2045 and beyond. However, new targeted measures will be needed to maintain the pace of reductions, as demand for technologies that currently predominantly use high-GWP refrigerants is anticipated to grow. Despite decarbonization efforts, high-GWP HFCs are expected to be among the last remaining persistent GHG emission sources, as shown in Figure 4-17.[460]

Figure 4-17: Hydrofluorocarbon emissions in 2022, 2030, and 2045 in the Scoping Plan Scenario



HFC emissions from new and existing sources should be addressed in tandem with building decarbonization efforts to maximize reductions.[461] As buildings are electrified in an effort to decarbonize them, the use of heat pumps for space conditioning, water heaters, and clothes dryers is expected to increase significantly. Heat pumps, while using

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[459] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, CC17. finalejacrecs.pdf (arb.ca.gov).

[460] Energy and Environmental Economics, Inc. 2020. *Achieving Carbon Neutrality.* https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf.

[461] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF26. finalejacrecs.pdf (arb.ca.gov).

electricity, not fossil gas, currently rely predominantly on high-GWP refrigerants. Very low- or no-GWP technologies and solutions are either available or emerging for various heat pump technologies, and likely to develop further as international efforts to mitigate HFCs continue. However, most of these technologies are still nascent in the United States. In addition, some of the alternatives cannot be used until California building codes are updated, which is currently expected at the earliest in mid-2024 for some technologies based on the recently adopted provisions in AB 209[462] requiring the California Building Standards Commission to adopt the latest safety standards for refrigerant containing equipment into California's building codes. The current updates to the building codes will allow the use of many refrigerants with lower GWPs than HFCs currently in use. However, additional building code updates are needed to expand the choices of ultra-low-GWP alternatives, and that will need to happen in the next few years. The adoption of low-GWP refrigerants must occur in parallel with building decarbonization efforts; without such efforts, the vast GHG benefits of the latter will be partially offset, and the proportion of HFC emissions from buildings will continue to grow.

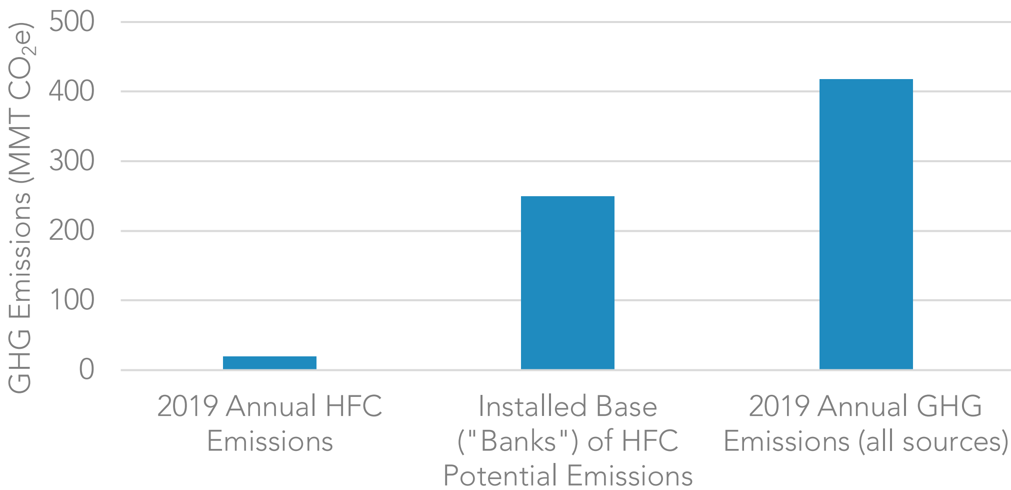
Leaks from existing air conditioning and refrigeration equipment are a major source of statewide and global HFC emissions. Once installed, refrigeration and air conditioning equipment can stay in place for decades, while leaking refrigerants into the atmosphere. This makes it very important that new installed equipment use refrigerants with a GWP as low as possible. The refrigerants inside existing equipment are sometimes collectively referred to as the *installed base* or *banks* of potential HFC emissions. If released spontaneously, the existing HFC banks would equal 60 percent of all annual statewide GHG emissions in California, as illustrated in Figure 4-18.[463]

The sales prohibitions on newly produced refrigerants set forth in SB 1206 (2022) and the national/international HFC phasedown will help in reducing HFC emissions from existing equipment by restricting the supply of and increasing the value of existing high-GWP HFCs, thus enabling a circular economy. In the 2022–2023 state budget, CARB received $45 million in incentive funding for climate-friendly refrigerant technologies; this funding will be critical in shifting the market toward the best available refrigerant technologies in various sectors.

[462] AB 209: Energy and climate change. *https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB209.*

[463] CARB. 2021. 2022 Scoping Plan Update – Short-Lived Climate Pollutants Workshop Presentation. September 8. *https://ww2.arb.ca.gov/sites/default/files/2021-09/carb_presentation_sp_slcp_september2021_1.pdf*.

Figure 4-18: Potential emissions from refrigerants in existing equipment



Strategies for Achieving Success

- Expand the use of very low- or no-GWP technologies in all HFC end-use sectors, including emerging sectors, like heat pumps for applications other than space conditioning, to maximize the benefits of building decarbonization.[464]
- Convert large HFC emitters such as existing refrigeration systems to the lowest practical GWP technologies.[465]
- Prioritize small-scale and independent grocers serving priority populations in addressing existing "banks" of high-GWP refrigerants.[466]
- Improve recovery, reclamation, and reuse of refrigerants by limiting sales of new or virgin high-GWP refrigerants and requiring the use of reclaimed refrigerants where appropriate.[467]
- Assist low-income and disadvantaged communities in obtaining low-GWP space conditioning units to protect vulnerable communities from heat stress and wildfire smoke.[468]

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[464] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF26. finalejacrecs.pdf (arb.ca.gov).

[465] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF22. finalejacrecs.pdf (arb.ca.gov).

[466] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, JT5 and JT6. finalejacrecs.pdf (arb.ca.gov).

[467] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, JT1. finalejacrecs.pdf (arb.ca.gov).

[468] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, NF28, JT5, and JT6. finalejacrecs.pdf (arb.ca.gov).

- Accelerate technology transitions in California and the U.S. overall by collaborating with international partners committed to taking action on HFCs under the Kigali Amendment to the Montreal Protocol; this includes addressing barriers to adoption of very low- or no-GWP refrigerant technologies such as high upfront costs, shortage of trained technicians, and lag in updating safety standards and building codes.

Anthropogenic Black Carbon

Significant progress has been made since 2013 to reduce anthropogenic black carbon emissions, primarily from decreased combustion of distillate fuels in the agricultural sector, as well as improvements to provide cleaner, on-road combustion technologies. Under current strategies, anthropogenic black carbon from transportation is expected to be reduced by over 60 percent in 2030. Continued reductions in combustion emissions across all sectors from both the state's climate and air quality programs will also help reduce anthropogenic black carbon emissions going forward.

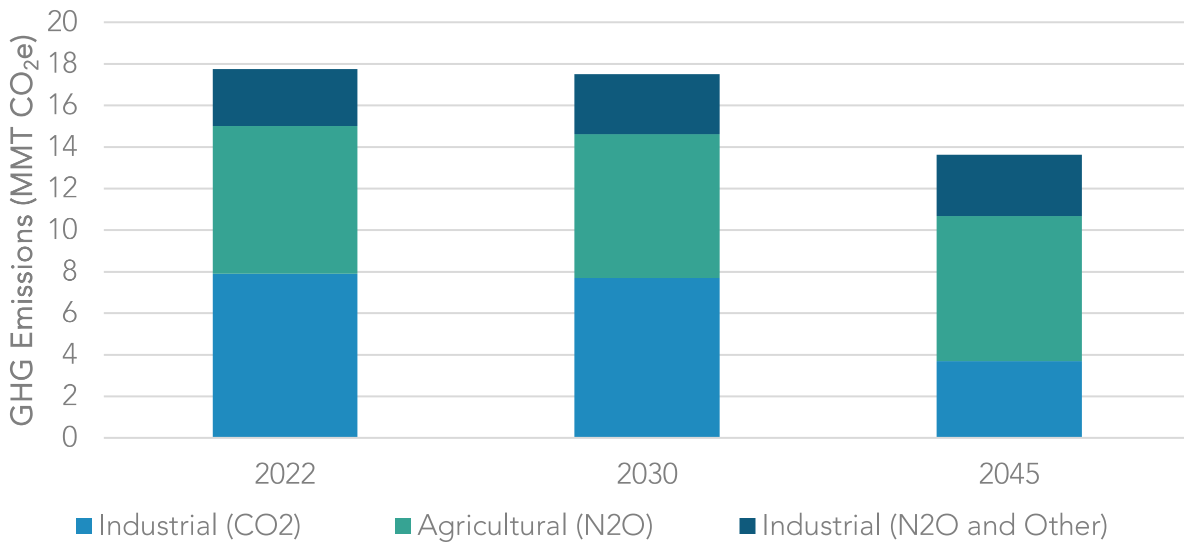
Strategies for Achieving Success

- Reduce fuel combustion commensurate with state's climate and air quality programs, particularly from reductions in transportation emissions and agricultural equipment emissions.[469]
- Invest in residential woodsmoke reduction.

In addition to SLCP emissions, some remaining non-combustion emissions are anticipated to persist in the coming decades, as shown in Figure 4-19. These include CO_2 from industrial processes such as cement manufacturing, oil and gas extraction, and geothermal electric power; N_2O from wastewater treatment, fertilizers, and livestock manure applied to agricultural soils; and other industrial, non-HFC GHG emissions.

[469] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, F1A and Appendix A (Table Summary of Direct Emission Reduction Strategies). "Emissions reductions from energy consumed by California's agricultural sector, including post-harvest processing, use of tractors and other farm equipment, and water import and irrigation." *finalejacrecs.pdf (arb.ca.gov)*.

Figure 4-19: Remaining non-combustion emissions in 2022, 2030, and 2045 in the Scoping Plan Scenario



Natural and Working Lands

California's natural and working lands (NWL) cover approximately 90 percent of the state's 105 million acres,[470] and include forests, grasslands, shrublands and chaparral, croplands, wetlands, sparsely vegetated lands, and the green spaces in urban and built environments. These lands include California Native American tribes' ancestral and cultural lands, parks and green spaces in our cities and communities, and the waters and the iconic landscapes we know and love. The diverse landscapes and biodiversity found throughout California's NWL provide a multitude of benefits to the people of California, including clean water, clean air, biodiversity, food, economic prosperity, recreational opportunities, continuation of traditional tribal ways of life, mental health benefits, and many others.

Our lands are a critical sector in California's fight to achieve carbon neutrality and build resilience to the impacts of climate change. Healthy land can sequester and store atmospheric CO_2. Healthy lands also can reduce emissions of powerful SLCPs, limit the release of future GHG emissions, protect people and nature from the impacts of climate change, and build our resilience to future climate risks. Creation of healthy lands through

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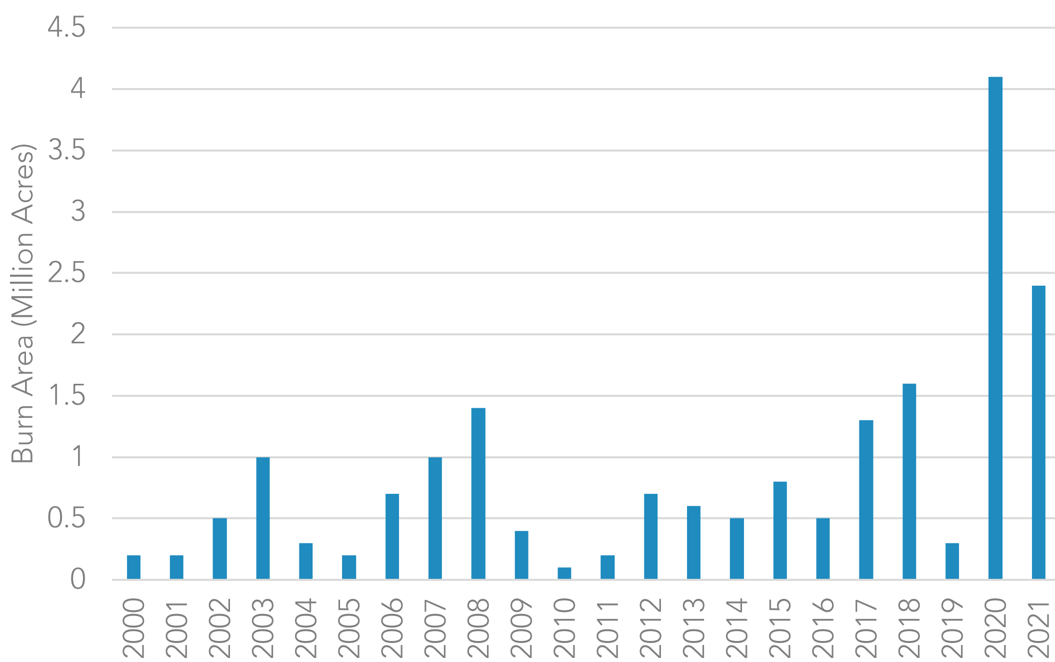
[470] CNRA. 2022. Natural and Working Lands Climate Smart Strategy. https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf.

multi-benefit and mitigation measures can also support tribal and local traditional lifeways. Unhealthy lands have the opposite effect—they release more GHGs than they store and are more vulnerable to future climate change impacts.

Climate change impacts have become more apparent in recent years and are having significant effects on communities throughout the state. One of these impacts is the much more frequent occurrence of unusually large, high-severity wildfires, which are being driven by climate change and by a recent history of fire-exclusion and land management practices that have resulted in forests with high levels of biomass. These recent large and high-severity wildfires have resulted in a significant amount of burned acreage and emissions in California (Figure 4-20).[471]

Figure 4-20: Acreage of burned wildland vegetation area



These wildfires deviate from the lower-severity fires that previously occurred at frequent intervals, around which California's forests evolved. As climate change accelerates, these large, uncharacteristic wildfires are likely to become more common and impact more of our landscapes. Climate change is also expected to have other significant effects on our lands, including more extreme droughts, floods, extreme heat, and the spread of invasive aquatic and terrestrial species, pests, diseases, and parasites. These impacts can lead

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[471] CARB. 2022. Wildfire Emission Estimates for 2021. https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/Wildfire%20Emission%20Estimates%202000-2021.pdf.

to negative feedback loops on human and ecological health; for example, increasing the spread of invasive species can lead to increases in pesticide use, if not managed through regulation or mitigation, which can pose risks to human health and the environment.

California's approach to climate action in the NWL sector is not solely focused on maximizing carbon stocks but instead on supporting carbon management that holistically fosters ecosystem health, resilience, provision of overall climate function, and other co-benefits.

Natural systems operate on a longer timescale than the energy and industrial sectors, and benefits from climate action on our lands can take decades to accrue. Scaling climate smart land management in California requires taking action now and playing the "long game" by establishing and maintaining consistent, patient approaches and programs.

Landscapes

For the first time, this Scoping Plan includes modeling for the NWL sector. The focus of the initial modeling is limited to seven land types that align with the those in the NWL Climate Smart Strategy.[472] Work will continue to incorporate more landscapes and management practices into the modeling over time. The initial landscapes included in the modeling for this Scoping Plan are:

- Forests
- Shrublands and Chapparal
- Grasslands
- Croplands
- Wetlands
- Developed Lands
- Sparsely Vegetated Lands

Each of these land types are a key component to the state's approach to increasing climate action in the NWL sector, as called for in Executive Order N-82-20 and AB 1757.[473] The Executive Order directs CARB to update the target for this sector in support of carbon neutrality by 2045 as part of this Scoping Plan, and to take into consideration the NWL Climate Smart Strategy. AB 1757 calls for the development of an

[472] CNRA. 2022. *Natural and Working Lands Climate Smart Strategy. Appendix B.* *https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/Appendix-B_04132022_ada.pdf*.

[473] AB 1757 California Global Warming Solutions Act of 2006: Climate Goal: Natural and Working Lands. *https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB1757*.

ambitious range of targets for the NWL sector to be integrated into the Scoping Plan and other state policies. It directs CARB and CNRA to work closely together to update the NWL Climate Smart Strategy, and establish an expert advisory committee to inform and advise on NWL modeling, targets, and implementation strategies.[474] Additionally, in 2021, the governor signed SB 27[475] (Skinner, Chapter 237, Statutes of 2021) into law. It directed CARB to establish CO_2 removal targets for 2030 and beyond and take into consideration the NWL Climate Smart Strategy. The governor's Executive Order, AB 1757, and SB 27 go beyond previous direction from the Legislature and past administrations. These directives emphasize the importance of quantifying land-based carbon both statewide,[476] and in programs and policies,[477] setting targets[478] for NWL to support the state's climate objectives, and advancing land management actions[479] that support the health and resiliency of these lands.

Blue carbon (also known as carbon captured and held in coastal vegetation and soils, such as seagrasses, seaweeds, and wetlands)—is also important to consider as we look at long-term climate goals. While this landscape is not currently covered by IPCC inventory guidelines or included in California's NWL Inventory, the United States was the first nation to include blue carbon in its national GHG emissions inventory. California's Ocean Protection Council and San Francisco Estuary Institute are partnering to create a new coastal wetlands, beaches, and watersheds inventory. CARB staff will utilize information from this effort and assess other available data to evaluate how this landscape may be integrated into our efforts in the future as more data become available.[480]

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[474] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N20. [finalejacrecs.pdf (arb.ca.gov)](https://ww2.arb.ca.gov).
[475] SB 27 Carbon sequestration: state goals: natural and working lands: registry of projects. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB27.
[476] SB 859 Public resources: greenhouse gas emissions and biomass (SB 859, Committee on Budget and Fiscal Review, Chapter 368, Statutes of 2016). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB859.
[477] SB 1386. Resource conservation: working and natural lands. (SB 1386, Chapter 545, Statutes of 2016). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1386.
[478] CARB. 2017. 2017 Climate Change Scoping Plan Update. Board Resolution 17-46. https://ww2.arb.ca.gov/sites/default/files/barcu/board/res/2017/res17-46.pdf.
[479] Executive Department. State of California. EO B-52-18. https://www.ca.gov/archive/gov39/wp-content/uploads/2018/05/5.10.18-Forest-EO.pdf.
[480] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N2. finalejacrecs.pdf (arb.ca.gov).

Trends of Carbon on Landscapes

CARB currently tracks the carbon stock changes though the Inventory of Ecosystem Carbon in California's Lands[481] (NWL Inventory), which is summarized in Chapter 1. The NWL Inventory is a key tool for tracking changes in carbon stocks across the state, and it will serve as the inventory of record for this sector, tracking sector-wide progress toward the target. The NWL Inventory provides a retrospective snapshot of the status of California's lands, and captures the gains or losses of carbon stocks that occur over time. In addition to tracking carbon stock changes, the NWL Inventory is an important tool for understanding the impacts of our efforts to increase climate action in this sector (such as those identified in this Scoping Plan and the NWL Climate Smart Strategy) on NWL carbon stocks. The inventory is also used as the foundation for Scoping Plan scenario modeling and target setting.

CARB's inventory shows that carbon stocks decreased in NWL lands from 2001 to 2011, releasing more carbon than they were storing, and then increased slightly from 2012 to 2014.[482] These trends highlight the interannual and interdecadal variability of lands and their ability to be both a source and a sink of carbon, and the importance of looking at NWL data and trends over multiyear and multidecadal time periods, as opposed to looking only at annual changes. This movement is part of the Earth's carbon cycle, where carbon transfers between the land, ocean, and atmosphere. As part of the carbon cycle, over decades or centuries, fire and plant respiration and decomposition move carbon from the land to the atmosphere, while plant growth and other processes move carbon from the atmosphere to the land. Emissions from fossil-fuel combustion are contributing to putting this cycle out of balance.

Additionally, some historic land management practices that have resulted in the loss of carbon from the soil are also contributing to the atmospheric rise of CO_2 while simultaneously exacerbating the imbalance of the water cycle, which is influenced by and linked to the carbon cycle. These emissions are also contributing to a feedback loop for California's lands: as CO_2 emissions accumulate in the atmosphere—and California experiences more warming, extreme heat events, and droughts—the risk and intensity of carbon losses also increases, which in turn transfers more carbon from the land to the atmosphere. And because forests and shrublands comprise approximately 85 percent of the carbon stocks in California, management strategies and disturbances in forest and

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[481] CARB. *An Inventory of Ecosystem Carbon in California's Natural & Working Lands.* 2018 Edition. nwl_inventory.pdf (ca.gov). Accessed 3/2/2022.
[482] These trends are consistent estimates in the most recent AB 1504 reporting period.

shrubland carbon play an important role in determining whether California's lands are providing either net carbon sequestration or net emissions on an annual basis.

The gains and losses of carbon on our lands will fluctuate in the future; what is important is to restore carbon in places where it has been lost and reduce large carbon losses on our NWL through active, attentive, and adaptive management. For additional details on the nexus between NWL and GHGs, see pages 5–6 of the NWL Climate Smart Strategy.

Goals and Accelerating Nature-Based Solutions

The state's climate mitigation targets are traditionally identified by individual years, (i.e., tons of GHG emissions in 2020 or 2030). However, because NWL processes fluctuate year to year and because it can sometimes take decades for climate action to fully impact carbon in NWL, it is important to consider the statewide, long-term trends of carbon stock change when identifying how this sector contributes to California's pathway to achieving carbon neutrality. Tracking carbon stock change over a multi-decadal period is the best way to assess the full direct impact climate action has on carbon storage. Such an approach filters out fluctuations from year-to-year weather variations and multi-year natural climate cycles, such as El Niño patterns.

Current data sources and methods allow us to track only certain carbon stocks that exist on NWL. For target tracking to be successful, each carbon pool must be inventoried using a methodology that can detect changes due to management and climate change. Certain carbon pools lack the scientific data and methodologies necessary for target-setting and tracking. For example, soils in forests, shrublands, and grasslands are not included in the Scoping Plan carbon stock target because, currently, there is no way to track statewide soil carbon through time in a way that would capture the effects of increased climate action and climate change.

When considering how NWL contribute to the state's goal of carbon neutrality, all lands' carbon stock gains and losses must be considered, and the Scoping Plan target is set in these terms. It is not sufficient to aggregate climate benefits only within areas where projects, management, or climate action occur. Much of the state does not receive active or quantifiable management, but these areas still contribute to the state's overall carbon stock change and GHG emissions. To incorporate the entire carbon balance toward true carbon neutrality, the Scoping Plan target is set in terms of carbon stock change across the entire state. This incorporates all lands that both receive and do not receive active management, and includes the end result of all sequestration, emissions, and other changes to carbon on the landscape.

However, carbon stock change is not equivalent to emissions. Currently, the data and emission quantification science is not sufficient to enable inventories to comprehensively track all NWL emissions in a way that would enable us to set an NWL target in terms of statewide emissions and sequestration. There is a great need, across the entire NWL sector statewide, for more empirical data, science, and tools to track all carbon stocks across each carbon pool, and to begin to track emission and sequestration rates. As California implements AB 1757, there is an opportunity to update the data, science, and tools to enable this level of tracking and target setting in the future.

As outlined in Chapter 2, California is projected to lose carbon stocks over the coming decades, but this Scoping Plan analysis also shows that increasing the pace and scale of climate smart land management in California will reduce the carbon stock losses and GHG emissions from the NWL sector. In response to EO N-82-20 and AB 1757, the proposed target for NWL is shown in Table 4-1.

Table 4-1: Scoping Plan modeled target for NWL, based on increasing action on NWL

	Total Carbon Stock % Change from 2014
2045	-4

Achieving this target will require significant expansion of the pace and scale of climate action on California's NWL, including the following:

- Increasing climate smart forest, shrubland, and grassland management to at least 2.3 million acres a year—an approximate 10x increase in management from current levels.
- Increasing climate smart agricultural practices by at least 78,000 acres adopted a year, annually conserving at least 8,000 acres a year of croplands, and increasing organic agriculture to comprise at least 20 percent of cultivated acres in California by 2045—an approximate 7.5x increase in healthy soils practices from previous levels and a 2x increase in total acres of organic agriculture.
- Increasing annual investment in urban trees in developed lands by at least 200 percent above historic levels and establishing defensible space on all parcels by 2045.
- Restoring at least 60,000 acres, or approximately 15 percent of all Sacramento–San Joaquin River Delta (Delta) wetlands, by 2045.
- Cutting land conversion of deserts and sparsely vegetated landscapes by at least 50 percent annually from current levels, starting in 2025.

If the carbon stock target above is met, and the management actions above are implemented, the modeling for NWL indicates that California's lands will be a net source of emissions, producing approximately 7 $MMTCO_2e$ of average annual emissions.

Additional climate smart management practices and additional landscapes, such as those included in the Climate Smart Strategy and discussed below in Additional Management Strategies, have the potential to increase carbon stocks and reduce GHG emissions from NWL beyond the levels modeled for this Scoping Plan.

The purpose of the NWL target and the above estimated outcomes is to provide a numerical guide that can support the state's efforts to accelerate both near-term and long-term climate action on California's lands, prioritizing durable solutions that deliver multiple outcomes. Taking these actions over the coming decades will reduce the potential carbon losses from NWL, reduce GHG emissions from some landscape types (such as croplands and Delta wetlands), and support sequestration of GHGs from NWL between 2025 and 2045. These actions will also deliver significant benefits to Californians beyond advancing our climate goals, such as reducing wildfire emissions and their associated health impacts, increasing habitat for biodiversity, reducing urban heat island effects, reducing harmful pesticide exposure, expanding economic opportunities, and others. Additional information on several economic and health outcomes from the Scoping Plan Scenario is included in Chapters 2 and 3.

Statewide planning and target setting for the NWL sector will only create meaningful change if followed by effective on-the-ground implementation. State government cannot accomplish this implementation alone. Effective large scale climate action is dependent on partnerships among tribal, federal, state, regional, and local partners, and across governmental, private, nonprofit, and commercial sectors. The NWL sector of the Scoping Plan sets a carbon target with climate action recommendations that can be used to achieve the quantified carbon, health, and economic outcomes. Implementation of these actions must be led by local or regional partnerships that plan and execute projects appropriate to the specific conditions. The technical expertise and local knowledge of land managers and stewards in all sectors must be elevated to ensure relevant, efficient, and effective climate action.

Implementation of climate action should contribute to state targets, maximize local benefits, and alleviate environmental injustices and other social inequities. On-the-ground action is largely executed and managed by local and regional actors, but state government agencies must support communities across the state in implementing nature-based climate solutions that address statewide objectives, such as the Scoping Plan carbon target. This includes providing resources and developing frameworks, while greatly increasing capacity and technical assistance to assist and empower local partners. Examples of how this can be done are the Regional Forest and Fire Capacity Program within the forestry sector, the UC Cooperative Extension in the agricultural and forestry sectors—as well as the work of the state's 10 regional Conservancies. These programs provide strong examples to emulate as they facilitate statewide coordination, and information and resource transfer from the state to the regional and local levels. The Regional Forest and Fire Capacity Program provides funding for local and regional groups to build their organizational capacity to plan and implement wildfire and forest management projects that are informed by their own local expertise. The UC Cooperative Extension is an example of how the state provides technical assistance to local landowners and community organizations, helping them apply the latest science-based management strategies to their lands. California's regional Conservancies play a pivotal role in implementing regional conservation, restoration, and land management efforts through activities such as grant funding, science generation, and planning assistance.

The state also has identified the need to incorporate and elevate traditional indigenous knowledge into climate action on the regional and local scales. Accomplishing this requires close partnerships with tribes for mutual knowledge and resource sharing, while protecting culturally sensitive knowledge and resources. As Tribes are sovereign nations with specialized cultural knowledge and experience in managing lands, climate action on these lands that contribute to the State of California's climate targets can only be accomplished with the full participation and under the leadership of the Tribes that govern those lands.

Strategies for Achieving Success: Crosscutting Items for all NWL

- Implement AB 1757 and SB 27.
- Implement the Climate Smart Strategy.
- Accelerate the pace and scale of climate smart action, consistent with the management levels identified above, as part of a collective effort between federal, state, private, nonprofit, and individual land managers.
- Prioritize and practice equity, including through meaningful community engagement and prioritizing implementation of nature-based solutions that benefit the communities most vulnerable to climate change.[483]
- Advance multi-benefit, collaborative, landscape-level approaches that engage communities and landowners, and incorporate adaptive managements.
- Consult and partner with California Native American tribes to increase co-management and tribal management authority; restore, protect, and enhance natural cultural resources, traditional foods, and cultural landscapes; respect tribal sovereignty; and support tribes' implementation of tribal expertise and Traditional Ecological Knowledge and cultural easements.[484]

[483] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N8. finalejacrecs.pdf (arb.ca.gov).
[484] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N1, N6, N16, N17, N18. finalejacrecs.pdf (arb.ca.gov).

- Leverage existing innovative financial and market mechanisms, and explore new ones, between the public, private, and philanthropic sectors to secure funding of climate smart land management.
- In partnership with communities, tribes, and the private sector, expand and develop new infrastructure for manufacturing and processing of climate smart agricultural and biomass products.
- Leverage and support technical assistance providers: such as the UC Cooperative Extension and California's 98 Resource Conservation Districts, that have track records of providing technical assistance to local landowners and implementing agriculture, forestry, natural resource management, and restoration projects across the state.
- Establish and expand mechanisms that ensure NWL are protected from land conversion and parcelization (e.g., conservation easements or Williamson Act), in line with the strategies outlined in CNRA's Pathways to 30x30 California.[485,486] Pair land conservation projects with management plans that increase carbon sequestration, where feasible.
- Increase opportunities for private and philanthropic investments in nature-based climate solutions, utilizing existing voluntary and compliance carbon markets, existing state and local programs, and the California Carbon Sequestration and Climate Resiliency Project Registry established pursuant to SB 27.
- Expand monitoring and tracking of management actions and outcomes consistent with the tracking and monitoring recommendations of the Climate Smart Strategy.

Forests, Shrublands, and Chaparral

At roughly 29 million acres, forests cover 27 percent of California. Shrublands and chaparral cover 31 percent of the state; roughly 33 million acres. Both types are distinct, with their own ecological dynamics and management strategies, and are modeled within a single model that is calibrated to treat them uniquely.

Together, forests, shrublands, and chaparral support a high biodiversity of plants and animals, in addition to high levels of carbon stocks. They provide important air and water quality benefits to all Californians, as well as recreational opportunities and, for forests, harvested wood products for the state. These landscapes are fire-adapted, and historical tribal management of these lands has fostered ecosystem health and resilience. Over the past century, these lands have been impacted severely by fire exclusion, including

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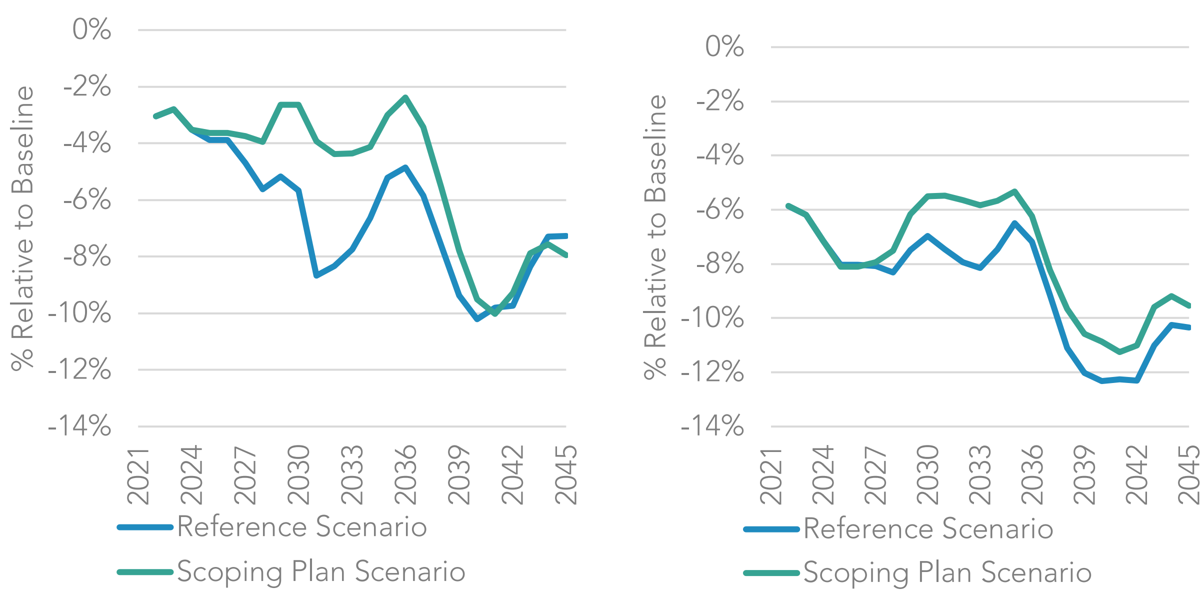
[485] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N5, N26, N27. finalejacrecs.pdf (arb.ca.gov).
[486] CNRA. 2022. *Pathways to 30x30 California*. https://www.californianature.ca.gov/pages/30x30.

exclusion of indigenous people's management and past management practices, which has resulted in less resilient ecosystems and communities and more destructive wildfires today. This, along with drought induced stress and mortality, has changed these landscapes from a carbon sink to a carbon source. Climate smart management can help make forests more resilient to climate change and less prone to catastrophic wildfire. Climate-smart management in shrublands and chaparral face additional challenges and uncertainty, but can still provide protection for threatened communities and natural resources. This management, if conducted on a regular basis to maintain forest health, can help reduce emissions from forests, shrublands, and chaparral, and help strengthen and maintain the co-benefits that Californians experience from them.

Under all management levels, forests and shrublands are expected to lose carbon over the next two decades due to climate change and wildfire (Figure 4-21).

Figure 4-21: Forest (left) and shrubland (right) carbon stocks by 2045[487,488]



While this decrease in carbon stocks may be inevitable, forest management under the Scoping Plan Scenario can help direct where and how carbon loss occurs. By proactively managing forests and shrublands, the loss of carbon from wildfire can be lessened as the risk of high severity fire is decreased, with the removed biomass going toward a more

487 AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N13. finalejacrecs.pdf (arb.ca.gov).

488 This analysis is the aggregation of all forests and shrublands from all ownerships across the entire state of California.

useful purpose such as harvested wood products, bioenergy, and engineered carbon removal. Managing for a diverse and resilient forest landscape also can help forests recover more quickly so that when climate change and wildfire impacts occur, forests will be less affected and can continue to thrive and sequester carbon. Additional details on the climate benefit potential of forests and shrublands/chapparal can be found in Section 2 of the NWL Climate Smart Strategy.

Strategies for Achieving Success

- Accelerate the pace and scale of climate smart forest management to at least 2.3 million acres annually by 2025, in line with the climate smart management strategies identified in this Scoping Plan, the NWL Climate Smart Strategy, and the Wildfire and Forest Resilience Action Plan.[489]
- Establish and expand mechanisms that ensure forests, shrublands, and grasslands are protected from land conversion and that support ongoing, rather than one-time, management actions.
- In collaboration with state and local agencies, accelerate the deployment of long-term carbon storage from waste woody biomass residues resulting from climate smart management, including storage in durable wood products, underground reservoirs, soil amendments, and other mediums.
- Expand infrastructure to facilitate processing of biomass resulting from climate smart management.
- Expand permit streamlining in collaboration with state and local agencies to accelerate implementation of climate smart forest management while protecting natural resources.

Grasslands

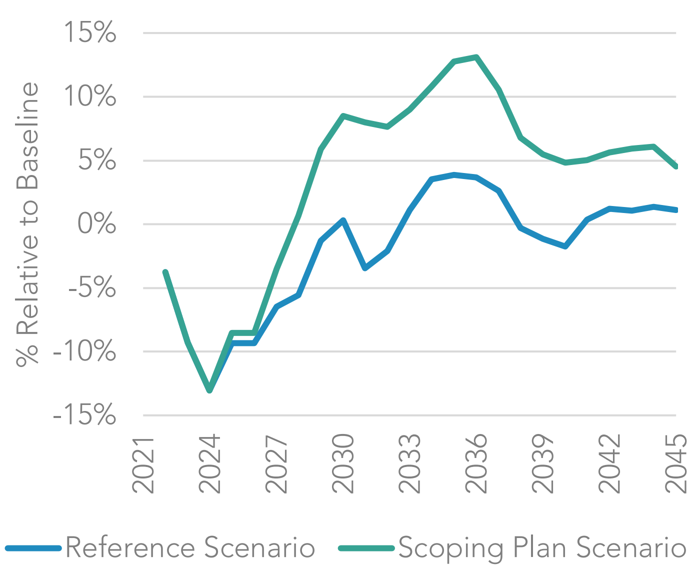
Grasslands cover 9 percent of California, roughly 10 million acres, and are found throughout the state in various landscapes, with concentrations in the foothills surrounding the Sacramento and San Joaquin Valleys. In addition to carbon storage (primarily in the soil), grasslands provide open space, wild habitat, grazing land, and important water filtration and recharge benefits. The protection of grasslands provides an opportunity to reduce sprawl and complement VMT reduction strategies. As grasslands are susceptible to invasive species, climate smart strategies can increase grassland

[489] Forest Management Task Force. 2021. *California's Wildfire and Forest Resilience Action Plan: Recommendations of the Governor's Forest Management Task Force.* https://www.fire.ca.gov/media/ps4p2vck/californiawildfireandforestresilienceactionplan.pdf.

resilience to climate change by improving species diversity and maintaining or increasing soil carbon stocks.

Modeling results show that increased fuels treatments and avoided land conversion can increase carbon stocks on grasslands by 2045, but sequestration rates fluctuate annually. Grasslands are capable of high carbon sequestration rates but are susceptible to carbon losses from wildfire and land conversion. Soil carbon is the major carbon pool on these lands, and continued future improvement of the monitoring and modeling of soil carbon is needed. Similar to forests and shrubland/chaparral, modeling alternatives that include fuels treatments resulted in greater carbon stocks compared to no management, and had lower wildfire emissions. Unlike forests and shrubland/chaparral, which have a general declining carbon stocks trend, the modeling results (Figure 4-22) show grasslands can maintain or increase carbon stocks with active management. Details on the climate benefit potential of grasslands can be found in Section 2 of the NWL Climate Smart Strategy.

Figure 4-22: Grassland carbon stocks by 2045



Strategies for Achieving Success

- Establish and expand mechanisms that ensure grasslands are protected from land conversion/parcelization and that support ongoing, rather than one-time, management actions that improve carbon sequestration.
- Deploy grassland management strategies, like prescribed grazing, compost application, and other regenerative practices, to support soil carbon sequestration, biodiversity, and other ecological improvements.

- Increase adoption of compost production on farms and application of compost in appropriate grassland settings for improved vegetation and carbon storage, and to deliver waste diversion goals through nature-based solutions.

Croplands

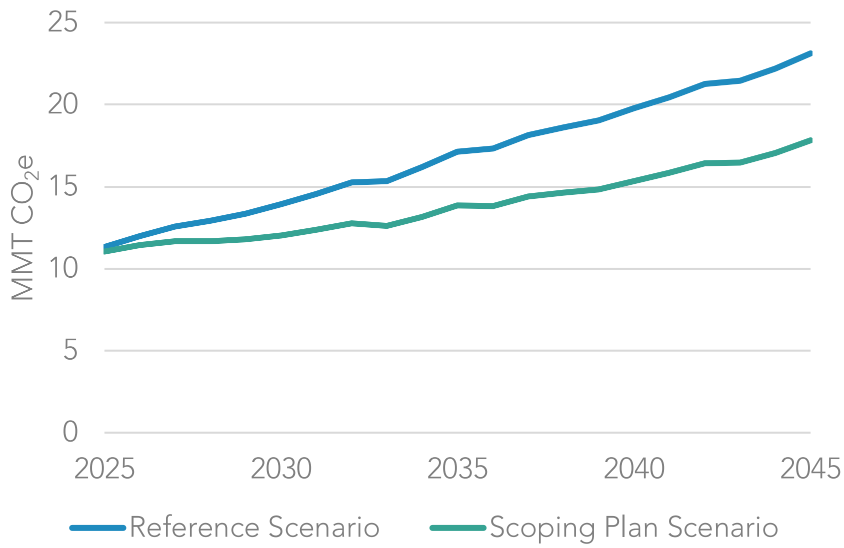
Croplands cover 9 percent of the state, roughly 9.5 million acres. This land is some of the most productive agricultural land in the world, and enables California to be a global leader in agriculture. Aside from developed lands, croplands are the most intensively managed landscapes in the state, and are closely tied to society through the food they produce and the constant, direct contact that people have with croplands through the course of management. In addition to food security, croplands provide considerable carbon storage in the soil and, in perennial croplands, in aboveground biomass. Climate smart practices can improve public health; for example, by reducing synthetic fertilizer and pesticide use. They also help to maintain or increase the climate resilience of cropland productivity through improved soil conditions and increased pollinator habitat.

There is also significant potential to transform this sector to increase soil carbon storage, reduce GHG emissions (Figure 4-23), and reduce pesticide exposure and health impacts. Moving to an agricultural system that improves soil health and water holding capacity reduces over-application of nitrogen, reduces the use of pesticides and fumigants, and increases biodiversity and pollinator habitat, supporting California's pathway to carbon neutrality while simultaneously improving the lives of those who live and work in the agricultural community. Croplands are intricately tied to people, communities, and their health, and through climate smart practices and cropland conservation, these lands have the potential to contribute more to society than just food.[490] The implementation of climate smart agricultural practices and diversified organic agriculture can help California achieve social and environmental benefits, like improving water use efficiency, increasing pollinator habitat, and reducing synthetic fertilizer and pesticide use.[491] Additional details on the climate benefit potential of croplands can be found in Section 2 of the NWL Climate Smart Strategy.

[490] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations In-part (N3, N4, N22), N5, N21. finalejacrecs.pdf (arb.ca.gov).

[491] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N11. finalejacrecs.pdf (arb.ca.gov).

Figure 4-23: Cumulative CO_2e emissions from annual croplands in 2045[492]



CARB recognizes the complex nature of croplands, cross-sector relationships, and the need to build on this analysis to further our understanding of cropland dynamics. Many more aspects of cropland management need to be explored for potential climate benefits, such as water and nutrient use management, pest control methods, crop rotations, and other management practices. The impacts of climate change on water availability, annual/perennial crop growth, and future carbon sequestration trends are uncertain, and recent policies such as the Sustainable Groundwater Management Act may also influence cropland management in unforeseen ways. Nonetheless, it is clear that greater climate smart practice implementation can prepare California for the future and yield tangible benefits for the state.

Strategies for Achieving Success

- Accelerate the pace and scale of healthy soils practices to 80,000 acres annually by 2025, conserve at least 8,000 acres of annual crops annually, and increase organic agriculture to 20 percent of all cultivated acres by 2045.

[492] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N11. *finalejacrecs.pdf (arb.ca.gov)*.

- Utilize the recommendations included in CDFA's Farmer and Rancher-Led Climate Change Solutions[493] report to accelerate deployment of healthy soils practices, organic farming, and climate smart agriculture practices.
- Establish or expand financial mechanisms that support ongoing deployment of healthy soils practices and organic agriculture.[494]
- Support strategies that achieve co-benefits of safer, more sustainable pest management practices and the health and preservation of ecosystems, such as implementing the California Department of Pesticide Regulation's (DPR's) Sustainable Pest Management Work Group recommendations.[495]
- Conduct research on the intersection of pesticides, soil health, GHGs, and pest resiliency via a multi-agency effort with DPR, CDFA, and CARB.[496]
- Conduct outreach and education to develop and facilitate the increased adoption of safer, more sustainable pest management practices and tools; reduce the use of harmful pesticides; promote healthy soils; improve water and air quality; and reduce public health impacts.
- In collaboration with state and local agencies, accelerate the deployment of alternatives to agricultural burning that increase long-term carbon storage from waste agricultural biomass, including storage in durable wood products, underground reservoirs, soil amendments, and other mediums.
- Work across state agencies to reduce regulatory and permitting barriers around some healthy soils practices (e.g., composting), where appropriate.
- Utilize innovative agriculture energy use and carbon monitoring and planning tools to reduce on-farm GHG emissions from energy and fertilizer application or to increase carbon storage, as well as to promote on-farm energy production opportunities.

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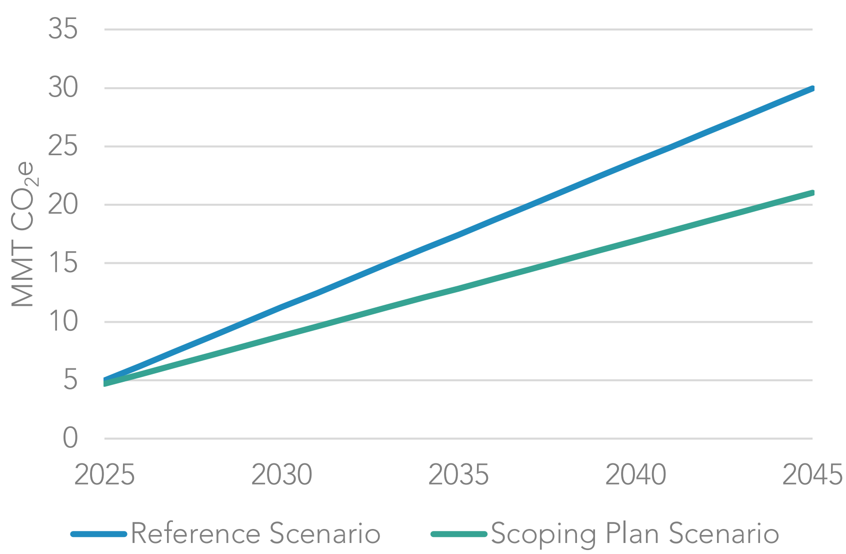
[493] California Department of Food and Agriculture. 2021. Farmer and Rancher Led Climate Change Solutions. https://www.cdfa.ca.gov/oefi/climate/docs/cdfa_farmer_and_rancher-led_climate_solutions_meetings_summary.pdf.
[494] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N5, N7. finalejacrecs.pdf (arb.ca.gov).
[495] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations N3, N4, N5, N7, N22. finalejacrecs.pdf (arb.ca.gov).
[496] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N11. finalejacrecs.pdf (arb.ca.gov).

Wetlands

Wetlands cover 2 percent of the state (roughly 1.7 million acres) and include inland and coastal wetlands, such as vernal pools, peatlands, mountain meadows, salt marshes, and mudflats. These lands are essential to California's communities as they serve as hotspots for biodiversity, contain considerable carbon in the soil, are critical to the state's water supply, and protect upland areas from flooding due to sea level rise and storms. Wetlands have been severely degraded through reclamation, diking, draining, and dredging practices in the past, resulting in the emissions of the carbon stored in the soils and the loss of ecosystem benefits. Climate smart strategies to restore and protect all the types of wetlands can reduce emissions while simultaneously improving the climate resilience of surrounding areas and improving the water quality and yield for the state. Restored wetlands also can reduce pressure on California's aging water infrastructure. These benefits beyond emissions reductions will help in the future, as climate change is predicted to negatively affect water supply.

Avoided conversion and restoration of Delta wetlands reduces CO_2 and methane emissions from wetlands, with GHG reductions scaling with implementation rates (Figure 4-24). Expansion of conservation and restoration efforts will generate benefits such as the conservation of biodiversity, improved water quality and supply, and reduced flood risk. Additional details on the climate benefit potential of wetlands can be found in Section 2 of the NWL Climate Smart Strategy.

Figure 4-24: Cumulative CO_2e emissions from Delta wetlands by 2045



Strategies for Achieving Success

- Restore 60,000 acres of Delta wetlands annually by 2045 to reduce methane emissions from wetlands and reverse the resulting subsidence.

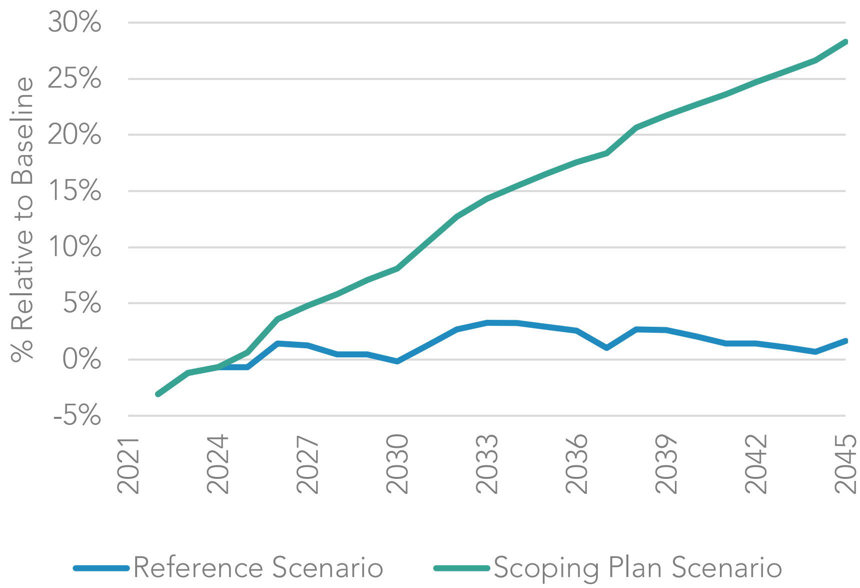
- Identify and prioritize wetland restoration efforts around climate vulnerable communities.
- Leverage other funding and institutions to support wetland restoration projects, including land trusts, local funding (e.g., San Francisco Measure AA), federal funding, and private and philanthropic funding to support wetlands restoration projects.
- Work across state agencies to reduce regulatory and permitting barriers around wetland restoration projects, where appropriate.

Developed Lands

Developed lands cover 6 percent of the state (roughly 6.8 million acres) and include urban, suburban, and rural areas, as well as transportation and supporting infrastructure throughout California. This area encapsulates the land on which the vast majority of Californians reside and call home. The vegetation within cities and communities, and along infrastructure, are all part of developed lands. This vegetation provides numerous benefits to surrounding areas, including carbon storage, air and water filtration, reduced urban heat island effect, and access to nature, aesthetics, and mental health, among others. These areas are susceptible to climate change as well, and climate smart strategies to protect and expand the urban forests, landscaping, green spaces, parks, and associated vegetation can increase their climate resilience and the benefits Californians derive from them. These strategies also have a significant opportunity to benefit disadvantaged communities, who may not have equitable access to these practices or the benefits they provide. Additional details on the climate and equity benefit potential of developed lands can be found in Section 2 and the Introduction of the NWL Climate Smart Strategy.

Urban forests have a significant potential to sequester carbon (Figure 4-25). They are vastly different from wildland forests, as they require investments to maintain and irrigate. This results in the need for a significant increase in investment to increase urban forest carbon. As urban forests become denser and management difficulty increases, the carbon stock returns on investment diminish, making it expensive to maximize carbon in urban forests. Water availability and irrigation efficiency are also an important consideration for increasing urban forest cover. As water becomes scarcer, the prioritization of irrigating trees over lawns or gardens may be required to achieve increases in urban forest carbon.

Figure 4-25: Carbon stocks in urban forests by 2045



Within wildland-urban interface (WUI) areas, defensible space can protect urban and rural communities from wildfire. Analysis results show that 48 percent of parcels are currently fully compliant with defensible space requirements. This highlights how much work needs to be done to protect communities and homes. Defensible space results in a decrease in carbon stocks, as expected when reducing fuels for wildfire.

Strategies for Achieving Success

- Increase urban forestry investment annually by 200 percent, relative to business as usual.
- Increase public awareness of urban forest benefits and, where appropriate, prioritizing irrigation of trees over lawns.
- Provide technical assistance and resources to disadvantaged communities to implement community urban greening projects to provide equitable access to the benefits of urban greening projects.[497]
- Work with state and local agencies to expand technical assistance for and enforcement of the defensible space requirements of PRC 4291 to reduce wildfire risk to homes and structures.

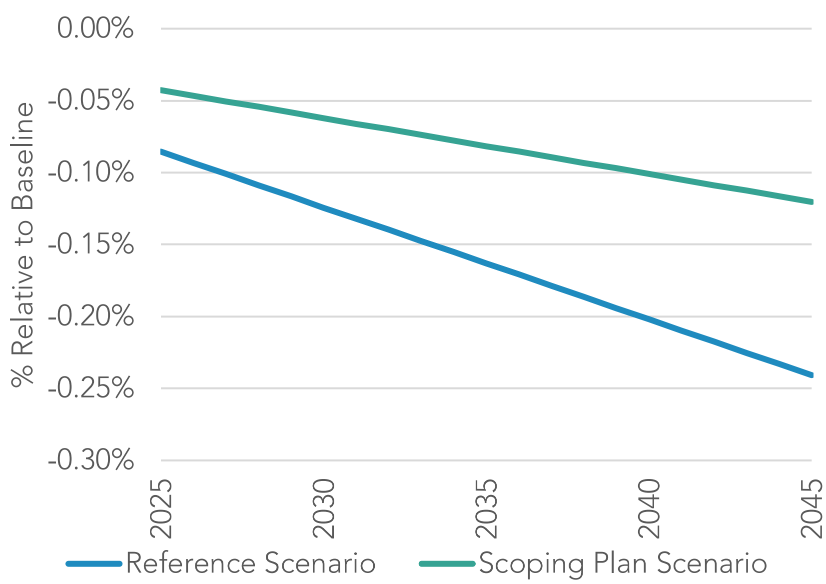
[497] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N8. finalejacrecs.pdf (arb.ca.gov).

Sparsely Vegetated Lands

Sparsely vegetated lands cover 10 percent of the state, roughly 10.2 million acres, primarily in the east and southern parts of California. These lands include deserts, beaches, dunes, bare rock, and areas covered in ice and snow (e.g., higher mountain elevations). The limited carbon storage of these lands varies from bare rock and mineral soil to more vegetated areas, though severe climate limits the amount of biomass. Nonetheless, sparsely vegetated lands are important for open space and provide rare and unique habitats for endemic species and a diversity of wildlife. These lands present important recreational opportunities for Californians and serve as important protective buffers in coastal and low-lying areas. Land use change threatens these lands, and conservation efforts are important for protecting these unique areas of California.[498]

Avoided conversion of sparsely vegetated lands reduces the organic carbon lost from the soil, which is the major carbon pool in this land type (Figure 4-26). In identifying the outcomes for sparsely vegetated lands, CARB modeled avoided land conversion to another land use.

Figure 4-26: Carbon stocks in sparsely vegetated lands by 2045



Strategies for Achieving Success

- Establish and expand mechanisms that ensure sparsely vegetated lands are

[498] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N26. *finalejacrecs.pdf (arb.ca.gov)*.

protected from land conversion, prioritizing those areas most vulnerable to climate change and loss.

Additional Management Strategies

Additional nature-based climate solutions beyond those management strategies modeled for this Scoping Plan are available for implementation, but either cannot currently be modeled and/or affect carbon and the landscape in ways that cannot currently be tracked. Nevertheless, it is important to take action even where these technical gaps exist. Some of these actions, such as cultural burning and indigenous farming practices, have been used on large scales for decades or even centuries, while others are relatively new concepts. The state nevertheless recommends implementing the additional solutions listed here to achieve potential additional climate benefits, as well as other co-benefits. These additional solutions were drawn from the NWL Climate Smart Strategy and stakeholder, tribal government, and interagency feedback.[499]

Considerations

Although these practices are recommended, because of the lack of in-depth modeling and analysis available, several considerations must be addressed when implementing them. These considerations also apply to the management strategies included in the Scoping Plan Scenario.

- Future climate change impacts are uncertain: The negative impact that climate change can have on the ability of these practices to maintain expected climate benefits is uncertain and may significantly change in the future. Climate change is expected to further diminish the already constricting growing conditions in California, with increasing droughts, more extreme weather events, and expanding disturbances from fire, insects, and disease. It is estimated that suitable habitat for many native plant and animal species could shift, creating novel ecosystems without historical precedent. Close monitoring of all practices, including no management, across our NWL will be critical to understand if and how future climate change affects outcomes and how to adapt management to meet the needs of the system under climate change.[500]

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[499] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N24. *finalejacrecs.pdf (arb.ca.gov)*.
[500] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N15. *finalejacrecs.pdf (arb.ca.gov)*.

- Local conditions: Not every practice is applicable, feasible, or even desirable in every location across California. Implementation of these practices should account for local conditions and needs that may affect the appropriateness of that practice.
- Long-term carbon storage: The ability to sequester additional carbon into NWL is only beneficial to the climate if that carbon stays out of the atmosphere. Many of the additional practices listed here may require continual incentives or interventions to ensure permanence of carbon storage in the soil and biomass. For example, in croplands, it is difficult to estimate how much of the carbon stored by no-tillage can be released by a single subsequent tillage, but a return to conventional tillage would usually be expected to erase most gains.[501,502]
- Scaling actions: There are uncertainties on how these practices may impact both the environment and communities when significantly expanded. For this reason, it is best to take a cautious and measured approach to ramping up actions to a larger scale.
- Infrastructure and operational needs: Scaling up the implementation of some of these practices demands transformational change in the supporting infrastructure and operational frameworks. For example, increasing forest management to the degree included in the Scoping Plan Scenario will require significant changes to wood-processing infrastructure, workforce capacity, permitting processes, technical assistance, and other operational constraints. The increased application of compost to croplands, and potentially to rangelands, will require a significant increase in organic waste and dairy manure collection to increase compost supply, in line with SB 1383. This will also require additional compost production facilities as well as compost/organic waste transportation and application methods.
- Co-benefits: Many co-benefits from these practices exist beyond the climate benefits. These co-benefits include improved public and worker health; improved microbial, insect, and wildlife habitat; enhanced biodiversity; greater labor demand in the nature-based economy; and improved climate resilience.
- Labor and Economics: Many of these practices require additional labor, and an evaluation of how many more jobs are needed to carry out many of these practices

[501] Muñoz-Romero, V., R. J. Lopez-Bellido, P. Fernandez-Garcia, R. Redondo, S. Murillo, and L. Lopez-Bellido. 2017. “Effects of tillage, crop rotation and N application rate on labile and recalcitrant soil carbon in a Mediterranean Vertisol.” *Soil Tillage Res.* 169, 118–123.
[502] Mitchell, J. P., A. Shrestha, W. R. Horwath, R. J. Southard, N. Madden, J. Veenstra, and D. S. Munk. 2015. “Tillage and cover cropping affect crop yields and soil carbon in the San Joaquin Valley.” *California. Agron. J.* 107, 588–596.

is currently unknown. There will also be the need to explore the costs and economic benefits of implementing these additional practices.
- Retreatments: All of these practices have limits on how long they can enhance carbon sequestration. Many of these practices need to be periodically repeated, followed by complementary practices, or maintained through time. This increases costs and requires diligence and long-term stewardship.

Additional NWL Actions and Strategies

Below is a set of additional actions that should be taken on California's natural and working lands. Again, these practices were not modeled for this Scoping Plan, and all of the considerations listed above should be taken into account before implementing the following actions.

- Conservation of all NWL types (in line with the NWL Climate Smart Strategy and CNRA's Pathways to 30x30 California) is critical to ensuring continued carbon sequestration and provision of co-benefits from these lands for all Californians.[503]
- Reforestation following disturbance, using appropriate species, is an impactful practice that can help prevent conversion away from forestland and establish new trees to sequester carbon. The number of acres that may need reforestation following high severity wildfires is estimated to continue to increase into the future.
- Restoration of shrublands, chaparral, riparian zones, and oak woodlands across California includes a variety of practices to alter their structure and return endemic species to the areas. These unique habitats provide multiple co-benefits to the state, such as clean water, reduced wildfire risk, and biodiverse habitats for flora and fauna.
- Conservation and restoration of wetlands, beyond the Delta wetlands included in the NWL modeling, can protect these unique habitats and the climate benefits they provide. These wetland types can include but are not limited to coastal wetlands, mountain meadows, vernal pool complexes, alkali sinks and meadows, and floodplains.
- Conservation and restoration of seagrasses and seaweeds provide a number of benefits, including carbon storage and sequestration, habitat provision for many culturally and commercially important species of fishes and invertebrates, shoreline protection, and tourism opportunities.[504]

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[503] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N26, N27. finalejacrecs.pdf (arb.ca.gov).

[504] AB 32 EJ Advisory Committee. 2022 Scoping Plan Recommendations, N2. finalejacrecs.pdf (arb.ca.gov).

- Prescribed herbivory utilizes various livestock to consume vegetation to reduce fuel loads across an area. This fuel management practice can be used in forests, grasslands, and shrublands as an effective alternative to herbicide use, and should be considered wherever local conditions allow.
- Urban and community greening efforts such as green schoolyards, urban farms, rain gardens, community gardens, community composting, and many more provide numerous health benefits to communities.
- Additional Healthy Soils Program practices on annual croplands such as conservation cover and crop rotation, biomass planting for borders, wind barriers, riparian areas, and improved nutrient management can improve soil health, water retention, and increase carbon stocks.
- Healthy Soils Program practices on perennial croplands and rangelands, such as compost application and alley cropping/cover cropping to improve soil health, water retention, erosion control, and biomass growth.[505]
- Stacking of these Healthy Soils Program practices, where appropriate, in perennial and annual systems, can synergistically improve soil health and provide multiple benefits.
- Mulching adds high carbon materials to croplands or fallowed lands to reduce competing vegetation and retain moisture. This practice can support other benefits such as reduced water use and reduced synthetic pesticide and fertilizer use, as well as provide a use for suitable forest and agricultural waste biomass.
- Reductions in the use of synthetic fertilizers in cropland management, generally supported by the implementation of new management tools or technologies, can lead to reductions in GHG emissions from the production and application of fertilizers. This benefit is in addition to the co-benefits of reduced chemical runoff into waterways and reduced exposure of human populations to their harmful effects.

[505] Various types of organic amendments are being researched for application to particular landscape types. For example, compost application to rangelands is a relatively new practice that has been shown to improve soil health and increase carbon sequestration in the short term, though the science on the long-term impacts of this practice is still developing and the supply of available compost may be limiting.

Chapter 5: Challenge Accepted

This chapter provides an overview of the next steps and partnerships that will be needed to successfully implement this Scoping Plan. The path forward is not dependent on one agency, one state, or even one country. It will take action on a global level to address the threat climate change poses. But, the work begins at home.[506] The state can lead by engaging Californians and demonstrating how action at the state, regional, and local levels of government, as well as action at community and individual levels, can contribute to addressing the challenge before us. We must build partnerships with academic institutions, private industry, and others to support and accelerate the transition to carbon neutrality. Ultimately, the success of this Scoping Plan will be measured by our ability to implement the actions modeled in the Scoping Plan Scenario at all levels of government and society. This will depend on a mix of legislative action, regulatory program development, incentives, institutional support, workforce and business development, education and outreach, community engagement, and research and development and deployment. Optimizing this mix will help to ensure that clean energy and other climate mitigation strategies are clear, winning alternatives in the marketplace and in communities—to promote equity, drive innovation, and encourage consumer adoption. Bold institutional action will catalyze continued research and push private investment to create jobs and bring innovative ideas to reality.

State-level Action

Achieving the targets described in this Scoping Plan will require continued commitment to and successful implementation of existing policies and programs and identification of new policy tools and technical solutions to go further, faster. California's Legislature and state agencies will continue to collaborate to achieve the state's climate, clean air, equity, and broader economic and environmental protection goals. It will be necessary to maintain and strengthen this collaborative effort, and to draw upon the assistance of the federal government, regional and local governments, tribes, communities, academic institutions, and the private sector to achieve the state's near-term and longer-term emission reduction goals and a more equitable future for all Californians.

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[506] This "polycentric" approach to climate challenges, engaging many levels of government, was articulated in leading papers by Nobel laureate Elinor Ostrom. See, for example, Ostrom, E. 2014. "A Polycentric Approach to Coping with Climate Change." *Annals of Economics and Finance* 15-1, 97–134.

Regulations and Programmatic Development

Meeting the AB 32 2020 GHG emissions reduction target several years earlier than mandated demonstrated that developing mitigation strategies through a public process, where all stakeholders have a voice, leads to effective actions that address climate change and yields a series of additional economic and environmental co-benefits to the state. Following adoption of this Scoping Plan, state agencies will continue to update and implement new and existing programs to align with the outcomes in the plan. Community, tribal, and stakeholder engagement will be a critical part of this work. Several state agencies, including CARB, the CEC, the California State Transportation Agency (CalSTA), the CPUC, and others will need to be part of various subsequent rulemaking processes. Each of these agencies' leadership and technical staff will engage with the public through public meetings, written and oral comment, and other methods of engagement. This work will be informed by evaluations of the health, air quality, environmental, equity, and economic benefits and impacts of regulations, including an assessment of the societal cost of carbon, as required under AB 197.

Incentive Programs

As described in Chapter 1, incentive programs are one of the most important tools the state has in advancing our low carbon future, especially for climate vulnerable communities. The programs ensure clean technology and energy are accessible and are critical to closing ongoing opportunity gaps. These programs also leverage private-sector investment and build sustainable, growing markets for clean and efficient technologies, and they are particularly necessary to support GHG emission reduction strategies for priority sectors, sources, and technologies. Clean technologies are often already the best and lowest cost option over their lifetimes but incentive funding is critical to ensure that they are broadly available, especially in climate vulnerable communities. Incentives also build on California's long track record of driving innovative technology developments, and creating new industries, with targeted investment. The Inflation Reduction Act also provides a new source of funding and tax incentives that must be leveraged to help achieve the state's climate goals.

Many state funding programs are designed to achieve multiple objectives simultaneously: reduce emissions from GHGs, criteria pollutants, and toxic air contaminants; manage natural and working lands for carbon sequestration; and address health and opportunity gaps in disadvantaged communities. California's incentive programs focused on jump-starting the transition to a zero emission transportation future are a good example of this "stacked" approach. The state is investing billions of dollars through programs such as the On-Road Heavy-Duty Voucher Incentive Program and Clean Cars 4 All in order to replace the light- and heavy-duty vehicles most responsible for the state's GHG emissions and poor air quality, all while bolstering the nascent ZEV market. Further strategies aid in developing new technologies, in ramping up access for all, and in shifting to cleaner modes of transport; for instance, by supporting investments in walkable, bikeable communities and transit, as well as in vehicles. This funding strategy is, of course, paired with the regulatory approach described above.

Local Action

Local action by cities can support and amplify efforts to reduce GHGs. For example, the City of Oakland requires all new construction to be all-electric and is currently working on electrifying existing buildings.[507] In addition, starting in 2023, the City of Sacramento will require all new buildings under three stories to be all-electric, and it extends the mandate to all new construction by 2026 with some limited exemptions. The City of Sacramento also requires levels of EV charging infrastructure in new construction starting in 2023, higher than the minimum state requirements, and provides parking incentives for zero-emission carsharing and EV charging.[508] Local governments asserting this type of leadership are critical partners in supporting state-level measures to contain the growth of GHG emissions associated with the transportation system and the built environment.

California must accommodate population and economic growth in a far more sustainable and equitable manner than in the past. Good climate policy can and should create affordable and pleasant places to live, with effective transport and clean air for all—a future in which local governments and communities are central partners. Local governments have the primary authority to plan, zone, approve, and permit how and where land is developed to accommodate population growth, economic growth, and the changing needs of their jurisdictions. They also make critical decisions on how and when to deploy transportation infrastructure, and can choose to support transit, walking, bicycling, and neighborhoods that do not force people into cars. Local governments also have the option to adopt building ordinances that exceed statewide building code requirements, and play a critical role in facilitating the rollout of ZEV infrastructure. As a result, local government decisions play a critical role in supporting state-level measures to contain the growth of GHG emissions associated with the transportation system and the built environment—the two largest GHG emissions sectors over which local governments have authority.

Local governments are also frequently the source of innovative and practical climate solutions that can be replicated in other areas. Their efforts to reduce GHG emissions within their jurisdictions are vital to achieving the state's near-term air quality and long-term climate goals. Local governments must continue to take action that affirmatively

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[507] City of Oakland. Building Electrification. https://www.oaklandca.gov/projects/building-electrification.

[508] City of Sacramento. Electrification of New Construction. http://www.cityofsacramento.org/SacElectrificationOrdinance.

builds the projects and expend the funds needed to further the state's collective path toward equitable emissions reductions. As such, aligning local jurisdiction action with state-level priorities to tackle climate change and the outcomes called for in this Scoping Plan is critical to achieving the statutory targets for 2030 and 2045. Local governments can implement climate strategies that can effectively engage residents by addressing local conditions and issues that also deliver local economic benefits.

Local Climate Action Planning and Permitting

California encourages local jurisdictions to take ambitious, coordinated climate action at the community scale; action that is consistent with and supportive of the state's climate goals.[509] As discussed in more detail in Appendix D (Local Actions), local jurisdictions can do much to enable statewide priorities, such as taking local action to help the state develop the housing, transport systems, and other tools we all need. Indeed, state tools—such as the Cap-and-Trade Program or zero-emission vehicle programs—do not substitute for these local efforts. Multiple legal tools are open to local jurisdictions to support this approach, including development of a climate action plan (CAP), sustainability plan, or inclusion of a plan for reduction of GHG emissions and climate actions within a jurisdiction's general plan. Any of these can help to align zoning, permitting, and other local tools with climate action.

Once adopted, the GHG emissions reductions plans detailed in CAPs can provide local governments with a valuable tool for coordinated climate planning in their community. When a local CAP complies with CEQA requirements, individual projects that comply with the CAP are allowed to streamline the project-specific GHG analysis.[510,511] Effectively, local governments that adopt a CEQA-compliant CAP enable project developers to use this streamlined approach. This saves time and resources and provides more consistent expectations for how GHG reduction measures are applied across projects in the jurisdiction. While the state encourages local governments to follow this approach, we acknowledge not all jurisdictions have the resources to develop a CAP that meets the CEQA requirements.

In addition to being required for a local CAP to comply with CEQA, local GHG reduction targets have long been recommended as part of the process of developing a climate

[509] This plan provides more detailed guidance and tools to local governments in Appendix D (Local Actions).

[510] Cal. Code of Regs., tit. 14, § 15183.5.

[511] California Governor's Office of Planning and Research. n.d. "General Plan Guidelines - Chapter 8 Climate Change."

action plan.[512] One challenge local jurisdictions have faced is how to evaluate and adopt quantitative, locally appropriate goals that align with statewide goals. An effective response to this challenge is to focus on goals that can help implement overall state priorities—enabling the key transformations California needs.

There are many ways that local governments can make key contributions to this transformation, depending on the characteristics of their jurisdiction and community. For example, some jurisdictions will inherently have more land capacity to remove and store carbon, whether through natural and working lands or by other means. Other jurisdictions will be host to GHG-emitting facilities that serve necessary functions and will take time to transition to clean technology (e.g., municipal wastewater treatment plants, landfills, and energy generation and transmission facilities). It is important to recognize that we will need to build new energy production and distribution infrastructure, and repurpose existing ones, for clean technology and energy before we are able to phase down existing fossil sources. There also will be a need to handle the significant amount of biomass resulting from sustainable forest management for catastrophic wildfire prevention, agricultural waste, and landfill diversion.

Regional efforts can support change too: energy and transportation systems that serve Californians do not stop at jurisdictional boundaries, and some local decisions can have ramifications for other communities. For instance, Metropolitan Planning Organizations (MPOs) can help to integrate local efforts by planning consistent with the Scoping Plan and Climate Action Plan for Transportation Infrastructure, including by removing polluting roadway capacity expansions from project pipelines and instead focusing on climate-friendly solutions. These varied capabilities and needs should be taken into account in setting targets for local climate plans. For instance, although net zero targets can often be valuable and achievable, and mitigation is important, targets should be considered in the larger context of these goals. This all means any GHG targets on a local scale should take into consideration the actions and outcomes included in this Scoping Plan. Jurisdictions considering "net zero" targets should carefully consider the implications such targets may have on emissions in neighboring communities and the ability of the state to meet our collective targets.

Jurisdictions without formal CAPs also have important opportunities within this context. These jurisdictions can still take actions that effectively translate key state plans, goals, and targets, including those articulated in this Scoping Plan for local action. For instance, state ZEV targets can advance local efforts to promote broad and equitable access to charging and fueling. Similarly, local jurisdictions can enable reduced dependence on

[512] Climate Smart Communities. 2014. Climate Action Planning Guide. https://cdrpc.org/wp-content/uploads/2015/05/CAP-Guide_MAR-2014_FINAL.pdf.

single-occupancy vehicles by supporting dense infill housing and transit, among other actions. Such actions can be reflected in particular project plans, in general plans, or through other local policies. Regional partnerships among these jurisdictions can also help tap resources and provide for more effective overall action.

Unlocking CEQA Mitigation for Local Success

The California Environmental Quality Act also provides important tools for lead agencies to support the achievement of the state's GHG and VMT reduction goals. Although many climate-friendly local government actions already fall into categories that may not require a full CEQA analysis, thanks to streamlining or other tools, and although certain product types (such as affordable infill housing) are generally clearly consistent with state climate goals, CEQA analyses may still sometimes be required. CEQA can be a powerful and useful tool to engage the public, identify additional opportunities to support climate efforts, and localize change. It is important that lead agencies look for ways to use CEQA to support these core purposes, ensuring that these processes do not become sources of delay but instead unlock more opportunities. The uncertainty analysis in Chapter 2 evaluates how project implementation delays can lead to missed state climate targets and continued dependence on fossil energy. Mitigation measures applied in the communities affected by projects subject to CEQA have the added benefit of improving health, social, and economic resiliency as climate impacts worsen.

Appendix D (Local Actions) explores the role of local government action and CEQA in detail. As discussed there, an important CEQA-related tool is mitigation—which can be used to further drive local action consistent with state climate goals. When a lead agency determines that a proposed project would result in potentially significant GHG impacts due to its GHG emissions or a conflict with state climate goals, the lead agency must impose feasible mitigation measures to minimize the impact. Appendix D (Local Actions) provides suggestions for prioritizing the various types of mitigation, starting with on-site GHG-reducing design features[513] and mitigation measures, such as methods to reduce VMT and support building decarbonization, access to shared mobility services or transit, and EV charging. After exhausting all the on-site GHG mitigation measures, CARB recommends prioritizing local, off-site GHG mitigation measures, including both direct investment and voluntary GHG reduction or sequestration projects, in the neighborhoods impacted by the project. This could include, for example, development of a neighborhood green space, investment in street trees, or expansion of transit services. Implementing GHG mitigation measures in the project's vicinity would allow the project proponent and the lead agency to work directly with the affected community to identify and prioritize the

[513] Cal. Code of Regs., tit. 14, § 15126.4(c)(2) and (3).

mitigation measures that meet their needs while minimizing multiple environmental and societal impacts.

Once all potential on-site and local off-site GHG mitigation measures have been incorporated to the extent feasible, Appendix D (Local Actions) provides further suggestions for prioritizing other mitigation types, including non-local off-site mitigation, and voluntary offsets issued by a recognized and reputable voluntary carbon registry (as listed on CARB's website[514]) may be appropriate. Additional in-state mitigation also may be available in the upcoming SB 27[515] (Skinner, Chapter 237, Statues of 2021) registry, which will serve as a database of projects in the state that drive climate action on natural and working lands. Lead agencies should use substantial evidence to demonstrate that the project proponent explored and prioritized investments in feasible, local mitigation prior to moving mitigation to a geography located farther away from the project.

Communities and Environmental Justice

As noted in Board Resolution 20-33,[516] it is incumbent on CARB to function as an agent of responsible social change, especially when it is clear that environmental injustices continue to persist for low-income communities, tribes, and communities of color.

State law defines *environmental justice* as the fair treatment of all people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.[517] Government Alliance for Race and Equity (GARE)[518] defines *racial equity* as when race can no longer be used to predict life outcomes and outcomes for all groups are improved.

For this Scoping Plan to be successful, it must address environmental justice and advance racial equity. Implementation of the plan needs to address the needs of those communities that are disproportionately burdened by climate impacts and continue to face significant health and opportunity gaps. Now, we need to ensure our actions allow these communities to not only have a seat at the table, but also inform and shape the policies

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[514] CARB. 2022. Offset Project Registries. https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/offset-project-registries.

[515] SB 27. Carbon sequestration: state goals: natural and working lands: registry of projects. (SB 27, Skinner, Chapter 237, Statutes of 2021). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB27.

[516] CARB. 2020. Resolution 20-33: A Commitment to Racial Equity and Social Justice. October 22. https://ww2.arb.ca.gov/sites/default/files/barcu/board/res/2020/res20-33.pdf.

[517] Gov. Code, § 65040.12, subd. (e).

[518] Local and Regional Government Alliance on Race and Equity. 2015. *Advancing Racial Equity and Transforming Government: A Resource Guide to Put Ideas into Action.* Page 9. https://racialequityalliance.org/wp-content/uploads/2015/02/GARE-Resource_Guide.pdf.

to ensure their communities thrive. With this Scoping Plan, the state also adds a new tool to identify which communities will be the least resilient in the face of selected climate impacts and will see disproportionate economic impacts as a result. As described in Chapter 3, the CVM will enable the state to target programs and policies to build resiliency in the specific regions that will feel climate impacts more acutely due to existing health and opportunity disparities leading to disproportionate economic impacts. This tool will be critical in the state's efforts to address climate impacts while accounting for environmental injustices and racial inequities. CARB will incorporate the CVM into its work as it moves forward and will share this new tool with other agencies to align our efforts. The goal is to keep expanding the CVM to incorporate additional climate impacts to better identify disproportionate economic impacts as community level data becomes available.

AB 617 is another important tool for both Air Districts and CARB to bring resources to communities that have long been disproportionately burdened by poor air quality. While AB 617 does not require local agencies to participate in the Community Air Protection Program, several AB 617 communities are finding ways to bring local land use agencies to the table to respond to community priorities. We look forward to more opportunities to foster relationships with local authorities and continued collaboration between state and air district programs.

In alignment with AB 32, and to ensure environmental justice and racial equity were integrated into this Scoping Plan, CARB reconvened the AB 32 Environmental Justice Advisory Committee (EJ Advisory Committee) to advise CARB on the development of this Scoping Plan. Since reconvening in May 2021, the EJ Advisory Committee has engaged in the following activities:

- In October 2021, the EJ Advisory Committee sent a letter to the governor requesting a timeline extension for the Scoping Plan process. In response to the EJ Advisory Committee's letter, CARB modified this Scoping Plan process[519] and committed to an active engagement with the EJ Advisory Committee following the approval of this Scoping Plan. The EJ Advisory Committee also presented to the CARB Board[520] at its October 2021 Board meeting, reiterating its request for a timeline extension, as well as sharing additional concerns about process.

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[519] Randolph, L. M. 2021. LMR October 19 response to Environmental Justice Advisory Committee Letter. *https://ww2.arb.ca.gov/sites/default/files/2021-10/LMR%20October%2019%20response%20to%20EJAC%20Letter%20Final.pdf*.

[520] Argüello, M. D., K. Hamilton, S. Taylor, and P. Torres. 2021. EJ Advisory Committee Co-Chair Informational Presentation to CARB Board. October 28. *https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2021/102821/21-11-4pres.pdf*.

- In December 2021, the EJ Advisory Committee shared its responses to Scenario Input Questions,[521] as well as a narrative document outlining their concerns[522] around the process, the need for evaluation, and the need for a tribal representative. In response to the EJ Advisory Committee Scenario Input Questions, CARB incorporated the EJ Advisory Committee responses into the Scenario Assumptions document,[523] and modeled results from PATHWAYS.[524] In response to the EJ Advisory Committee's concerns, CARB worked diligently to appoint a tribal representative[525] in February 2022, and to outline additional opportunities for the EJ Advisory Committee to engage in the Scoping Plan process.[526]
- In March 2022, the EJ Advisory Committee presented at the joint EJ Advisory Committee / CARB Board meeting[527] and walked through their preliminary draft recommendations to inform this Scoping Plan. In April, the EJ Advisory Committee shared its revised preliminary draft recommendations[528] to inform this Scoping Plan.
- In September 2022, the EJ Advisory Committee presented at the joint EJ Advisory Committee / CARB Board meeting[529] and engaged in discussion about priority items as they relate to incorporating environmental justice into the Scoping Plan. By the end of September, the EJ Advisory Committee shared its final

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[521] EJ Advisory Committee. 2021. EJ Advisory Committee Final Responses to CARB Scenario Inputs. December 2. https://ww2.arb.ca.gov/sites/default/files/2021-12/EJAC%20Final%20Responses%20to%20CARB%20Scenario%20Inputs_12_2_21.pdf.

[522] EJ Advisory Committee. 2021. EJ Advisory Committee Responses to Scenario Input Questions. EJ Advisory Committee narrative document regarding scenario input recommendations. December 1. https://ww2.arb.ca.gov/sites/default/files/2021-12/EJAC%20Narrative%20Document%20re%20Scenario%20Input%20Recommendations%2012_1_2021.pdf.

[523] CARB. 2021. PATHWAYS Scenario Modeling. https://ww2.arb.ca.gov/sites/default/files/2021-12/Revised_2022SP_ScenarioAssumptions_15Dec.pdf.

[524] E3. 2022. CARB Draft Scoping Plan AB32 Source Emissions Initial Modeling Results. March 15. https://ww2.arb.ca.gov/sites/default/files/2022-03/SP22-Model-Results-E3-ppt.pdf.

[525] CARB. AB32 EJ Advisory Committee Meeting, February 28, 2022 CARB Update. https://ww2.arb.ca.gov/sites/default/files/2022-02/CARB%20EJAC022822presentation.pdf.

[526] Fletcher, C. 2021. CARB Response to EJ Advisory Committee Narrative. CARB. December 15. https://ww2.arb.ca.gov/sites/default/files/2021-12/CARB%20response%20to%20EJAC%20Narrative.pdf.

[527] EJ Advisory Committee. 2022. EJ Advisory Committee Presentation: Preliminary Draft Recommendations. March 10. https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/031022/ejacpres.pdf.

[528] AB 32 EJ Advisory Committee. Draft Recommendations. https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/031022/ejacrecsrevised.pdf.

[529] EJ Advisory Committee. 2022. EJAC Presentation. September 1. https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/090122/ejacpres.pdf

recommendations[530] to inform this Scoping Plan. To the extent possible, CARB has incorporated and cited these recommendations through this Scoping Plan.

In addition to the activities listed above, Central Valley EJ Advisory Committee members hosted a successful community engagement workshop[531] in San Joaquin Valley in February 2022 with over 100 attendees. Members of EJ Advisory Committee hosted a statewide community engagement workshop[532] in June 2022 with more than 165 attendees. Throughout the EJ Advisory Committee's process, members of the Committee continued to work with their communities to ground truth their recommendations to inform the development of the Scoping Plan. The EJ Advisory Committee worked hard to ensure the voices of those communities most burdened by climate impacts were reflected in the plan. The EJ Advisory Committee will continue to play an ongoing role in the implementation of this Scoping Plan to ensure environmental justice and racial equity are prioritized in our effort to address the climate challenge before us.

To the extent possible, the EJ Advisory Committee's recommendations were integrated throughout the plan. This plan directly cites instances where there is alignment between the plan and the EJ Advisory Committee recommendations. This approach seeks to ensure there is more transparency and identify consensus that exists, as well as relevant ways equity and environmental justice are addressed in this plan and in the planning for future related implementation activities. CARB is dedicated to its efforts to ensure this plan does not leave communities behind.

As this Scoping Plan moves into the implementation phase, there will be a need to better understand how to address EJ Advisory Committee recommendations on the following topics:

- Actions under the jurisdiction of other agencies: there are certain EJ Advisory Committee recommendations that are outside of CARB's jurisdiction. As the EJ Advisory Committee continues to convene, it would be helpful to understand the

[530] EJ Advisory Committee. 2022. EJAC 2022 Scoping Plan Recommendations. September 30. https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/090122/finalejacrecs.pdf

[531] San Joaquin Valley Climate Justice & the Scoping Plan. 2022. https://ww2.arb.ca.gov/sites/default/files/2022-07/SJV%20Climate%20Justice%20%26%20the%20Scoping%20Plan%20Workshop%20Report%20out%20%26%20Recommendations_5.2022.pdf

[532] EJAC. 2022. *EJAC/Community Engagement Synthesis Report '22.* https://ww2.arb.ca.gov/sites/default/files/2022-07/EJAC-CommunityEngagement-SynthesisReport-2022-English%26Spanish.pdf.

role that CARB can play as it relates to the EJ Advisory Committee's recommendations for actions outside CARB's jurisdiction and coordinates with sister agencies.

- Actions that require legislative direction: there are certain EJ Advisory Committee recommendations that would require legislative action. As the EJ Advisory Committee continues to convene, it will be helpful to understand how CARB can work with the EJ Advisory Committee to share these recommendations with the appropriate members of the Legislature.
- Actions directly tied to implementation activities: This Scoping Plan is not an implementation document; it is a plan to chart a course to continue to reduce GHG emissions and achieve carbon neutrality. Once the Scoping Plan is approved, there will be follow-up action at CARB, as well as at other agencies. In these follow-up efforts, there will be a role for ongoing EJ Advisory Committee engagement.
- Actions to implement recent legislation, such as SB 905.

CARB proposes to continue to work with the EJ Advisory Committee to better understand how to move forward on EJ Advisory Committee recommendations that fall into the topics listed above and any other recommendations that were not included in this plan. It is also important to note that there are numerous recommendations where CARB shares the goals of the EJ Advisory Committee and can assist in implementation steps. Examples include the following:

- CARB shares the goal of prioritizing non-fossil energy generation and supports non-fossil projects and opportunities to locate behind-the-meter clean resources in communities of concern in programs such as the Solar on Multifamily Affordable Housing program.
- CARB will engage with agencies and academic institutions to further workforce development.
- Many other recommendations related to financial support for various energy projects, such as microgrids, are within the purview of the CPUC or local publicly owned utilities. Similarly, utility scale projects are within the jurisdiction of other agencies. However, CARB supports strategies identified in the recommendations such as offshore wind to reduce the reliance on fossil fuel generation.
- CARB is supportive of rooftop solar, although it is not within CARB's jurisdiction to determine how incentives for those projects are structured.
- CARB is supportive of strong energy decarbonization goals, recognizing that increased reliance on electrification in transportation and other sectors will create significant demand for electricity, and therefore ensuring reliability of a decarbonized grid is a critical need for the state.
- In the transportation sector, CARB is supportive of the EJ Advisory Committee's recommendations to maintain aggressive zero emission vehicle goals consistent

with its statutory mandate to ensure regulations are technologically feasible and in alignment with Governor Newsom's ZEV Executive Order (EO N-79-20). CARB looks forward to continued engagement on rulemakings that will implement these goals.

- As noted elsewhere in this plan, CARB is supportive of the Caltrans California Transportation Plan 2050 and the California Climate Action Plan for Transportation Infrastructure.
- CARB is supportive of additional public support for transit. CARB is supportive of locating EV charging in low-income communities and communities of color.
- CARB is supportive of prioritizing funding incentives for transit and heavy- and medium-duty vehicles, although CARB does believe there is an important role for incentives that support adoption of light-duty vehicles for the time being. CARB will also be opening a rulemaking on the Low Carbon Fuel Standard to ensure it continues to support clean fuels that will displace petroleum fuels and will consider the EJ Advisory Committee recommendations on this program.
- In the industrial sector, in addition to the strategies discussed more fully in this Scoping Plan, CARB continues to work with the Legislature, local agencies, and air districts to support, implement, and enforce effective reductions in emissions of GHGs and air pollutants in stationary sources. The air districts have the authority to directly issue permits addressing a facility's criteria pollutant and toxics emissions levels. These levels are set after careful permit review, under district regulation and statute. However, AB 617 directs and authorizes CARB to take several actions to improve data reporting from facilities, air quality monitoring, and pollution reduction planning for communities affected by a high cumulative exposure burden. CARB will continue to implement AB 617 and look for ways to strengthen the Community Air Protection Program.
- Considerations around the phaseout of oil and gas extraction and refining, and the role of carbon capture are discussed more thoroughly in Chapter 2.

As CARB continues to engage with the EJ Advisory Committee—in addition to the EJ Advisory recommendations that have been integrated throughout this plan—below are the following commitments that CARB is making to ensure that environmental justice is integrated in this plan and its implementation:

- Building decarbonization is a pillar of this Scoping Plan and CARB commits to working closely with state and local agencies to implement the EJ Advisory Committee recommendations that call for prioritization for residents in low-income communities and communities of color in this transition.
- CARB commits to sharing the EJ Advisory Committee's recommendations with the CEC, CPUC, and other agencies administering funds to support building

decarbonization, and to work closely with those agencies as they engage in public processes to further building decarbonization.

- CARB has committed to review the Cap-and-Trade program and determine what potential legislative or regulatory amendments could be necessary to ensure the program continues to deliver GHG reductions needed to achieve the statutory climate goals. In that process, CARB will consider the recommendations of the EJ Advisory Committee[533] and Independent Emissions Market Advisory Committee,[534] as well as others.

Critically, the EJ Advisory Committee makes numerous recommendations centered around tracking progress of the various strategies in this Scoping Plan. Currently, progress is tracked and reported in numerous ways, including the annual GHG inventory and reports to the Legislature. Part of the ongoing work of implementation, however, will include consideration of ways to provide more data and information to the public, such as rates of deployment of clean energy and technology as described in Chapter 1. CARB will also continue to collaborate with CDPH and OEHHA on health metrics to track cumulative benefits of air pollution and climate programs, especially in low-income communities and communities of color.

As noted earlier in this document, the EJ Advisory Committee will continue to play a vital role in the Scoping Plan and its implementation to ensure environmental justice and racial equity are prioritized in our effort to address the climate challenge before us. This includes ongoing EJ Advisory Committee engagement to advise CARB on the development of the Scoping Plan and any other pertinent matters in implementing AB 32. The ongoing EJ Advisory Committee will help to ensure integration of environmental justice in implementation efforts as it relates to AB 32, and also help CARB as we work toward a future where race is no longer a predictor for life outcomes.

Academic Institutions and the Private Sector

Academic institutions produce and present the latest science on both the impacts of, and actions to reduce, climate change damages. They are also leading the way by

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[533] California Legislative Information. Bill Text – AB 32. Air pollution: greenhouse gases: California Global Warming Solutions Act of 2006. (AB 32, Nuñez, Chapter 488, Statutes of 2006). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

[534] California Legislative Information. Bill Text – AB 398. California Global Warming Solutions Act of 2006: market-based compliance mechanisms: fire prevention fees: sales and use tax manufacturing exemption. (AB 398). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB398.

establishing their own climate goals and GHG emissions reductions targets.[535, 536, 537] They are incubators for innovation and knowledge in clean energy and technology and play an important role in adding to the wealth of robust information to inform policies and programs. Academic institutions have the ability to fill knowledge gaps and push us toward new frontiers. As we move forward, we will continue to see these institutions as partners and resources that can help CARB look for ways to accelerate and introduce actions to reduce GHG emissions and remove and store carbon.

As such, it will be important to maintain and enhance relationships with academic institutions, including community colleges. Community colleges are more likely to have a large proportion of first generation students or students that come from low-income communities or communities of color. The perspective of this diverse student body will be critical to inform discussions on climate change damages and mitigation efforts. This student body is also a future workforce, and courses to teach the skills for a sustainable economy are a chance to close historical opportunity gaps. Importantly, many of the students at community colleges are local residents and community members. This engagement provides another way to invest in communities across our state. The Foundation for California Community Colleges is already leading the way through innovate programs such as their Good Jobs Challenge - California Resilient Careers in Forestry.[538] These types of programs could be replicated across other sectors. CARB will evaluate how to leverage the requirements in AB 680 on workforce development in the California Climate Investments programs with the work at the Foundation for California Community Colleges.

As noted in Chapter 1, public and private partnerships will be important as we move forward in the great energy transition. But the private sector is also important in the context of research and development and deployment. Many of these companies have the resources and expertise to build and produce the clean technology and energy we will need. It was through the efforts of several private companies (Bell, Exxon, Telecom

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535 University of California. Our Commitment. https://www.universityofcalifornia.edu/initiative/carbon-neutrality-initiative/our-commitment.

536 California State University. Energy, Sustainability, & Transportation. https://www.calstate.edu/csu-system/doing-business-with-the-csu/capital-planning-design-construction/operations-center/Pages/energy-sustainability.aspx.

537 California Community Colleges Chancellor's Office. Climate Action and Sustainability. https://www.cccco.edu/About-Us/Chancellors-Office/Divisions/College-Finance-and-Facilities-Planning/Facilities-Planning/Climate-Action-and-Sustainability?msclkid=4a72350ec4f511ecaf292c6b14ac9a4f.

538 Foundation for California Community Colleges. 2022. Good Jobs Challenge. Developing Resilient Careers in Forestry for Californians. https://foundationccc.org/What-We-Do/Workforce-Development/Good-Jobs-Challenge.

Australia) that the photovoltaic solar panels in use today were developed.[539] Similarly, it was companies such as General Electric and Texas Instruments that contributed to the development of hydrogen fuel cells.[540] This Scoping Plan includes the known and emerging clean technologies and fuels available today. The private sector spirit of invention, improvement, and innovation must continue to deliver new tools in the fight against climate change.

Individuals

This Scoping Plan not only projects ambitious availability of clean technology and energy, but also includes aggressive assumptions about consumer adoption of ZEVs, heat pumps, and other energy efficiency practices, among others. When it comes to climate change mitigation, the sum of the parts matters. Only when we add up the impacts of the choices we make do we understand the true impact on GHG emissions. Today, many Californians have opportunities to choose between driving a car, taking a bus, biking, or walking. Many can choose to install a heat pump or buy an electric cooktop. Together, we can increase these opportunities and pick the future we want. We can start or transform businesses that create clean jobs, innovate new technologies, or introduce new systems. We can engage with fellow workers to support durable paths for labor in a clean economy. And we can choose to engage with our community, tribes, and our governments to advocate for change, call out challenges, and propose solutions. Our choices will help determine California's climate future. Down one path is a future of climate impacts that will continue to worsen and further increase disparities across communities. Down the other is a future that avoids the worst impacts of climate change, improves air quality—especially for the most burdened communities—and fosters new economic and job opportunities to support a sustainable economy.

Importantly, we must acknowledge that historical decisions have resulted in health and opportunity gaps for residents in low-income communities and communities of color. Not everyone has the resources or access to make these choices—to buy a ZEV, install a heat pump, or use public transit to get to work. It is here that government can help. Government, at multiple levels, can fund programs and structure policies to provide consumers with more choice and to support them in adopting cleaner technology options. Whether through affordable energy rates or assistance in purchasing zero emission vehicles and appliances, we can use the transition to a carbon neutral economy as an opportunity to close some of these persisting opportunity gaps. By acting now, we can

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[539] Californiasolarcenter.org. Passive Solar History. *http://californiasolarcenter.org/old-pages-with-inbound-links/history-pv/*.
[540] Fuel Cell Store. History of Fuel Cells. *https://www.fuelcellstore.com/blog-section/history-of-fuel-cells?msclkid=04a19450c50211ec8d20f2afff4039fe*.

change our planet’s fate and build a more resilient, healthier, and equitable future for all Californians.

Exhibit C

Caltrans SB 743 Program

Mitigation Playbook

July 2022

DRAFT

SUSTAINABILITY
People, planet, prosperity

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INTRODUCTION

Caltrans seeks to avoid inducing new traffic, as measured in VMT, as it manages and evolves the State Highway System. This commitment arises out of the department's implementation of CEQA as amended by SB 743 (2013) and the resultant OPR Technical Advisory (2018). It also responds to research findings that induced traffic from highway expansions tends to undermine the purpose of many of those expansions, congestion relief.

This guide describes mitigation methods for VMT induced by highway capacity projects. It should be noted, however, that mitigation is not the first option for addressing induced VMT. The primary method is to plan and develop projects in a way that does not induce VMT in the first place. Where induced VMT is unavoidable, design and lane-management strategies may minimize it. Mitigation is required when significant induced VMT remains after exhausting these options. Formally, mitigation is memorialized in an environmental document, where it must meet CEQA standards for additionality[1] – the need for mitigation must be caused by the project – and be enforceable – the mitigation must be firmly committed to by the relevant parties. The mitigation must also be additional to any other VMT reduction required by law, or which would occur otherwise. And, most relevant to this guide, it must be quantifiable and effective at reducing VMT.

For transportation agencies, mitigation is a familiar concept with respect to other types of environmental impacts. Mitigation for induced VMT is less familiar for most of those agencies, but it has a long history in other settings. Local and regional governments and Transportation Management Associations, for example, have run programs aimed at reducing SOV transportation demand for many years.[2] More recently, since passage of SB 743, many local governments in California have established VMT

[1] For more on additionality, see this Aug. 26, 2021, bulletin from the SB 743 Program.

[2] Note that many of these programs are aimed at reducing peak-period congestion, rather than VMT. Often, but not always, measures aimed at peak period congestion also reduce VMT. See "Modernizing Mitigation: A Demand-Centered Approach" (SSTI, 2018) for more details.

calculators or other tools, which describe a menu of quantifiable VMT-reduction measures that land-use developers can use for VMT mitigation.

That history means that there is a substantial body of work on which to base mitigation decisions. In California, a particularly authoritative compilation of VMT-reducing measures was published in 2010 and recently updated in December 2021 by the California Air Pollution Control Officers Association. "Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity" is, as the title suggests, aimed at GHG impacts. However, in many instances described in the handbook, GHG reductions are accomplished through VMT reductions, and so the measure descriptions and quantification are useful in considering VMT mitigation for roadway expansions. The CAPCOA handbook is referred to frequently in the discussion on mitigation measures in this document, but we have not exhausted it as a source of mitigation ideas, so it is a recommended resource for anyone charged with the development and analysis of VMT mitigation.

Related, many local governments have developed VMT calculators, based on CAPCOA or the same body of literature used by CAPCOA. In this guide we use the Alameda County VMT calculator[3] as an example and list others in Appendix B. These calculators, like CAPCOA, can provide ways of assessing many potential VMT-reduction measures. Direct use is quite convenient because the calculators come pre-loaded with default data. Where such custom calculators do not exist, the formulas for making assessments can be useful, though the burden on the analyst to find data is greater.

With CAPCOA, the calculators, and other sources, we are able assess many mitigation measures for effectiveness. But not all. In this guide we include measures that are well-defined and quantified, and those that are conceptually effective but do not yet

[3] The Alameda County calculator referenced in this playbook uses 2010 CAPCOA data.

have standard metrics associated with them. We hope to develop some of these measures further both through ongoing Caltrans-funded research and through the efforts of the many stakeholders in the state and elsewhere. As development occurs, we will update and extend this guide.

Even though substantial and growing research to evaluate VMT mitigation measures exits, this does not mean mitigating VMT is easy. On the contrary, it is likely to be difficult, as highway capacity projects may generate VMT in the millions per year and creating offsetting reductions can be a significant undertaking. That is one reason the preferred route to VMT neutrality is to avoid VMT-inducing projects whenever possible. Best practices for considering VMT impacts early on in the project development process can be found in the SB 743 Environmental Essentials in Project Development and Delivery document, published by Caltrans.[4]

Caltrans and many stakeholders are interested in organizing mitigation efforts through banks or exchanges. If such efforts succeed, an entity would collect and validate VMT mitigation opportunities – from land-use developers, transit agencies, TMAs,[5] local active transportation programs and others – and make them available to transportation agencies whose projects are in need of mitigation. At the moment no such arrangement has emerged, so project development teams must either develop VMT-reduction measures, e.g. pedestrian facilities, or connect with mitigation providers themselves. Sharing this guide with likely providers in the area is one way to help surface possible mitigation options.

The rest of this guide summarizes mitigation measures, providing factors to consider, methods for measuring, and some examples of assessing measure efficacy.

[4] https://dot.ca.gov/-/media/dot-media/programs/sustainability/documents/sb-743-environmental-essentials-for-project-development-and-delivery-a11y.pdf
[5] See Appendix A for a list of TMAs in California.

HOW TO USE THIS PLAYBOOK

Though this playbook lays out various quantifiable approaches to mitigating VMT, it is not comprehensive. In some cases, entities may wish to use mitigations which are not in this playbook, are not readily available in other sources such as CAPCOA and may be difficult to quantify.

For example, take the case of transit facility comfort improvements such as benches and shade. These are both relatively low-cost system improvements, which—in theory—should have a positive effect on ridership, especially in places with higher temperatures and sun exposure. However, little research has been done on this question and no widely accepted quantification measures exist. If an entity wishes to use such improvements as VMT mitigation measures, more analysis would need to be done to develop a reasonable estimate. The analyst could review the existing literature on the topic—which is fairly scarce—to find any applicable evidence (either quantitative or qualitative) that would help build a case. Moreover, the analyst could rely on internal data, if such data showed an increase in transit ridership corresponding to the installation of shade facilities. Regardless of the specific methodology used, VMT reductions should be reasonable. In the shade facility installation case, it wouldn't be reasonable to expect a drastic ridership increase due to the installation of shade facilities and thus the VMT reduction would likely be fairly small in most cases.

This playbook includes other mitigation measures, such as park and ride lots, without given quantification approach. While various methodologies exist to calculate the VMT reductions from these mitigations, they are much more context sensitive and likely vary on a case-by-case basis. Additional research is likely needed in order to successfully quantify the effects of these mitigations. As Caltrans develops more guidance on these measures, this playbook will be updated.

Lastly, it is important to acknowledge that this playbook is not comprehensive and that the field and practice of VMT quantification and mitigation is rapidly evolving. Caltrans is currently funding a research project focused on assessing the effectiveness of potential VMT mitigation measures, the outcome of which may supersede this playbook.

MITIGATION MEASURES

Table 1 summarizes many mitigation measures that could be applied to a project to offset induced travel. "Ease of implementation" is higher when costs are lower and fewer parties are involved. "Efficacy" is higher for measures that have the potential to reduce more VMT in most common situations. "On-System" or "Off-System" refers to whether the measure applies directly to the SHS or not. The ratings are general and actual conditions will vary with particular projects. Note that while these measures could constitute mitigation, they could alternatively serve as projects or elements of projects, reducing or eliminating the need for mitigation. For example, added highway capacity may induce 1 million VMT annually, while transit improvements that are part of the same project may reduce VMT by 500,000 annually, leaving 500,000 VMT in need of mitigation (per CEQA). Alternatively, the transit improvements may be funded as mitigation.

Mitigation measures may be combined. However, in most cases a combination would reduce the effectiveness of each individual measure. Consider a combination of new transit service and dense affordable housing, aimed at reducing 1 million VMT. By themselves we calculate transit would offset 10 percent or 100,000 of the VMT from a project, while the dense affordable housing would offset 20 percent or 200,000. However, if transit reduces VMT to 900,000, then the dense affordable housing effect would be 20 percent of that figure, or 180,000. Thus, the total reduction would be 280,000 VMT. CAPCOA p. 38 and in introductions to measure descriptions provides guidance for combining measures.

Table 1. VMT mitigation measures summarized. Note that this list is not exhaustive, and other measures that satisfy CEQA requirements could be developed.

Measure	Ease of implementation	Efficacy	On- or Off-System	Key considerations
Active transportation	High	Low[6]	Both (Note: for the SHS, may be most effective when integrated with conventional "main-street" highways)	Must provide access to destinations, not simply recreational opportunities.
Land use – residential	Low	High	Off	Requires partnership agreements with land use jurisdictions housing authorities, and private developers. VMT benefits come from density, affordability and location.
Land use – employment	Low	High	Off	Requires partnership agreements with land use jurisdictions housing authorities, and private developers. VMT benefits come from density and location.
TDM	High	Medium	Off	Services can be tailored to meet specific user needs. Must be supported with long term maintenance of effort.
Transit service improvement	Low to high	Low to high	Both	Usually requires partnership agreements with transit operators.
Local road networks/ connectivity	Low to high	Low to high	Off	Can relieve pressures on SHS and provide more direct, multimodal access to destinations.

[6] This is not to imply that Active Transportation projects are not a high priority for Caltrans and worth doing for their own sake. While Active Transportation projects do have a downward VMT effect, the amount of VMT that can be reduced by these projects is often much smaller than the VMT induced by highway projects. This scale is important to consider when developing mitigations.

Measure	Ease of implementation	Efficacy	On- or Off-System	Key considerations
Micro-mobility	High	Low	Both	Requires partnership agreements with transit operators and/or transportation network companies.
Telecommuting	High	Minimal	NA	Telecommuting tends to shift trip-making, but not reduce VMT. Any claim here would need careful, specific support.
Schedule-shifting	NA	None	NA	Reschedules rather than reduces trips. Likely increases VMT.
Road diets	High	High	Both	Lane removals can be considered roughly equivalent to lane additions for similar facilities.
Pricing	Low to high	High	Both	Operational details and market analysis needed during PA&ED.
Lane management	Low to high	Low	On	VMT effect depends on specific management strategy such as transit/HOV priority.
Parking pricing/ restrictions	High	High	Off (On in some limited cases)	Potentially powerful tool for specific land uses in a highway corridor.
Park and ride lots	High	Low	Both	Removes commute trips. Effect on total VMT needs to be addressed in mitigation plan.
Land preservation	High	Unclear	Off	Could work in theory but measurement is difficult. May be best combined with transfer of development rights to spur infill TOD.

Active transportation

Providing complete streets or dedicated active transportation facilities is an integral part of achieving Caltrans' goals. Safe and convenient walking and biking environments should be provided regardless of the need for VMT mitigation. When mitigation funds are used for active transportation, the active transportation improvement must reduce motor vehicle use. For example, a new or improved AT facility that garners only recreational use would not serve as mitigation (though it may be worthwhile for other reasons).

<u>Factors to consider:</u>

- Proximity: Most transportation-related use of AT facilities is for short trips – less than 20 minutes, or about a mile walking or 3 miles cycling. Demand curves are steep; an additional minute or two can reduce AT demand significantly. Therefore transportation-generating facilities must link land uses that are fairly close, with as few traffic stops or diversions (including lengthy stairs or ramp for overcrossings) as possible (see Figure 1). Therefore, projects that reduce travel time between relatively proximate land uses are good candidates for VMT reduction. For example, a pedestrian overpass connecting two relatively dense residential and commercial areas that are separated by a highway would be an ideal VMT-reducing active transportation project

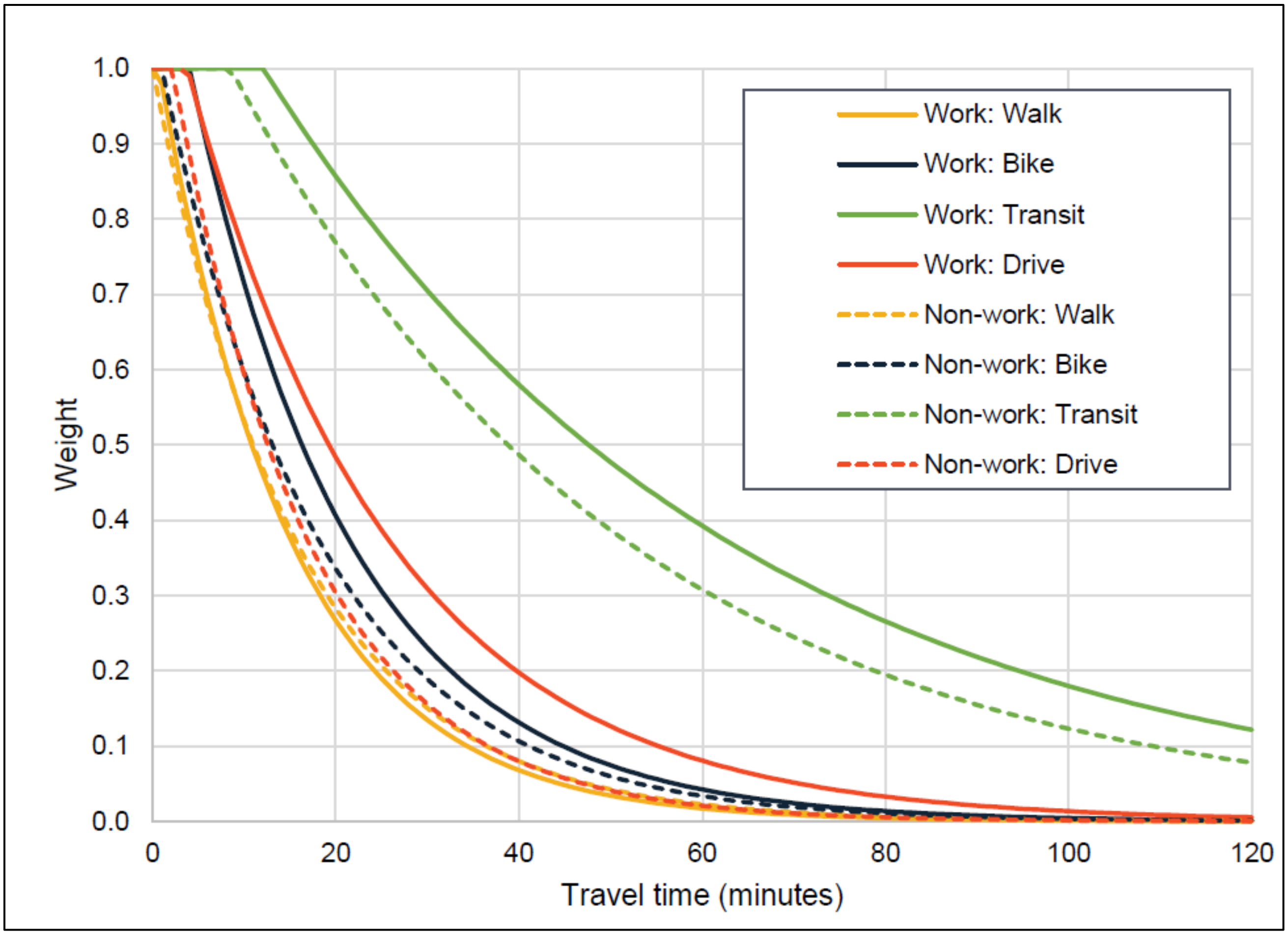


Figure 1. AT usage drops rapidly as time and distance increases. Source: SSTI.

- Level of traffic stress: Even if the network for AT appears robust on a map, with destinations in close proximity, travelers will not use it if it is perceived to be unsafe. Therefore, projects that reduce level of traffic stress, for example by providing buffered or separated cycling lanes, are good candidates for VMT reduction.
- Scale: Large highway projects generally have large impacts as they can affect auto accessibility across a region. AT projects are almost always more modest in scope, affecting in a narrower area, and in terms of VMT impact. In general AT improvements will offset a small percentage of induced VMT from a highway project.

Ways to measure VMT reduction:

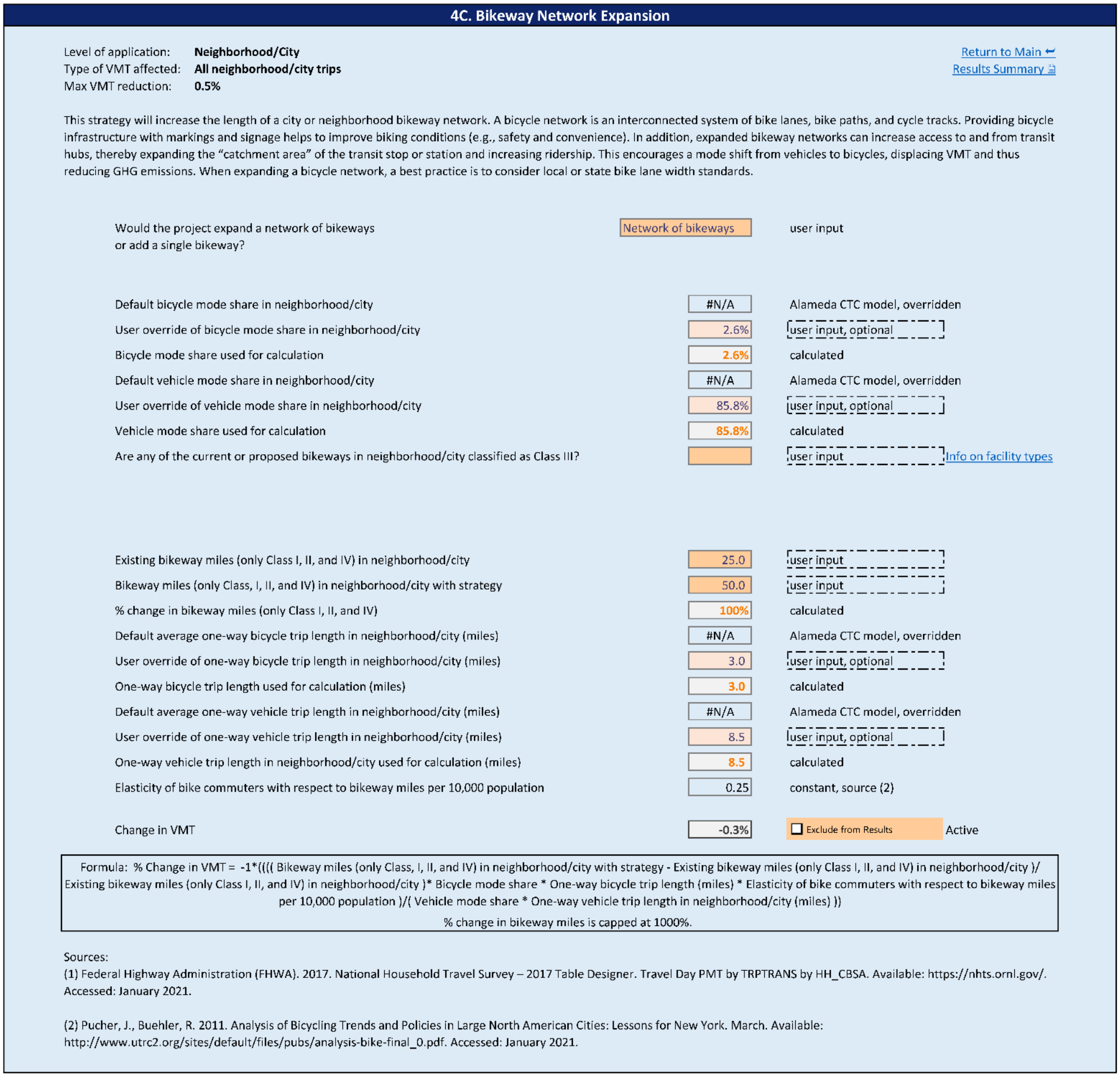
- Most demand models are unable to measure effects from AT projects, due to lack of granularity. Should a region invest in a parcel-based model, it could be so employed. For a very large new AT facility, such as a river or freeway crossing that links two transportation analysis zones, a conventional demand model might be employed.
- Various data/software packages are available to measure outputs from small network and land use changes. Urban Footprint is a commonly used package, and it could estimate effects from AT network changes. Caltrans' local partners may have access to this tool.
- Some local governments have adopted VMT estimation tools for use in evaluating land-use and transportation projects. These tools often include AT facility improvements as measures, giving VMT outcomes. An example is the Alameda CTC tool. Where these tools are available online or as macro-enabled spreadsheets, they can be of use in assessing VMT impacts from AT facilities. It may also be possible to use one of these tools where it exits in a neighborhood similar to one where the project will be, if there is no tool there. Alternatively, the underlying formulas may be of use with project-area data; the Alameda formulas are cited below.
- For new pedestrian facilities, several formulas exist, including[7]:
    - "Alternative Quantification Method" prepared for CARB in 2019. See pp. 26-30.
    - "Pedestrian Facility Improvement" prepared for Alameda County (similar to formulas used by other local governments). See pp. 34-35.

[7] Note that the changes in VMT indicated will be for a relatively small project area, compared to the area affected by highway VMT.

- For new bike facilities, several formulas exist, including[1]:
    - o "Alternative Quantification Method" prepared for CARB in 2019. See pp. 5-7.
    - o "Bikeway Network Expansion" and "Bike Facility Improvement" prepared for Alameda County (similar to formulas used by other local governments). See pp. 37-40.
- For improvements in level of traffic stress, formulas also exist. These may be applied along with the new-facility formulas; for example, if a facility may be considered utility-constrained by LTS, with improvements counting toward additional utility and VMT reduction:
    - o "Low-Stress Bicycling and Network Connectivity" by the Mineta Transportation Institute in 2012. See pp. 17-22 for segments, pp. 23-26 for intersection approaches, pp. 27-30 for crossings.
    - o "Level of Traffic Stress" by the State Smart Transportation Initiative in 2021. See pp. 27-29.
    - o The Alameda County provides adjustment factors for various bike improvements. If a new Class II bike lane is the base, a new Class 1 bike path or Class IV bikeway will be 1.54 times as impactful, while a Class II to Class IV conversion will be 0.54 times as impactful. See pp. 38-9.
- Sometimes a more ad hoc or qualitative case can be made. This might be the case if new or improved AT facilities were designed to serve a particular, perhaps new, activity center. If trip lengths can be determined, the Auto Substitution rates in the CARB formulas may help estimate the VMT displaced. As well, facilities that clearly improve AT connectivity and/or traffic stress in relatively dense areas with a variety of land uses can be assumed to have beneficial VMT impacts. In the Sacramento region, SACOG's Project Performance Assessment tool provides density and land-use mix data for project areas, which can be easily inputted.

Examples:

- New AT elements: Consider an expansion of bikeways. The Alameda County calculator, or similar calculators in other cities, are a convenient way to determine VMT impacts. Figure 2 below shows the calculator estimate, using built-in default values and a handful of user inputs to show the location and extent of the bikeway improvements. The result is in terms of percentage of VMT, so a final step would be to apply that percentage to total VMT in the affected area, which could be obtained from the MPO or other planning entity, or from a big-data tool. Caltrans also tracks VMT at the municipal and county levels, though most active transportation improvements would affect much smaller geographies. Where calculators are not available, the formulas above or in the calculator may be used, but data burden will be higher.
- Improved AT elements: Consider an improvement to a facility, rather than new facilities. The analyst needs to make a finding about the improved utility. If the improvement is very significant, e.g. there was a pedestrian route but it was very difficult to use, not ADA compliant, and/or clearly unsafe, and the improved route addresses such issues, it might be considered to have as much impact as a new facility. More typically, an improved facility will get "partial credit." For example, the Alameda calculator documentation cited above would provide 54 percent of the VMT reduction for a Class II to Class IV conversion, compared to a new facility.



4C. Bikeway Network Expansion

Level of application: **Neighborhood/City**
Type of VMT affected: **All neighborhood/city trips**
Max VMT reduction: **0.5%**

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Results Summary

This strategy will increase the length of a city or neighborhood bikeway network. A bicycle network is an interconnected system of bike lanes, bike paths, and cycle tracks. Providing bicycle infrastructure with markings and signage helps to improve biking conditions (e.g., safety and convenience). In addition, expanded bikeway networks can increase access to and from transit hubs, thereby expanding the "catchment area" of the transit stop or station and increasing ridership. This encourages a mode shift from vehicles to bicycles, displacing VMT and thus reducing GHG emissions. When expanding a bicycle network, a best practice is to consider local or state bike lane width standards.

Would the project expand a network of bikeways or add a single bikeway?	Network of bikeways	user input
Default bicycle mode share in neighborhood/city	#N/A	Alameda CTC model, overridden
User override of bicycle mode share in neighborhood/city	2.6%	user input, optional
Bicycle mode share used for calculation	2.6%	calculated
Default vehicle mode share in neighborhood/city	#N/A	Alameda CTC model, overridden
User override of vehicle mode share in neighborhood/city	85.8%	user input, optional
Vehicle mode share used for calculation	85.8%	calculated
Are any of the current or proposed bikeways in neighborhood/city classified as Class III?		user input Info on facility types
Existing bikeway miles (only Class I, II, and IV) in neighborhood/city	25.0	user input
Bikeway miles (only Class, I, II, and IV) in neighborhood/city with strategy	50.0	user input
% change in bikeway miles (only Class I, II, and IV)	100%	calculated
Default average one-way bicycle trip length in neighborhood/city (miles)	#N/A	Alameda CTC model, overridden
User override of one-way bicycle trip length in neighborhood/city (miles)	3.0	user input, optional
One-way bicycle trip length used for calculation (miles)	3.0	calculated
Default average one-way vehicle trip length in neighborhood/city (miles)	#N/A	Alameda CTC model, overridden
User override of one-way vehicle trip length in neighborhood/city (miles)	8.5	user input, optional
One-way vehicle trip length in neighborhood/city used for calculation (miles)	8.5	calculated
Elasticity of bike commuters with respect to bikeway miles per 10,000 population	0.25	constant, source (2)
Change in VMT	-0.3%	Exclude from Results Active

Formula: % Change in VMT = -1*(((Bikeway miles (only Class, I, II, and IV) in neighborhood/city with strategy - Existing bikeway miles (only Class I, II, and IV) in neighborhood/city)/ Existing bikeway miles (only Class I, II, and IV) in neighborhood/city)* Bicycle mode share * One-way bicycle trip length (miles) * Elasticity of bike commuters with respect to bikeway miles per 10,000 population)/(Vehicle mode share * One-way vehicle trip length in neighborhood/city (miles)))

% change in bikeway miles is capped at 1000%.

Sources:

(1) Federal Highway Administration (FHWA). 2017. National Household Travel Survey – 2017 Table Designer. Travel Day PMT by TRPTRANS by HH_CBSA. Available: https://nhts.ornl.gov/. Accessed: January 2021.

(2) Pucher, J., Buehler, R. 2011. Analysis of Bicycling Trends and Policies in Large North American Cities: Lessons for New York. March. Available: http://www.utrc2.org/sites/default/files/pubs/analysis-bike-final_0.pdf. Accessed: January 2021.

Figure 2. Alameda County VMT calculator, an Excel tool. Addition of 25 miles of bikeway results in a 0.3 percent reduction in VMT.

Land use – residential (density and affordability)

Compact housing can reduce VMT compared to housing that is lower density. Affordable housing produces less VMT compared to market-rate housing. To the extent a project contributes to such housing, it can take credit for the VMT reduction compared to business as usual. Compared to other options, denser, more affordable housing is a powerful VMT-reduction tool.

<u>Factors to consider:</u>

- Density of housing relative to typical or existing
- Affordability of new housing
- Current household VMT
- The level of contribution committed by the mitigation
- Location of the housing project

<u>Ways to measure VMT reduction:</u>

- For projects that provide density, CAPCOA provides an elasticity of -.22. That is, for every percentage increase in density, VMT decreases by -.22 percent. Additionally, there is a starting point; density must by higher than typical in order to qualify as a VMT reducer. CAPCOA sets that starting point at 9.1 units/acre. Lower density developments would not reduce VMT. And CAPCOA caps the reduction at 30 percent. For more details, see CAPCOA, pp. 70-72. Table A-3.1 shows VMT reductions in percentages and per household (assuming typical VMT), for various densities.

Equation 1: Increase Residential Density

$$A = \frac{B - C}{C} \times D$$

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project VMT in study area	0–30.0	%	calculated
User Inputs				
B	Residential density of project development	[]	du/acre	user input
Constants, Assumptions, and Available Defaults				
C	Residential density of typical development	9.1	du/acre	Ewing et al. 2007
D	Elasticity of VMT with respect to residential density	-0.22	unitless	Stevens 2016

See table A-3.1 in Appendix 3 for comprehensive VMT reduction values for increased residential density.

- For projects that include affordable multifamily housing[8], VMT for units dedicated as affordable can be estimated at 28.6 percent reduced from market. For more details, see CAPCOA, pp. 80-83.
- Note that the source material from CAPCOA considers density at the project level. However, if a very large housing project increases density in a larger

[8]CAPCOA defines affordable housing: "Multifamily residential units must be permanently dedicated as affordable for lower income families. The California Department of Housing and Community Development (2021) defines lower income as 80 percent of area median income or below, and affordable housing as costing 30 percent of gross household income or less."

geography, such as a TAZ or Census block group, it would be fair to consider the increase across the full geography, adding a VMT reduction for the existing homes to the calculation for the project itself.

- CAPCOA cautions that "This measure is most accurately quantified when applied to larger developments and/or developments where the density is somewhat similar to the surrounding neighborhood." It is unlikely that a small project would be attractive as mitigation for a highway project. However the second caution is important. A dense housing project in a very disconnected, low-density area will be unlikely to provide the VMT benefits desired. In other words, infill rather than edge development is the goal.
- If a project contributes half of the backing (funding, land, infrastructure, etc.) needed to deliver the housing units that reduce VMT by 10,000 miles/day, it could claim 5,000 miles/day as VMT reduction.
- Caltrans is working to acquire an accessibility tool to help quantify the effect of a project that is located with high destination activity – where residents and visitors can access many destinations with short auto trips, or by other modes. For now, this aspect can be cited directionally, e.g. to add more support to claims of reduced VMT for a dense housing project. See CAPCOA, p. 52.

Examples:

- New density: CAPCOA assumes a typical density of 9.1 dwelling units/acre. Housing provided at greater than 9.1 units/acre can be assessed for VMT reduction as follows: A new project will provide 1,000 housing units at a density of 10 units/acre, a 10 percent increase over BAU. Per the elasticity cited in CAPCOA, we should expect VMT to be reduced by 2.2 percent, or 427 miles annually for a typical household. For 1,000 units, the development will reduce VMT by 427,371 per year.

In addition, the project raises the density of the neighborhood (TAZ, block group or similar geography) by 5 percent, to 9.6 du/acre (above the 9.1 threshold). There are 2,000 existing households in the geography. The 5 percent increase in density equates to 1.2 percent reduction in VMT, or 237 miles/year/household. For 2,000 households, this produces another reduction of 474,857 VMT per year.

- Affordability: For the example above, if a project proposed 1,000 affordable housing units at the standard 9.1 units/acre, it could assume an annual VMT reduction of 5,618 per household based on the 28.6 percent reduction from the typical 19,641.8 per year. Based on this reduction, 1,000 units could claim a reduction of 5,617,555 VMT per year. If the project was also denser than 9.1 units/acre, it could claim both reductions from affordability and density, subject to the rules of combining measures in CAPCOA (discussed on page 6).
- Proportion of impact: Consider the affordability example. The project costs $20 million. Caltrans, in mitigating a highway mitigation project, provides surplus land valued at $3 million, in-kind infrastructure work valued at $4 million, and $3 million in funding, covering half the project cost. Caltrans could claim 2,808,777 annual VMT in mitigation.

Land use – employment (density)

As with residential density, job density can shorten trips and reduce VMT. If a transportation project contributes to development of dense employment facilities, it could claim some VMT reduction as mitigation.

Factors to consider:

- Density of prospective employment center.
- Typical VMT for employment in the area.
- Proportion of backing for the employment center from the mitigation effort.
- Per CAPCOA guidance, this measure is most effectively quantified when used in the context of either a large new development and/or a new development with similar surrounding densities.

Ways to measure impacts:

- CAPCOA (pp. 73-5) provides a density-to-VMT elasticity of -0.07. It sets 145 jobs/acre as a floor for seeing VMT benefits, and a cap of 30 percent on VMT reductions from density. Reductions are shown in Table A-3.2. These must be applied to typical commute VMT for the development, a number that may be developed during the traffic and parking study or may be available from the MPO or other planning entity. Local VMT calculators may also provide estimates. If typical commute VMT is not available, it could be calculated by referring to the ITE Trip Generation Manual and multiply the trips by trip lengths from a big-data tool.

Equation 2: Increase Job Density

$$A = \frac{B - C}{C} \times D$$

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project VMT in study area	0–30.0	%	calculated
User Inputs				
B	Job density of project development	[]	jobs per acre	user input
Constants, Assumptions, and Available Defaults				
C	Job density of typical development	145	jobs per acre	ITE 2020
D	Elasticity of VMT with respect to job density	-0.07	unitless	Stevens 2016

See table A-3.2 in Appendix 3 for comprehensive VMT reduction values for increased job density.

- Local VMT calculators may also provide estimates of outcomes from employment density. The Alameda County calculator does so, requiring the user to input location and density information.

Example:

- New job center: In order to mitigate VMT from a transportation project, funds are made available to an office developer that is planning a new activity center. The activity center will cost $20 million, and mitigation supplies $10 million in order to capture half the VMT reduction benefit as mitigation. The facility will house 2,000 workers at 400 employees per acre. From the table, this level of density implies a 12.3 percent reduction in commute VMT compared to typical conditions. A traffic study for the project indicates typical commute VMT in the area is 75 miles per week per employee. The denser development will reduce commuting by 9.2 miles per week for 2,000 workers, or 18,466 per week, or 960,207 per year assuming a 52-week year, for the workforce. Because the project provided half the support to develop the employment center, it can claim 480,103 in reduced annual VMT as mitigation.

Transportation Demand Management (TDM)

Transportation Demand Management (TDM) is a longstanding practice most often aimed at getting workers to their jobs while reducing peak-hour vehicle travel. However, TDM can also be focused on other groups, such as students or tourists, or at a general community level. While TDM was developed as a response to peak-hour congestion, most of the measures commonly employed also tend to reduce VMT. Exceptions, discussed elsewhere in this guide, are telecommuting and schedule-shifting, which have peak-hour benefits but minimal or no VMT benefits. Measures that are more useful to consider include transit and micro-mobility pass discounts, carpool matching and incentives, parking pricing (discussed separately in this guide), bike facilities at workplaces, vanpools, emergency-ride-home service for non-driving employees, education and information on non-SOV travel, and more. "Modernizing Mitigation" (2018) from the State Smart Transportation Initiative, describes VMT-focused TDM in more detail.

Factors to consider:

- SB 743-relevant TDM measures may replace car trips with other modes or by increasing vehicle occupancy in motor vehicle trips (e.g. carpooling). As well, TDM measures could work in tandem with workplace and residential density measures to reduce distances traveled.
- TDM may be supported with capital mitigation funds as new highway capacity opens – resources would need to provide VMT reductions for the project's lifecycle – or it could be funded on an ongoing basis out of tolls from the project itself.
- TDM may be accomplished by requirements from local units of government. The various local VMT calculators in Appendix B are largely aimed at reducing VMT from new development through TDM and other measures. TDM is also offered by Transportation Management Associations (TMA), listed in Appendix A, and by Congestion Management Associations (CMA). TMAs are typically public-private partnerships, or entirely private organizations, frequently formed as voluntary

non-profit organizations by partnering jurisdictions and large employers. CMAs are typically governmental agencies, frequently incorporated under state and federal law by Regional Transportation Planning Agencies as a part of their planning, programming, and service delivery portfolios. Other providers include local governments, employers, college campuses, transit systems (e.g. with free or discounted transit passes), and residential landlords (e.g. with priced parking).

Ways to measure impacts:

- The large number of TDM measures available, combined with variable effects by setting, make it impossible to summarize measurement methods in this short guide. However, TDM providers may be able to calculate VMT effects of their services, based on the CAPCOA guide or similar literature, or their own analysis of their programming. Some of the local VMT calculators capture this effect; the Alameda County calculator calculates effects for employee and residential transit subsidies and vanpools for specific sites. (Note that the calculator does show reductions for telecommuting for employment sites, but it does not address effects other driving, so it would not be useful for VMT mitigation of a highway project.) If a TMA or other entity has ready evidence of program effectiveness, purchasing VMT reduction may be fairly straightforward. In other cases, project teams will have to work with the literature, local VMT calculators, or other sources to estimate VMT effects.

Example:

- Transit-pass subsidies: Consider a highway project that adds HOT lanes. The city through which the highway passes has piloted a mobility wallet program, which provides free passes for transit and bike- and scooter-share. The program costs $50 per participant per month, and surveys of pilot participants showed that on average each reduced their VMT by 50 miles per month while in the program. As part of its mitigation package, the highway project commits toll revenues of

$50,000 per month to support 1,000 users, claiming 50,000 miles of reduced VMT per month.

Transit service improvement

Transit can be an important VMT reduction strategy. Not only may it replace auto trips, but over time it can foster transit-oriented development (TOD), which provides low-VMT housing, employment, retail, and other land uses. TOD may be developed intentionally around transit service, or it may occur organically as land uses adapt with features such as higher densities (accomplished in part by parking reductions), walkability and public-area amenities, and a mixture of land uses in close proximity. Note that even community members who never ride transit will enjoy shorter trips via this effect. VMT reduction though the land use effect is sometimes referred to as a "transit multiplier."

<u>Factors to consider:</u>

- Mitigation should be based on actual transit service improvements. It is not enough to say that congestion reduction on a facility might allow for better service. It would be more compelling to work with a transit provider to determine the actual effect on travel times, headways and potential increased service would result from highway improvements, such as transit-signal priority, lane management and others. Direct support for transit that increases service would, of course, be an even more compelling case for mitigation.

<u>Ways to measure impacts:</u>

- Determining the VMT effect from increased transit service can be done with two calculations:
    - Ridership. For major transit projects, the provider will estimate ridership for New Starts, Small Starts or state capital funding. Such applications could provide the needed estimate, which should be in the form of passenger-miles-traveled. If such an application is not being made, the transit provider would need to make an estimate using similar methods.
    - VMT. Converting ridership into VMT is thoroughly discussed in "An Update on Public Transportation's Impacts on Greenhouse Gas Emissions" (TCRP, 2021). In summary, a passenger-mile on transit directly replaces .329 VMT

(not all transit trips would have been taken by car). Adding the powerful land-use multiplier effect, which reduces travel for transit users and non-users alike, the overall savings in VMT is 2 miles for every 1 passenger-mile.

- Alternatively, local VMT calculators may provide VMT reduction estimates. The Alameda County calculator provides estimates both for transit network expansions and for transit frequency improvements.

Example:

- Lane-management: A freeway expansion includes transit-priority at ramps and lane-management that gives buses markedly improved travel times and reliability[9]. The transit provider is able to improve headways as well, because buses are no longer stuck in traffic. As a result of these improvements, the transit provider estimates a ridership increase of 100,000 passenger-miles per year. With the TCRP formula discussed above, such ridership should reduce VMT by 200,000 per year. If the transit priority and lane-management strategies are committed for the project lifecycle, the 200,000 VMT reduction could be used to offset the VMT increase from the highway project (as part of the project's estimated net VMT or as a mitigation measure).
- Light-rail extension. A transit provider has a planned but unfunded light-rail extension in a corridor where Caltrans is adding an HOV lane, which will be converted to HOT, for $400 million. Capital cost of the transit project is $200 million. The freeway contributes $100 million in mitigation, and the transit provider raises the other $100 million for the project. The transit provider estimates the extension will grow ridership by 2 million passenger-miles per year. Employing the mode-shift factor and transit multiplier from TCRP, this ridership would imply a reduction of 4 million VMT per year. Project mitigation

[9] Bus on Shoulder (BOS) projects are another important type of transit service improvement on state highway facilities.

paid half the capital cost and could claim 2 million VMT in mitigation, assuming it also covers half the ongoing operating cost from toll revenues.

Local road networks/connectivity

Though highways were originally conceived as intercity or rural-serving facilities, today in most places they facilitate mostly local and intraregional travel. The large volume of short-distance traffic is both a problem – it undercuts highways' original purpose, for example by delaying intercity or farm-to-market freight in traffic – and an opportunity. In many cases local travelers use the state highway system (SHS) for short trips because local networks are incomplete or disconnected. Creating better-connected, multimodal networks off the SHS offers options for travelers to make more direct trips, sometimes by non-auto modes, reducing not only VMT but pressures to add expensive highway capacity. The planning literature cites "intersection density" as a measure of connectivity, and one that indicates lower VMT. Assisting owner-operators of local networks could thus reduce the need for highway capacity and mitigation and may provide mitigation opportunities where needed as well.

<u>Factors to consider:</u>

- Origins and destinations of travelers in a corridor or on a facility.
- Gaps and other identified needs in the local modal networks.

<u>Ways to measure impacts:</u>

- Needs and gaps can be demonstrated through the use of big data, to examine origins and destinations of travelers, and circuity of routing. Where travelers are diverting significantly from direct routes, or where they are nearly all driving despite origins and destination that are close by, improvements in the auto and active transportation networks are worth considering. See Figure 5 as an example.
- Accessibility tools can measure gaps in the multimodal systems as well, comparing existing accessibility to ideal accessibility where origins and destinations are linked directly.
- If local network improvements are sufficient to avoid capacity on the SHS, and they are screened as unlikely to induce VMT, mitigation is a moot issue. If new capacity on the SHS is still pursued, local network improvements may be applied

to mitigate some of the resulting induced VMT. Quantification of new active transportation facilities and improved transit service are discussed in a separate section. A more robust street network would likely require analysis with a travel demand model or a similar tool, e.g. Urban Footprint, to demonstrate it was not adding VMT-inducing capacity and to assess VMT reductions from greater connectivity.

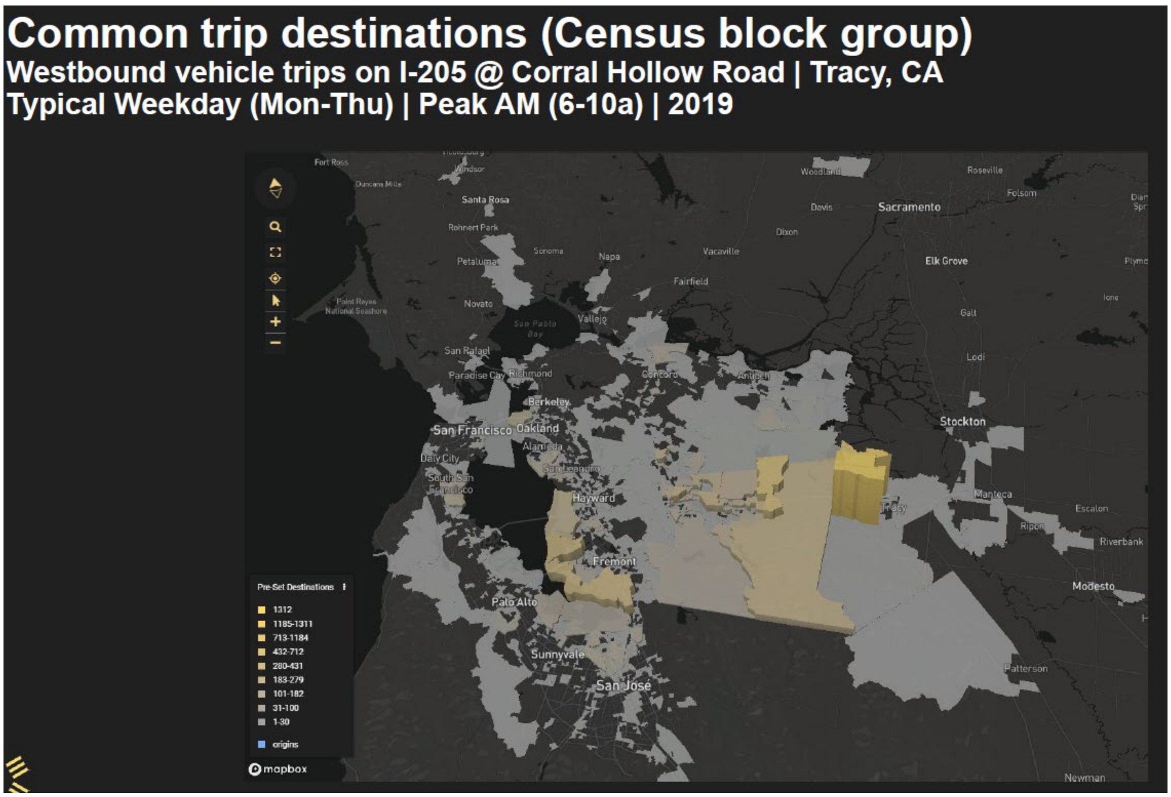


Figure 3. Big data indicates destinations of travelers passing through a select link in Tracy. While some travel long distances, a large number are making local trips, suggesting local network improvements might relieve pressures on the Interstate.

<u>Example:</u>

- Critical added link: A freeway serving a major activity center is experiencing congestion, and widening is under consideration. Some of the heaviest traffic occurs on a bridge connecting the activity center to medium-density neighborhoods and smaller activity centers. There is no nearby surface facility paralleling the freeway bridge, but the locality has been studying such an option, potentially carrying autos, bikes, pedestrians, and extended light-rail service. Origin-destination studies show significant circuitous auto travel in the corridor, which might divert to the more direct route afforded by a new bridge. While the bridge is not screened as categorically unlikely to induce travel, travel-demand analysis suggest it will provide meaningful route-shortening, and a delphi panel determines that as a slow-speed, local-serving surface facility connecting likely infill areas, it is unlikely to induce low-VMT land use. Transit and active transportation provide additional VMT reductions. A decision is made to table the freeway widening and to support the local government in pursuit of the VMT-reducing reliever bridge.

Micro-mobility

Micro-mobility programs can reduce VMT and provide other benefits such as enhanced mobility. However, widescale deployment of micro-mobility programs is ongoing, and the VMT-reducing effects of such programs are not well-understood and vary greatly by context.

Factors to consider:

- For its cost, micro-mobility delivers fewer benefits than other potential mitigations.

Ways to measure impact:

- CARB recommends a simple approach to quantify VMT reductions from Micro-mobility implementation. Using default assumptions on bike and scooter share trip lengths and induced trips, VMT reductions can be derived given an expected number of micro-mobility trips. Equation 3 below can be used to estimate VMT reduction given an expected number of trips.

Equation 3: Implement micro-mobility

$$\boldsymbol{R} = (\boldsymbol{T}) \times (\boldsymbol{A}) \times (\boldsymbol{L})$$

ID	Variable	Value	Unit	Source
		Output		
R	Reduction in auto VMT	[]	VMT	calculated
		User Inputs		
T	Number of annual trips expected in the first year	[]	trips	user input
		Constants, Assumptions, and Available Defaults		
A	Adjustment factor to account for induced trips and recreational bike share use	0.5 (bike and scooter)	unitless	CARB 2019
L	Average length of micro-mobility trip	1.5 (bike), 1 (scooter)	miles	CARB 2019

<u>Examples:</u>

- At mitigation for a large highway widening project, Caltrans funds the rollout and operations of a dock-less bikeshare program for a one-year period in a mid-sized city where the widening will occur. Based on previous dock-less bikeshare rollouts in similar-sized cities, it is expected that approximately 500,000 trips will occur during the first year. Using the assumptions for bikes, the bike-share program is expected to reduce VMT by 375,000 annually, or by 1,027 per day. Since Caltrans funded the program, the full 375,000 annual VMT reduction can be claimed as mitigation for one year.

Telecommuting

Telecommuting is a tool that has been used to reduce peak-hour congestion, and one that has been popular as workplaces shut down during the COVID pandemic. It may appear attractive as a VMT-reduction measure, but caution is warranted.

Factors to consider:

- Telecommuting's effect in reducing VMT is doubtful, and it may actually generate more VMT. CAPCOA (p. 54) cautions that "While this measure [telework] certainly reduces commute-related VMT, recent research has shown that total VMT from telecommuters can exceed VMT from non-telecommuters (Goulias et al. 2020)." Pandemic-era VMT patterns documented in big data suggest "WFH didn't necessarily mean all workers were driving less. Many just may have been driving differently. Our analysis found a shift in peak driving hours, with a dip in morning driving but a slight rise and wider peak time for afternoon driving. Also, essential workers still commuted, and Census data showed a large increase in online retail, which created more delivery vehicle miles." More evidence of telecommuting's poor performance in reducing VMT is here and here.

Ways to measure impacts:

- Measuring reduction in commute VMT is straightforward if motor-vehicle-based commute volumes and distances are known, and the effect of a telecommuting program were also predictable. However, any claim for reduced VMT from telecommuting would need careful, specific support to show how it would address non-work travel, or longer work-travel distances created when workers who frequently telecommute move further from the workplace.

Examples:

- NA

Schedule-shifting

Alternative work schedules, encouraging workers to commute during non-peak hours, is a congestion-reduction strategy, but probably not a VMT-reduction strategy. Some alternative work schedule arrangements eliminate some workdays and thus some work trips. However, the impacts of such a policy may be limited and the removal of work trips doesn't necessarily reduce overall VMT (as discussed in the previous Telecommuting section).

<u>Factors to consider:</u>

- Because it shifts travel times rather than eliminating or shortening them, there is no rationale for considering it as a VMT-reduction measure. Schedule-shifting may actually increase VMT if it allows commuting during periods of faster traffic and/or involves off-peak work travel when transit service is less robust.

<u>Ways to measure impacts:</u>

- NA

<u>Examples:</u>

- NA

Road diets

Caltrans determines VMT impacts by considering highway capacity, essentially as a proxy for reduced travel times that spur additional driving. Because additional lane-miles are a critical factor in calculating increases in VMT, it may be useful to think about lane reductions, aka road diets, as a VMT-reduction measure. Road diets have become popular in recent years, as reduced road widths can improve safety at intersections or along the roadway due to speed reductions, and they can accommodate bike lanes and/or wider sidewalks, as well as parking for local destinations. They are screened as unlikely to induce VMT (TAF, p. 14). Where lane reductions can offset lane additions, the reduction can be used to offset VMT predicted to occur from the additions.

Factors to consider:

- Reducing lanes to offset added lanes can avoid burdens around calculating VMT outcomes. The showing of net-zero lane additions would be sufficient for full mitigation.
- The offsetting reductions must be reasonably equivalent to the lanes being added. A freeway lane-mile could not be offset by reducing a lane-mile on a collector street. In general, induced VMT decreases with functional classification. Therefore, it would be appropriate to cite lane reductions for a facility equal to or higher in functional classification of the facility receiving the additional lanes.
- Any multimodal benefits from the lane reduction such as added bikeways or sidewalks, or safer crossings or operating speeds, should be cited to provide extra evidence for the VMT-reducing effects of the road diet.
- The road diet does not need to be within the project boundaries of the capacity project, or in the same corridor. However, if the widening project adds VMT in a distressed community and the road diet benefits a different community, particularly one that is not distressed, equity would be a policy concern.

Ways to measure impacts:

- Show that lane reductions are equal or greater to lane additions both in terms of length of travel lanes affected and functional classification. Cite multimodal improvements as additional support.
- Where lane reductions do not fully mitigate a project's lane additions, they can be used in combination with other mitigation measures.
- It may be possible to show a mitigation benefit where functional classifications or project types are not easily comparable, e.g. where the road diet on a minor arterial is part of a mitigation package for a freeway addition or for an interchange. As of now there is no simple formula for this instance, and it would require substantial specific analysis by a project team and/or a consultant.

Example:

- Road diet offset: A project to add two lane-miles to a principal arterial in an industrial neighborhood (functional class 3) will generate 500,000 VMT annually. A mile away in a residential/commercial neighborhood, the locality is considering reducing a four-lane principal arterial to two travel lanes, a turn lane, and bike lanes. That project would reduce travel lanes by 2.5 miles. Conditioning the widening project on funding and construction of the road diet would lead to a net reduction of travel lanes and would satisfy the VMT mitigation requirement for the widening project.

Pricing

(Under development)

Pricing literally raises the cost of travel, which would seem to discourage driving and reduce VMT. However, when lanes are priced to improve flows, travelers may find it advantageous to pay the dollar cost in exchange for time-cost savings. In addition, some studies have shown that HOV-to-HOT conversions result in travelers paying to avoid carpooling, lowering vehicle occupancy and raising VMT. Determining when pricing reduces VMT, and by how much, remains under investigation.

Lane management

(Under development)

Lane management strategies vary and with them VMT outcomes. Caltrans guidance, for example, treats the addition of an HOV2+ lane as the equivalent in most cases as the addition of a general-purpose lane, because HOV2s on the facility simply sort themselves into the new lane. HOV3+ holds more promise for raising vehicle occupancy and reducing VMT compared to general purpose lanes. We are investigating ways to quantify outcomes from such strategies.

Parking

Parking management is one of the more powerful measures that either spurs driving or reduces it. Typically, these measures are applied at multifamily residential or employment land uses, in the form of parking charges or capacity limitations. As such, these measures could work in tandem, subject to the rules of combining measures, of denser housing or employment. There could be ways to achieve VMT benefits from parking management outside of specific land uses, though the calculations would be more complex. Note that some localities enforce parking minimums and would require exceptions for major capacity limitations.

Factors to consider:

- Standard parking-demand rates (based on unlimited free parking).
- Type and degree of parking management (extent of capacity limitation, amount of fees).

Ways to measure impacts:

- For capacity limits at residential land uses, CAPCOA calls for calculating the standard parking demand from the "ITE Parking Generation Manual," finding the difference between that figure and the proposed lower figure, and applying constants. The result is a percentage decrease in VMT compared to typical conditions; that percentage could be applied to an average household VMT figure to get the predicted reduction in VMT per household. The reduction is capped at 15.7 percent. An important caveat is that this measure will not work if free parking is readily available on the street or elsewhere near the housing project. For more details, see CAPCOA pp. 122-5.
- For parking charges at residential land uses, CAPCOA provides a formula that only requires the amount of the fee. Results are shown in Table A-3.3, based on the household VMT average from the 2017 NHTS. The percentage reduction would be applied to an average household VMT figure to get the predicted reduction in VMT per household. The reduction is capped at 15.7 percent. For more details, see CAPCOA, pp. 126-9.

Equation 4: Unbundle Residential Parking Costs from Property Cost

$$A = \frac{B}{C} \times D \times E$$

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project VMT in study area	0-15.7	%	calculated
User Inputs				
B	Annual parking cost per space	[]	$ per year	user input
Constants, Assumptions, and Available Defaults				
C	Average annual vehicle cost	$ 9,282	$ per year	AAA 2019
D	Elasticity of vehicle ownership with respect to total vehicle cost	-0.4	unitless	Litman 2020
E	Adjustment factor from vehicle ownership to VMT	1.01	unitless	FHWA 2017

See table A-3.3 in Appendix 3 for comprehensive VMT reduction values for unbundled parking costs.

- For parking charges at employment land uses, CAPCOA offers a variation on the residential formula. See CAPCOA, pp. 109-112. It produces percentage decreases in commute VMT associated with the land use, which would need to be separately calculated. It caps the reduction at 20 percent.
- Some local VMT calculators provide easy ways to calculate VMT reductions from parking policies. The Alameda County calculator, for example, has options for pricing residential and employee parking, as well as "parking cash-out" (another form of pricing), and for limiting parking supply.

Example:

- Unbundled residential parking: A highway expansion is mitigating induced VMT by supporting a new housing development (see Land Use – residential). The development will produce 1,000 housing units, and the project is providing half the backing to build the project. The development is located in an area where street parking requires residential permits, which are not available to residents of the new buildings. It will charge $200 per month for parking in addition to rent. Per Table 2, the $2,400 annual parking cost implies a reduction of 10.4 percent in VMT, or 2,051.8 in lowered VMT compared to typical households. The development as a whole produces 2,051,800 less VMT than typical in a year. Because mitigation is responsible for half the backing of the project, it amounts to 1,025,900 per year. If the housing is denser than 9.1 units per acre, it could also claim VMT reductions for density, subject to the rules of combining measures in CAPCOA.

Park-and-ride lots

(Under development)

Park-and-ride lots, when serving transit, can be important means of reducing commute travel. If they serve a well-defined activity center, calculating the VMT reduction is straightforward. If they serve carpooling or less-well-defined activity centers, the math becomes more complicated. Moreover, any rebound effects – do park-and-ride lots encourage employees to live further from work, in high VMT neighborhoods – are not clear.

Land preservation

(Under development)

Generally speaking, open space lands in regional hinterlands that are feasible to convert into residential uses, regional service centers, or large-scale, stand-alone employment centers can lead to sprawling development patterns that drive increases in VMT. There are several tools available to acquire and preserve or otherwise enter into agreements that place permanent conservation easements on developable open space and channel future growth toward VMT efficient development patterns. For example, Transfer of Development Rights (TDR) is a zoning technique used to permanently protect land with conservation value (such as farmland, community open space, or other natural or cultural resources) by redirecting development that would otherwise occur on this land (the sending area) to an area planned to accommodate growth and development (the receiving area). TDR programs financially compensate landowners for choosing not to develop some or all of their land. These landowners are given an option under municipal zoning to legally sever the development rights from their land and sell these rights to another landowner or a real estate developer for use at a different location. The land from which the development rights have been severed is permanently protected through a conservation easement or a restrictive covenant. The development value of the land where the transferred development rights are applied is enhanced by allowing for new or special uses; greater density or intensity; or other regulatory flexibility that zoning without the TDR option would not have permitted. Other land use planning tools such as the Density Bonus can also be paired with TDRs as a larger package of incentives intended to help make affordable, location efficient housing more economically enticing to develop. Density bonus tools include reduced parking requirements and concessions such as reduced setback and minimum square footage requirements. And a local government can purchase open space outright.

By establishing partnerships with local land use authorities and interested developers, Districts could engage and influence strategic TDRs and even directly participate in the creation of Development Agreements that steer future development to where it is adequately supported by active transportation, transit, intercity passenger rail, and similar non-auto mobility options. This might be a particularly valuable strategy where there is interest by local or regional governments (or even non-governmental conservation organizations) to employ land preservation strategies or where there is interest by individual developers to swap development rights for locations or increased densities that might be more lucrative or less expensive to develop.

The VMT effect of land preservation will be context-specific. It is even possible to increase VMT by creating more dispersed development. Caltrans is not aware of a simple way to measure the effect.

Appendix A: Congestion Management Authorities and Transportation Management Associations

Two potentially valuable sources of VMT mitigation partnerships are Congestion Management Authorities (CMAs) and Transportation Management Associations (TMAs). CMAs are governmental agencies incorporated under state law that typically provide TDM services as a part of their regional planning, programming, and service delivery portfolios. TMAs are typically private or public-private partnerships, frequently formed as voluntary non-profit organizations involving large employers.

These organizations each provide different services to different user groups in different travel sheds. They also have differing levels of data collection capabilities needed to document VMT reduction for use toward SB 743 mitigation purposes. Practitioners are advised contact the CMAs and TMAs in their areas and proactively participate in data collection and/or program development activities as needed. This could range from simply requesting available data from existing TDM measures to working collaboratively with relevant partners in order to identify expanded TDM services that could specifically serve as VMT mitigation measures for SHS projects. Given that Caltrans will likely not be the primary implementer of most regional TMD strategies, creating strong working relationships and mitigation agreements with CMAs and TMAs could also prove valuable when it comes to the long-term maintenance-of-effort that will likely be needed for them to be successful in reducing VMT.

CMAs

In order to identify a variety of potential mitigation measures for SHS projects, Caltrans practitioners can review relevant planning documents produced by CMAs, such as the Regional Transportation Plan or Short-Range or Long-Range Transit Development Plans. These types of regional planning documents outline specific mobility services, TDM measures, and in-fill development opportunity areas have been planned but are not fully funded and they provide valuable data such as service-specific ridership forecasts that could be used as the basis for estimating related VMT reductions if the services were to be funded as mitigation. Other good sources for identifying potential TDM measures and acquiring important data on potential VMT reduction is active participation on regional Transit Coordinating Committee and Social Services Transportation Advisory Councils, engaging in the annual Unmet Transit Needs Hearing process. In such venues, Caltrans staff may identify pilot services that are being planned for a test period to measure actual ridership against forecast ridership or to determine if farebox recovery requirements can be meet. Transit operators and CMAs may have also developed grant applications for new start or expansion services based on projected ridership. To attract and support this projected ridership, they may also have Transit Asset Management Plans that outline fleet needs, capital investments, or supporting infrastructure such as shelters or modal-transfer stations that could also be used as mitigation.

In essence, the planning processes that CMAs and RTPAs manage can provide valuable data on the potential for specific TDM services to reduce VMT. The most direct way to explore the potential mitigation partnerships and acquire related data is for relevant district staff, including District Transit Representatives, to schedule meetings with their transit operators and CMA counterparts to discuss it with them directly.

Below is a list of regional agencies that Districts can contact regarding information about California's CMAs and their VMT reduction efforts:

Table A-A.1: List of Congestion Management Authorities (CMAs)

Congestion Management Authorities (CMAs)
Alameda County Transportation Commission
City/County Association of Governments of San Mateo County
Contra Costa Transportation Authority
Fresno Council of Governments
Kern Council of Governments
Los Angeles County Metropolitan Transportation Authority
Napa Valley Transportation Authority
Orange County Transportation Authority
Placer County Transportation Planning Agency
Riverside County Transportation Commission
Sacramento Area Council of Governments
San Bernardino County Transportation Authority
San Diego Association of Governments
San Francisco County Transportation Authority
San Joaquin Council of Governments
Santa Barbara County Association of Governments
Santa Clara Valley Transportation Authority
Santa Cruz County Regional Transportation Commission
Shasta County Regional Transportation Planning Agency
Solano Transportation Authority
Sonoma County Transportation Authority
Stanislaus Council of Governments
Transportation Agency for Monterey County
Transportation Authority of Marin
Tulare County Association of Governments
Valley Transportation Authority (VTA)
Ventura County Transportation Commission
Yolo County Transportation District

TMAs

Although TMAs are typically non-governmental organizations and they do not carry out the same comprehensive regional transportation planning functions, they are similar to CMAs in that they may have identified TDM measures that they would like to implement but are not fully funded and could be used as potential mitigation measures. However, one significant difference between TMAs and CMAs that practitioners should be aware of is the differing levels of sophistication and capacity with regard to data collection and analysis. Specifically, while most all TMAs collect data on their service users in terms of "auto-trips avoided," additional data such as user trip lengths may need to calculate VMT reduction.

This is another example of the need for District Transit Representatives or similar staff members to proactively contact potential mitigation partners and discuss available options with them directly. Similar to identifying mitigation options and measuring effectiveness through the regional transit planning process, there are limitation on using existing VMT reduction methodologies based on current research, as TDM efficacy will vary based on context-specific market factors and travel-shed characteristics. Further, Districts will ultimately need to form long range relationships or even programmatic agreements to address and resolve issues such as monitoring, reporting, and maintenance-of-effort (i.e. the mitigation "performance period").

A partial list of TMAs in California is shown below:[10]

[10] https://www.apse.org/wp-content/uploads/docs/TMAs%20-%20National%20Directory.pdf

Table A-A.2: List of Transportation Management Associations (TMAs)

Transportation Management Associations (TMAs)	Location
50 Corridor Transportation Management Association	Sacramento
Altrans TMA	San Jose
Anaheim Transportation Network	Anaheim
Burbank Transportation Management Organization	Burbank
City of Santa Monica Transportation Management Association	Santa Monica
Emeryville Transportation Management Association	Emeryville
Glendale Transportation Management Association	Glendale
Hacienda Business Park	Pleasanton
McClellan Park TMA	McClellan
Moffett Park & Business Transportation Association	Sunnyvale
North Natomas TMA	Sacramento
Pajaro Valley TMA	Watsonville
Placer County Transportation Management Association	Auburn
Point West Area TMA	Sacramento
Ride-on TMA	San Luis Obispo
Sacramento TMA	Sacramento
San Francisco International Airport Commission	San Francisco
South Natomos TMA	Sacramento
Spectrumotion TMA	Irvine
The Presidio Trust	San Francisco
TMA of San Francisco	San Francisco
Traffic Solutions	Santa Barbara
Truckee North Lake Tahoe TMS	Truckee
Warner Center TMO	Woodland Hills
Yolo TMA	Woodland

A comprehensive list of local/regional transit operators, specialized transportation service providers, and Consolidated Transportation Services Agencies that has been assembled by the American Public Transportation Association can be found here.

For further information on opportunities to connect with mobility service providers, Districts can contact the California Association for Coordinated Transportation, or CalAct.

Appendix B: Local VMT calculators

Performance Assessment Tools and VMT Calculators: Several local planning jurisdictions and regional planning agencies such as SACOG have launched performance assessment tools to analyze anticipated outcomes from transportation investments at the project level. The goal of the Project Performance Assessment tool is to align with federal and state emphasis on outcome-based performance measurement and to prioritize cost-effective transportation projects with desired performance benefits, such as increased travel reliability and reducing VMT per capita. In light of the fact that these tools typically result from extensive development and data-collection efforts, development reports may be valuable references to cite the methodologies used, explain the variable considered, understand how to add user inputs, and how to extract VMT reduction figures from the tool's indicators output table. Caltrans practitioners are encouraged to contact their RTPA/MPO counterparts to identify the availability of any such tools for their collective use. For example, Appendix 3 of the tool's Development report, Supplemental Indicator Methodology, gives a detailed technical description of several complex data sources and indicators. Given that potential mitigation measures are similar in many respects to planned mobility improvements, performance indicators from these types of tools can be applied to assess their impact on VMT reduction. For VMT, the SACOG tool looks at the number of transit trips and average vehicle occupancy that a freeway project would add, the number of jobs and dwelling units, mixed uses, and neighborhood services that a complete-street project would provide access to, and the change in jobs, dwelling unit, mixed uses and neighborhood services that a transit or local network expansion would result in.

Similarly the City of Los Angeles Department of Transportation Vehicle Miles Traveled (VMT) Calculator uses an MXD methodology and was originally developed by the U.S. Environmental Protection Agency to better estimate trip generation in urban areas considering a number of factors including the relative numbers of residents and jobs, the density of development, the connectivity for walking or driving among different activities, the availability of transit, the number of convenient trip destinations within the immediate area, vehicle ownership, and household size. The calculator's assumptions were validated and are explained in the calculator's development report for practitioners to cite in their analysis on the potential VMT reductions available from 22 different types of TDM site modifications, system improvements, and operational changes. The calculator follows CAPCOA guidance by either directly applying the CAPCOA methodology, applying the alternative literature methodology, or adjusting the methodology offered by CAPCOA to account for local needs. A methodology is specified for each TDM strategy, with individual levels of anticipated effectiveness identified. The calculator uses four place-types, or travel behavior zones, (Urban, Compact Infill, Suburban Center, and Suburban) and allows TDM strategies to be combined with a maximum VMT reduction result of 75% for measures in urban locations, 40% compact infill locations, 20% for suburban center locations, and 15% for suburban locations.

The calculator's TDM measures and maximum VMT reduction rates are show below and specific methodologies are provided here:

1. Reduce Parking Supply: 12.5%
2. Unbundle Parking: 26% of residential-based VMT
3. Parking Cash-Out: 7.7% of commute VMT
4. Price Workplace Parking: 19.7% of commute VMT
5. Residential Area Parking Permits: 0.25%
6. Reduce Transit Headways: 2.5%
7. Implement Neighborhood Shuttle: 13.4%
8. Transit Subsidies: 20%
9. Voluntary Travel Behavior Change Program: 8%
10. Promotions & Marketing: 4%

11. Required Commute Trip Reduction Program: 21% of commute VMT
12. Alternative Work Schedules and Telecommute Program: 5.5% of commute VMT
13. Employer Sponsored Vanpool or Shuttle: 13.4% of commute VMT
14. Ride Share Program: 15% of commute VMT
15. Car Share: 0.7%
16. Bike Share: 0.25%
17. School Carpool Program: 15.8% of school VMT, or 0.9% of overall VMT
18. Implement/Improve On-Street Bicycle Facility: 0.625%
19. Include Bike Parking: 0.625%
20. Include Secure Bike Parking and Showers: 0.625%
21. Traffic Calming Improvements: 1%
22. Pedestrian Network Improvements: 2%

A variety of similar VMT calculators have been developed for local and regional agencies across the state that Districts could explore for mitigation purposes. The following are among other VMT calculators and TDM assessment tools that have been developed by some of Caltrans external partners:

- Fresno Council of Governments
  - https://www.fresnocog.org/project/vmt-tool/
- San Gabriel Valley Council of Governments
  - https://www.sgvcog.org/vmt-analysis-tool
- Valley Transportation Authority
  - https://www.vta.org/projects/level-service-los-vehicle-miles-traveled-vmt-transition
- County of Santa Barbara
  - https://www.countyofsb.org/plndev/projects/SB743.sbc
- City of San Jose
  - https://www.sanjoseca.gov/your-government/departments-offices/transportation/planning-policies/vehicle-miles-traveled-metric

- San Diego Association of Governments
    - https://www.icommutesd.com/planners/tdm-local-governments
- San Diego Association of Governments
    - https://www.sandag.org/index.asp?classid=13&subclassid=97&projectid=592&fuseaction=projects.detail
- Alameda County Transportation Commission
    - AlamedaCTC_VMT_Final_Tool_20210826.xlsx (live.com)

Further, some local jurisdictions have already completed updates to their local impact assessment guidelines that include specific methodologies for estimating VMT reductions from various TDM mitigation measures that Caltrans District staff could adapt for use on transportation projects. For example, below are just a few examples from across the state that District staff could refer to:

- See Appendix H of the Escondido Transportation Impact Analysis Guidelines : https://www.escondido.org/Data/Sites/1/media/Engineering/TIACRAIG/EscondidoTransportationImpactAnalysisGuidelines2021.pdf
- See Appendix H of the City of Long Beach Transportation Impact Analysis Guidelines:

  https://www.longbeach.gov/globalassets/city-manager/media-library/documents/memos-to-the-mayor-tabbed-file-list-folders/2020/june-30--2020---vehicle-miles-traveled--vmt--standards-for-development-review

- See Appendices A-C of the City of Fremont's Transportation Impact Analysis Handbook:

  https://www.fremont.gov/DocumentCenter/View/48317/TIA-Handbook_Final_June2020?bidId=

- See Appendix C of the City of Carlsbad's VMT Analysis Guidelines: https://www.carlsbadca.gov/home/showpublisheddocument/312/637425981341500000

Appendix C: VMT Reduction Tables for Select Mitigation Measures

Table A-C.1: VMT effects from dense residential development following the CACOA formula. Household figures assume an adjusted typical household annual VMT of 19,641.8, from the [2017 NHTS](#).

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
9.1	0.0%	0.00
9.2	-0.2%	-47.49
9.3	-0.5%	-94.97
9.4	-0.7%	-142.46
9.5	-1.0%	-189.94
9.6	-1.2%	-237.43
9.7	-1.5%	-284.91
9.8	-1.7%	-332.40
9.9	-1.9%	-379.89
10.0	-2.2%	-427.37
10.1	-2.4%	-474.86
10.2	-2.7%	-522.34
10.3	-2.9%	-569.83
10.4	-3.1%	-617.31
10.5	-3.4%	-664.80
10.6	-3.6%	-712.29
10.7	-3.9%	-759.77
10.8	-4.1%	-807.26
10.9	-4.4%	-854.74
11.0	-4.6%	-902.23
11.1	-4.8%	-949.71
11.2	-5.1%	-997.20
11.3	-5.3%	-1,044.68
11.4	-5.6%	-1,092.17
11.5	-5.8%	-1,139.66
11.6	-6.0%	-1,187.14
11.7	-6.3%	-1,234.63

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
11.8	-6.5%	-1,282.11
11.9	-6.8%	-1,329.60
12.0	-7.0%	-1,377.08
12.1	-7.3%	-1,424.57
12.2	-7.5%	-1,472.06
12.3	-7.7%	-1,519.54
12.4	-8.0%	-1,567.03
12.5	-8.2%	-1,614.51
12.6	-8.5%	-1,662.00
12.7	-8.7%	-1,709.48
12.8	-8.9%	-1,756.97
12.9	-9.2%	-1,804.46
13.0	-9.4%	-1,851.94
13.1	-9.7%	-1,899.43
13.2	-9.9%	-1,946.91
13.3	-10.2%	-1,994.40
13.4	-10.4%	-2,041.88
13.5	-10.6%	-2,089.37
13.6	-10.9%	-2,136.86
13.7	-11.1%	-2,184.34
13.8	-11.4%	-2,231.83
13.9	-11.6%	-2,279.31
14.0	-11.8%	-2,326.80
14.1	-12.1%	-2,374.28
14.2	-12.3%	-2,421.77
14.3	-12.6%	-2,469.25
14.4	-12.8%	-2,516.74
14.5	-13.1%	-2,564.23
14.6	-13.3%	-2,611.71
14.7	-13.5%	-2,659.20
14.8	-13.8%	-2,706.68
14.9	-14.0%	-2,754.17
15.0	-14.3%	-2,801.65
15.1	-14.5%	-2,849.14
15.2	-14.7%	-2,896.63

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
15.3	-15.0%	-2,944.11
15.4	-15.2%	-2,991.60
15.5	-15.5%	-3,039.08
15.6	-15.7%	-3,086.57
15.7	-16.0%	-3,134.05
15.8	-16.2%	-3,181.54
15.9	-16.4%	-3,229.03
16.0	-16.7%	-3,276.51
16.1	-16.9%	-3,324.00
16.2	-17.2%	-3,371.48
16.3	-17.4%	-3,418.97
16.4	-17.6%	-3,466.45
16.5	-17.9%	-3,513.94
16.6	-18.1%	-3,561.43
16.7	-18.4%	-3,608.91
16.8	-18.6%	-3,656.40
16.9	-18.9%	-3,703.88
17.0	-19.1%	-3,751.37
17.1	-19.3%	-3,798.85
17.2	-19.6%	-3,846.34
17.3	-19.8%	-3,893.82
17.4	-20.1%	-3,941.31
17.5	-20.3%	-3,988.80
17.6	-20.5%	-4,036.28
17.7	-20.8%	-4,083.77
17.8	-21.0%	-4,131.25
17.9	-21.3%	-4,178.74
18.0	-21.5%	-4,226.22
18.1	-21.8%	-4,273.71
18.2	-22.0%	-4,321.20
18.3	-22.2%	-4,368.68
18.4	-22.5%	-4,416.17
18.5	-22.7%	-4,463.65
18.6	-23.0%	-4,511.14
18.7	-23.2%	-4,558.62

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
18.8	-23.5%	-4,606.11
18.9	-23.7%	-4,653.60
19.0	-23.9%	-4,701.08
19.1	-24.2%	-4,748.57
19.2	-24.4%	-4,796.05
19.3	-24.7%	-4,843.54
19.4	-24.9%	-4,891.02
19.5	-25.1%	-4,938.51
19.6	-25.4%	-4,986.00
19.7	-25.6%	-5,033.48
19.8	-25.9%	-5,080.97
19.9	-26.1%	-5,128.45
20.0	-26.4%	-5,175.94
20.1	-26.6%	-5,223.42
20.2	-26.8%	-5,270.91
20.3	-27.1%	-5,318.40
20.4	-27.3%	-5,365.88
20.5	-27.6%	-5,413.37
20.6	-27.8%	-5,460.85
20.7	-28.0%	-5,508.34
20.8	-28.3%	-5,555.82
20.9	-28.5%	-5,603.31
21.0	-28.8%	-5,650.79
21.1	-29.0%	-5,698.28
21.2	-29.3%	-5,745.77
21.3	-29.5%	-5,793.25
21.4	-29.7%	-5,840.74
21.5	-30.0%	-5,888.22

Table A-C.2: VMT reductions from increased job density, following the formula in CAPCOA.

Density (jobs per acre)	Percent VMT reduction from typical
145	0.0%
150	-0.2%
155	-0.5%
160	-0.7%
165	-1.0%
170	-1.2%
175	-1.4%
180	-1.7%
185	-1.9%
190	-2.2%
195	-2.4%
200	-2.7%
205	-2.9%
210	-3.1%
215	-3.4%
220	-3.6%
225	-3.9%
230	-4.1%
235	-4.3%
240	-4.6%
245	-4.8%
250	-5.1%
255	-5.3%
260	-5.6%
265	-5.8%
270	-6.0%
275	-6.3%
280	-6.5%
285	-6.8%
290	-7.0%
295	-7.2%
300	-7.5%
305	-7.7%

Density (jobs per acre)	Percent VMT reduction from typical
310	-8.0%
315	-8.2%
320	-8.4%
325	-8.7%
330	-8.9%
335	-9.2%
340	-9.4%
345	-9.7%
350	-9.9%
355	-10.1%
360	-10.4%
365	-10.6%
370	-10.9%
375	-11.1%
380	-11.3%
385	-11.6%
390	-11.8%
395	-12.1%
400	-12.3%
405	-12.6%
410	-12.8%
415	-13.0%
420	-13.3%
425	-13.5%
430	-13.8%
435	-14.0%
440	-14.2%
445	-14.5%
450	-14.7%
455	-15.0%
460	-15.2%
465	-15.4%
470	-15.7%
475	-15.9%
480	-16.2%

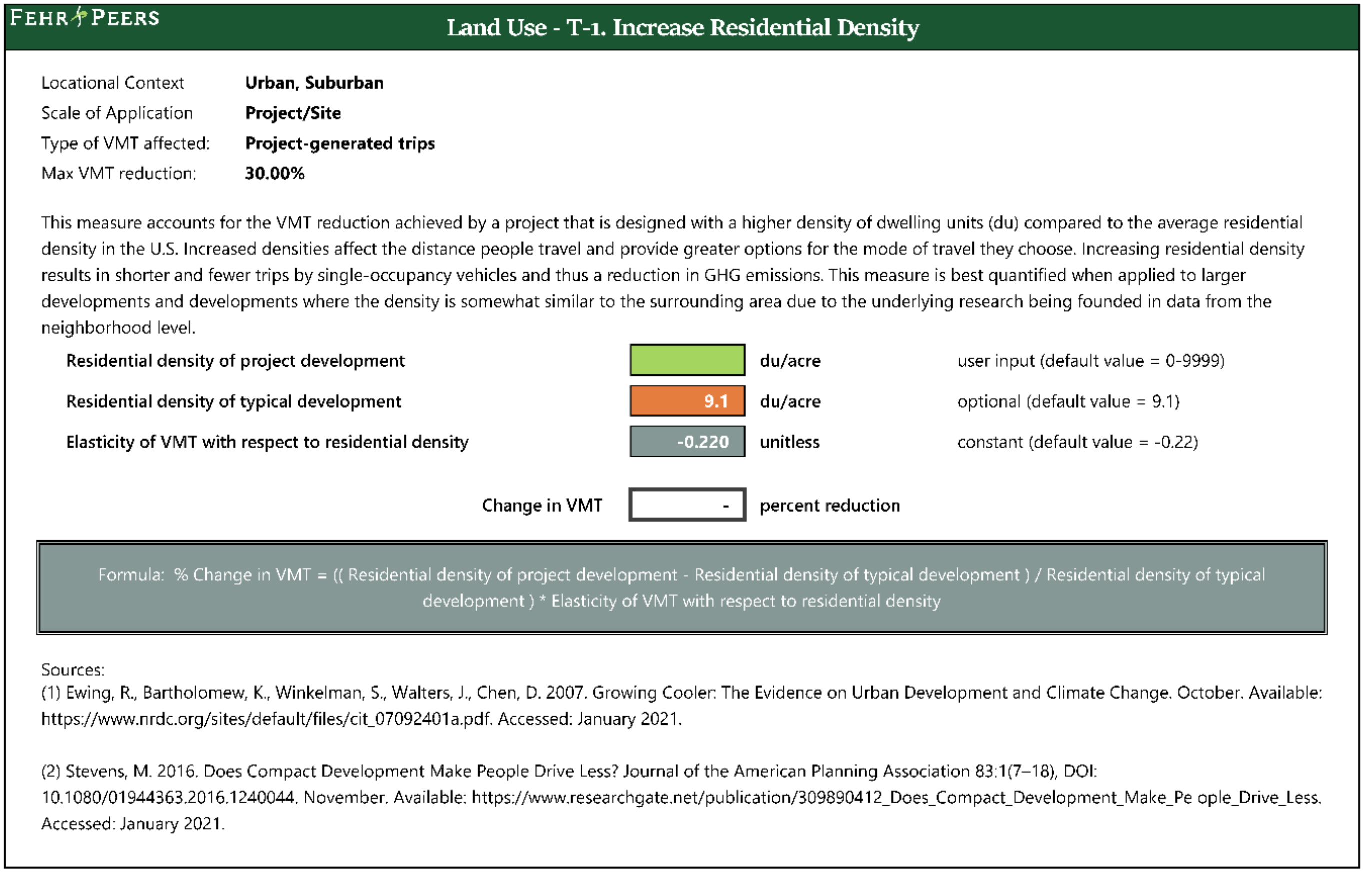
Density (jobs per acre)	Percent VMT reduction from typical
485	-16.4%
490	-16.7%
495	-16.9%
500	-17.1%
505	-17.4%
510	-17.6%
515	-17.9%
520	-18.1%
525	-18.3%
530	-18.6%
535	-18.8%
540	-19.1%
545	-19.3%
550	-19.6%
555	-19.8%
560	-20.0%
565	-20.3%
570	-20.5%
575	-20.8%
580	-21.0%
585	-21.2%
590	-21.5%
595	-21.7%
600	-22.0%
605	-22.2%
610	-22.4%
615	-22.7%
620	-22.9%
625	-23.2%
630	-23.4%
635	-23.7%
640	-23.9%
645	-24.1%
650	-24.4%
655	-24.6%

Density (jobs per acre)	Percent VMT reduction from typical
660	-24.9%
665	-25.1%
670	-25.3%
675	-25.6%
680	-25.8%
685	-26.1%
690	-26.3%
695	-26.6%
700	-26.8%
705	-27.0%
710	-27.3%
715	-27.5%
720	-27.8%
725	-28.0%
730	-28.2%
735	-28.5%
740	-28.7%
745	-29.0%
750	-29.2%
755	-29.4%
760	-29.7%
765	-29.9%

Table A-C.3. Calculated values for VMT reduction from CAPCOA formula.

Annual parking price	% VMT change	Absolute VMT change per household
$200	-0.9%	-171.0
$300	-1.3%	-256.5
$400	-1.7%	-342.0
$500	-2.2%	-427.5
$600	-2.6%	-512.9
$700	-3.0%	-598.4
$800	-3.5%	-683.9
$900	-3.9%	-769.4
$1,000	-4.4%	-854.9
$1,100	-4.8%	-940.4
$1,200	-5.2%	-1,025.9
$1,300	-5.7%	-1,111.4
$1,400	-6.1%	-1,196.9
$1,500	-6.5%	-1,282.4
$1,600	-7.0%	-1,367.9
$1,700	-7.4%	-1,453.3
$1,800	-7.8%	-1,538.8
$1,900	-8.3%	-1,624.3
$2,000	-8.7%	-1,709.8
$2,100	-9.1%	-1,795.3
$2,200	-9.6%	-1,880.8
$2,300	-10.0%	-1,966.3
$2,400	-10.4%	-2,051.8
$2,500	-10.9%	-2,137.3
$2,600	-11.3%	-2,222.8
$2,700	-11.8%	-2,308.3
$2,800	-12.2%	-2,393.8
$2,900	-12.6%	-2,479.2
$3,000	-13.1%	-2,564.7
$3,100	-13.5%	-2,650.2
$3,200	-13.9%	-2,735.7
$3,300	-14.4%	-2,821.2
$3,400	-14.8%	-2,906.7
$3,500	-15.2%	-2,992.2

Appendix D: TDM+ VMT Reduction Quantification Tool


FEHR PEERS

Land Use - T-1. Increase Residential Density

Locational Context	**Urban, Suburban**
Scale of Application	**Project/Site**
Type of VMT affected:	**Project-generated trips**
Max VMT reduction:	**30.00%**

This measure accounts for the VMT reduction achieved by a project that is designed with a higher density of dwelling units (du) compared to the average residential density in the U.S. Increased densities affect the distance people travel and provide greater options for the mode of travel they choose. Increasing residential density results in shorter and fewer trips by single-occupancy vehicles and thus a reduction in GHG emissions. This measure is best quantified when applied to larger developments and developments where the density is somewhat similar to the surrounding area due to the underlying research being founded in data from the neighborhood level.

Residential density of project development		**du/acre**	user input (default value = 0-9999)
Residential density of typical development	9.1	**du/acre**	optional (default value = 9.1)
Elasticity of VMT with respect to residential density	-0.220	**unitless**	constant (default value = -0.22)
Change in VMT	-	**percent reduction**	

Formula: % Change in VMT = ((Residential density of project development - Residential density of typical development) / Residential density of typical development) * Elasticity of VMT with respect to residential density

Sources:
(1) Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., Chen, D. 2007. Growing Cooler: The Evidence on Urban Development and Climate Change. October. Available: https://www.nrdc.org/sites/default/files/cit_07092401a.pdf. Accessed: January 2021.

(2) Stevens, M. 2016. Does Compact Development Make People Drive Less? Journal of the American Planning Association 83:1(7–18), DOI: 10.1080/01944363.2016.1240044. November. Available: https://www.researchgate.net/publication/309890412_Does_Compact_Development_Make_Pe ople_Drive_Less. Accessed: January 2021.

Figure 4. TDM+ Excel tool interface.

The TDM+ tool is a spreadsheet-based tool that calculates VMT reductions based on strategies presented in the 2021 CAPCOA handbook. Many of the strategies discussed in this playbook are included in the tool, which provides a simple interface to input project information and perform analysis.

Detailed instructions on how to use the tool are provided on the "START HERE" tab. Basic input data is required such as the mitigation type, geographic location and place type, and amount of mitigation being provided. The tool can automatically detect conflicting measures and flags them on the 'Conflicts' tab. For measures that can be combined (discussed earlier in this playbook on page 6), the tool automatically applies multiplicative dampening to make these adjustments.

The "Results" tab shows the combined VMT reduction (as a percentage) by the strategy type. For example, VMT reduction is reported for 'Land Use: Project Site', which includes four strategies within it. With this information, the analyst can apply these percent reductions (once conflicts have been resolved) to a VMT estimate to estimate a VMT reduction in absolute terms.

This tool is currently a beta, and only includes six core-based statistical areas as available parameters. Future iterations of the tool will include expanded drop-down options. For each mitigation strategy, orange cells indicate default values, sometimes based on the selected core-based statistical area. These default values can be overridden if more accurate data is available. The TDM+ tool can be accessed here.

Exhibit D

EVALUATION OF THE SACRAMENTO AREA COUNCIL OF GOVERNMENTS' SB 375 2020 SUSTAINABLE COMMUNITIES STRATEGY

October 2020

CALIFORNIA
AIR RESOURCES BOARD

Electronic copies of this document are available for download from the California Air Resources Board's internet site at:

https://ww2.arb.ca.gov/our-work/programs/sustainable-communities-climate-protection-program

In addition, written copies are also available. Please email California Air Resources Board program staff at sustainablecommunities@arb.ca.gov to place your request.

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Background

The Sustainable Communities and Climate Protection Act (SB 375) is intended to support the State's broader climate goals by encouraging integrated regional transportation and land use planning that reduces greenhouse gas (GHG) emissions from passenger vehicle use. California's metropolitan planning organizations (MPO) develop regional Sustainable Communities Strategies (SCS) – as part of their regional transportation plans (RTP) – which contain land use, housing, and transportation strategies that, when implemented, can meet the per capita passenger vehicle GHG emission reduction targets for 2020 and 2035 set by the California Air Resources Board (CARB or Board). Once an MPO adopts an SCS, SB 375 directs CARB to accept or reject an MPO's determination that its SCS, when implemented, would meet the targets.

On November 18, 2019, the Sacramento Area Council of Governments (SACOG), which serves as the MPO for the Sacramento region, adopted its 2020 Metropolitan Transportation Plan/Sustainable Communities Strategy (2020 SCS).[1] SACOG provided for CARB staff's review a complete submittal of the 2020 SCS and all necessary supporting information on June 5, 2020. SACOG's 2020 SCS estimates a 14 percent and a 19 percent decrease in GHG per capita emissions from light-duty passenger vehicles by 2020 and 2035, respectively, compared to 2005. The region's per capita GHG emission reduction targets are 7 percent in 2020 and 19 percent in 2035, compared to 2005 levels, as adopted by the Board in 2018.[2] This report reflects CARB's evaluation of SACOG's 2020 SCS GHG quantification.

CARB's Evaluation

After CARB set the first SB 375 GHG emission reduction targets in 2010, CARB staff developed the first guidelines[3] on how SCSs would be evaluated for the purposes of CARB's determination in 2011. These 2011 Evaluation Guidelines focused on the technical aspects of regional travel demand modeling and analysis for how CARB would determine acceptance or rejection of an MPO's determination that it met its applicable

[1] Sacramento Area Council of Governments. *2020 Metropolitan Transportation Plan/Sustainable Communities Strategy*.
[2] Board Resolution 18-12 (March 22, 2018).
[3] California Air Resources Board. Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies Pursuant to SB 375. July 2011.

GHG emission reduction targets. In 2018, when CARB updated the SB 375 GHG emission reduction targets, the Board directed CARB staff to place greater attention on the strategies, key actions, and investments committed by the MPOs rather than on modeling outputs. Pursuant to Board direction, CARB staff updated its 2011 Evaluation Guidelines in the document *Final Sustainable Communities Strategy Program and Evaluation Guidelines*[4] (2019 Evaluation Guidelines). Under CARB staff's 2019 Evaluation Guidelines, evaluation of SCS strategies, key supporting actions and investments serve as the basis for accepting or rejecting an MPO's SB 375 GHG determination.

CARB's evaluation of the SCS consists of the determination and reporting components and is based on the general method described in CARB staff's 2019 Evaluation Guidelines. This report summarizes CARB staff's evaluation of SACOG's 2020 SCS.

The determination component covers the analyses conducted by CARB staff to determine whether the SCS would achieve the applicable GHG emission reduction targets when implemented. This component consists of a series of four policy analyses, which evaluate whether the strategies, key actions and investments from the SCS support its stated GHG emission reductions. These four analyses include Trend Analysis, Policy Analysis, Investment Analysis, and Plan Adjustment Analysis. CARB staff's evaluation relied on a review of SACOG's 2020 SCS, additional SCS submittal materials provided by SACOG further explaining its modeling inputs and assumptions, performance indicator trends, key actions, investments, and current trends and plan adjustments, as well as on information gathered in follow-up conversations with SACOG staff. For a summary of strategies and quantification methods evaluated as part of SACOG's 2020 SCS submittal see Appendix A.

With respect to the reporting component, the 2019 Evaluation Guidelines includes three elements: tracking implementation, incremental progress, and equity. Tracking implementation reporting captures progress the region has made toward its SCS implementation based on observed data, and whether it is on track to meet the GHG reduction targets based on how well the observed data tracks with what the plan said would happen. Incremental progress reports on whether an MPO's SCS includes more or enhanced strategies compared to its prior SCS that are consistent with the information the MPO shared during the 2018 target-setting process. The equity section identifies the efforts the MPO has undertaken to meet federal and State requirements

[4] California Air Resources Board. *Final Sustainable Communities Strategy Program and Evaluation Guidelines*. November 2019.

related to equity. The reporting component is included as Appendix C: MPO Reporting, and serves to identify the effectiveness of prior SCS implementation efforts and increase overall transparency of the SCS for the public and other stakeholders.

Trend Analysis

This section summarizes CARB staff's analysis of key plan performance indicators to determine if the data provided by SACOG supports the 2020 SCS's stated GHG and vehicle miles traveled (VMT) reductions. As part of the 2019 Evaluation Guidelines, CARB staff requested data on the following eight performance indicators: 1) household vehicle ownership, 2) mode share, 3) average travel time by mode, 4) daily transit ridership, 5) average trip length by mode, 6) seat utilization, 7) VMT per capita, and 8) GHG per capita. These indicators represent how a region can show changes to its per capita VMT over time through policies and investments undertaken and reflected in its SCS.

SACOG provided data associated with these metrics from the output of its travel demand model, SACSIM19. Staff analyzed how these metrics change over time (i.e., 2005 to 2035), and whether the change is directionality consistent with the 2020 SCS planned outcomes. In other words, staff determine whether these eight SCS performance indicators are trending in a direction that supports GHG/VMT reductions. Table 1 provides a summary of the trend analysis for SACOG's 2020 SCS. SACOG did not provide transit seat utilization data, so CARB staff could not review the trend for those data.

Table 1. Trend Analysis Results

Performance Indicator	Forecast Change 2005 to 2035*	Trend Analysis
Average Trip Length	SOV (-8.6%) HOV (+0.7%) Transit (+15.8%) Walk/Bike (+45.4%)	SACOG's 2020 SCS forecasts a decrease in the average single-occupancy vehicle (SOV) trip length from 8.04 miles/day in 2005, to 7.85 miles/day in 2016 and 7.35 miles/day in 2035. Over the same time period, trip lengths for bike/walk increase from 1.63 (2005), 2.3 (2016) and 2.37 (2035), and transit increases from 5.39 (2005), 5.83 (2016) and 6.24 (2035). CARB staff finds these trends directionally supportive and consistent with the relationship shown in the empirical literature that reducing SOV trip length reduces VMT and GHG emissions. Please see Appendix B: Data Table for more details.
Average Travel Time	SOV (-6.7%) HOV (~0%) Transit (~0%)	SACOG's 2020 SCS forecasts a decrease in the average SOV travel time from 15 minutes in 2005 to 14 minutes in 2016 and 2035, with no changes in travel time for high-occupancy vehicle (HOV) (12 minutes in 2005 and 2035), and transit (40 minutes[5] in 2005 and 2035) over the same time period. CARB staff finds the 2005 to 2016 trend directionally supportive of reducing GHG emissions and consistent with the relationship shown in the empirical literature that travel time and trip length change proportionally. However, the lack of change in travel time in SOV trips beyond 2016, even though trip length decreases, as noted above, is not consistent and may not be supportive of reducing GHG emissions. Please see Appendix B: Data Table for more details.

[5] Note, for SACOG's equity analysis (see Appendix C), for accessibility to key destinations by transit SACOG uses a 30-minute benchmark for travel time.

Performance Indicator	Forecast Change 2005 to 2035*	Trend Analysis
Mode Share	SOV (-2.2%) Transit (+1.1%) Walk/Bike (+2.6%)	SACOG's 2020 SCS forecasts that the mode share will modestly change by 2035. SOV decreases from 43.7% in 2005 to 41.5% in 2035; transit increases from 1.3% to 2.4%; and walk/bike increases from 9.2% to 11.8% over the same period. CARB staff finds these trends directionally supportive and consistent with the relationship shown in the empirical literature that shifting away from driving alone to other modes such as transit, walk and bike reduces per capita VMT and GHG emissions. Please see Appendix B: Data Table for more details.
Daily Transit Ridership	+172%	SACOG's 2020 SCS forecasts daily transit ridership increases from 138,460 riders in 2005 to 376,040 in 2035. CARB staff finds these trends directionally supportive and consistent with the relationship shown in the empirical literature that increasing transit ridership will reduce GHG emissions. However, CARB staff has concern about this trend when looked at in the context of transit travel in 2035 (40 minutes as noted above) compared to drive-alone trips (14 minutes as noted above). Transit travel time is almost three times longer than driving alone for similar trip lengths. This is not consistent with the empirical literature that longer travel time would increase transit ridership and reduce GHG emissions. Please see Appendix B: Data Table for more details.

Performance Indicator	Forecast Change 2005 to 2035*	Trend Analysis
Household Vehicle Ownership	-5.7%	SACOG's 2020 SCS forecasts a decrease in household vehicle ownership from 1.9 vehicles per household in 2005 to 1.8 in 2016 and 2035. CARB staff finds the 2005 to 2016 trend directionally supportive of reducing GHG emissions and consistent with the relationship shown in the empirical literature that reducing vehicle ownership reduces GHG emissions. However, CARB staff has concern about this trend when looked at in the context of transit ridership per household trends (i.e., 0.18 in 2005 to 0.34 in 2035). The increase in transit forecasted may not be consistent with the modest reduction in vehicle ownership between 2016 and 2035 even though transit ridership increases over the same period. This is contrary to the empirical literature where a household uses more transit tends to own less vehicles. These results are not consistent and may not support reducing GHG emissions. Please see Appendix B: Data Table for more details.
VMT per Capita	-15.5%	SACOG's 2020 SCS forecasts VMT to decrease from 24.1 to 20.3 VMT/capita/day in 2035. CARB staff finds these trends directionally supportive and consistent with the relationship shown in the empirical literature that a reduction in VMT per capita will reduce GHG emissions. Please see Appendix B: Data Table for more details.
GHG per Capita Reduction Between 2005 and 2020	-14%	The GHG per capita reduction forecasted by SACOG meets the target established by CARB. Please see Appendix B: Data Table for more details.

Performance Indicator	Forecast Change 2005 to 2035*	Trend Analysis
GHG per Capita Reduction Between 2005 and 2035	-19%	The GHG per capita reduction forecasted by SACOG meets the target established by CARB. Please see Appendix B: Data Table for more details.
Seat Utilization	SACOG did not provide data	NA

Note:
* (-) decreasing, (+) increasing, (~) no change
NA means not available

CARB staff finds that taken as a whole, the performance indicators used to conduct the Trend Analysis support the GHG reductions projected in SACOG's SCS.

Policy Analysis

The following section summarizes CARB staff's evaluation of whether or not SACOG's 2020 SCS contains key policy, investment, and other actions that support its identified strategies for meeting its GHG emission reduction targets using the general method described in CARB's 2019 Evaluation Guidelines. This analysis focuses on what policy commitments are contained in the SCS to support implementation and provides CARB with qualitative evidence on whether an MPO's claimed GHG reductions from its SCS strategies are likely, risky, or unlikely. CARB staff's analysis is organized across four broad SCS strategy categories: land use and housing, transportation infrastructure and network, local/regional pricing, and electric vehicle and new mobility. Within each strategy category, CARB staff discusses: the applicable SCS strategies; the planned outcomes that the SCS assumes will occur in 2035 when strategies are fully implemented; and CARB staff's analysis of whether the SCS contains key policy and investment actions that will support implementation of the SCS strategies and planned outcomes.

CARB staff's analysis of key supporting actions looked at a number of policy factors that, when considered together, are expected to explain how the MPO region will achieve the development pattern, transportation network characteristics, and travel patterns assumed in its SCS by 2035. In general, across all strategy categories, CARB staff looked for:

- Whether the SCS provided policy actions that corresponded to each of its individual strategies.
- Whether the actions were clear with respect to scope, who will be involved, what will be done, and the anticipated implementation timeline.
- Whether the actions were measurable and included specific regional investment commitments in the RTP/SCS project list; policy and/or financial incentives; technical assistance; and if legislative or other entity action is needed, partnership activities to advance needed changes.

Information used for this effort was collected from SACOG's 2020 SCS and through additional supporting materials provided by SACOG in its submittal to CARB. See Appendix C for a summary table of SACOG's 2020 SCS strategies and identified associated key support actions.

Land Use and Housing Strategy Commitments

SACOG's 2020 SCS includes land use- and housing-related strategies that seek to support the creation of compact and diverse land uses and put residents and activity locations closer together, which would ultimately shorten passenger vehicle trips in the region and reduce per capita GHG emissions. SACOG's land use and housing strategies that shorten vehicle trips include: jobs-housing balance, infill development, and transit-oriented development. SACOG estimates these strategies, in aggregate, will result in a 5 percent decrease in per capita GHG emissions.

SCS Planned Outcomes

The SCS includes assumptions about the type and character of new land use and housing development that will take place in the region between 2016 and 2035, which include: [6]

- Adding 223,571 new housing units and 218,265 new jobs to the region.
- Increasing the region's residential density by 25 percent.
- Accommodating 95,834 new housing units (43 percent of total new units) as single-family housing, and 127,737 (57 percent) as multi-family or attached housing.
- Locating 133,100 new housing units and 87,332 new employees within a ½-mile of high-quality transit stations (a 25 percent and 16 percent increase, respectively, compared to 2016 levels).
- By 2040, accommodating 168,026 new housing units[7] (65 percent of total new units) and 228,902 new employees (85 percent of total new employees) through infill development in the region's center/corridor and established communities, and 92,102 new housing units (35 percent of the total new units) and 41,159 (15

[6] This subsection includes information based on the data table and compares demographic and land use indicators from the 2016 base year to 2035. CARB staff also looked at changes between the SB 375 2005 target baseline year and 2035, where SACOG provided 2005 data. However, given greater 2016 data availability across the SCS land use and transportation metrics, CARB staff have summarized what the SCS says needs to occur to meet the region's 2035 GHG emission reduction target compared to latest observed 2016 regional conditions.

[7] Information in this bullet point refers to data from Table 3.2: Summary of Expected Housing and Employment Growth by Community Type in the MTP/SCS. Data in this bullet compare the 2016 base year to the 2040 horizon year as no data were provided for 2035 by community types.

percent of the total new employees) in developing suburban and rural residential communities.

Supporting Actions

While MPOs create SCSs that forecast regional growth patterns, local government staff and elected officials have almost exclusive authority over land use decisions relevant to implementing the SCS. Achieving the plan outcomes discussed above will therefore require local government action. Local actions that do not align with regional goals, such as allowing leapfrog development out in natural or agricultural areas, and failing to allow enough infill, especially affordable housing and growth in walkable or transit-oriented areas, stifles the Sacramento region's ability to implement the plan.

CARB staff checked for evidence that appropriate funding, other incentives, technical assistance, or other key actions were present to support the assumed development pattern in the SCS. In particular, CARB staff considered whether the SCS identified region-specific funding or technical assistance programs that support developers and local governments in prioritizing growth in the SCS's preferred growth areas. In addition, CARB staff checked to see how the SCS's assumptions about future housing unit development within the SCS's preferred growth areas compared against existing local plans, as alignment of regional and local plans is an important first step toward ensuring that future needs can be accommodated.

CARB staff found that the 2020 SCS land use and housing planned outcomes are supported by region-specific funding and planning program actions. In particular, the 2020 SCS carries over a number of positive, well-established programs and commitments to support implementation of the Sacramento region's SCS land use and housing strategy. Notable examples include SB 375 California Environmental Quality Act (CEQA) streamlining resources and assistance, which allows for streamlined environmental review and analysis of residential or mixed-use projects that are consistent with the SCS.[8] SACOG also continues its Civic Lab Program[9], which focuses on designing and launching pilot projects that address regional challenges through action at the local level. This program includes projects to help address barriers to infill development, place-making, and private investment. The program recently focused on 12 commercial corridors in the Sacramento region, including corridors like

[8] SACOG CEQA streamlining.
[9] SACOG Civic Lab Program.

Main Street in the City of Isleton, Upper Broadway in the City of Placerville, and Del Paso Boulevard in the City of Sacramento.

The 2020 SCS also calls out the Green Means Go Pilot Program[10] as the key new mechanism to encourage infill development in the region. Through this pilot program, local jurisdictions will designate Green Zones, in which they must take specific actions to promote and accelerate infill development, provide travel options, and increase electric vehicle deployment. In addition, SACOG has introduced two additional supporting actions focused on the development of a Regional Housing Needs Plan with action steps and incentives, and an update to the region's Blueprint development plan.

Table 2 shows CARB staff's summary of SACOG's 2020 SCS land use and housing strategy commitments and associated supporting actions and investments.

[10] SACOG Green Means Go Program

Table 2. SACOG's 2020 SCS Land Use and Housing Strategy Commitments and Supporting Actions

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Shortened Passenger Vehicle Trips: Jobs/ Housing Balance	-5% (When combined with all listed Shortened Passenger Vehicle Trips strategies)	SACOG will provide data, research, analysis, incentives, and other support to housing-rich communities actively trying to promote job growth and to jobs-rich communities to promote housing growth. SACOG will continue to provide incentives, tools, and other project support to grow regional jobs and housing. Examples include the Economic Prosperity Plan, Housing Policy Toolkit, SB 375 and SB 743 CEQA streamlining.	Actions Identified:[11] Yes Funding in the RTP/SCS Project List:[12] N/A[13] SACOG Program Funding Available:[14] Yes, SACOG has identified resources to provide research and technical assistance.

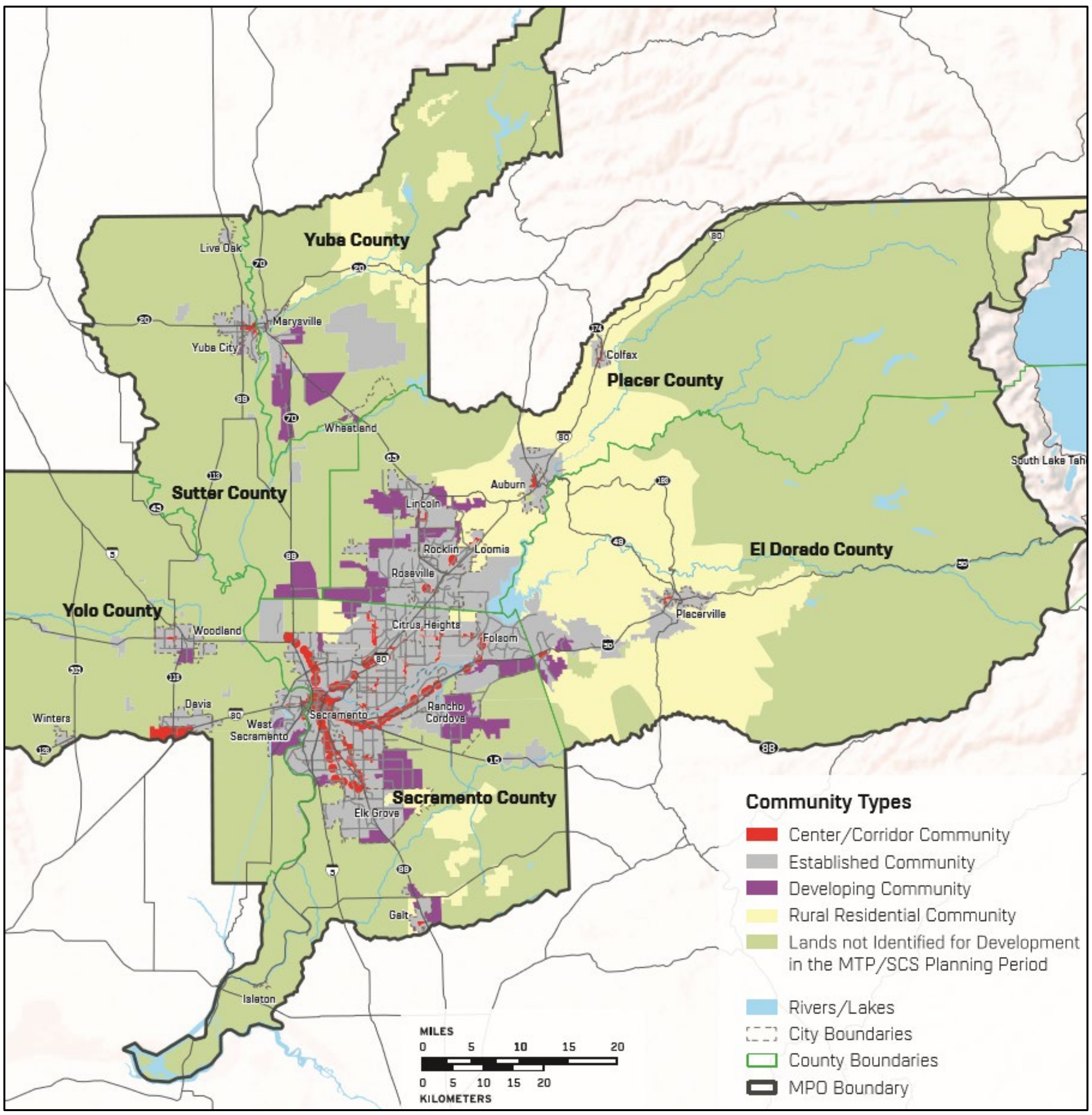
[11] Actions identified refers to if SACOG has identified how the SCS strategy will be implemented through actions.
[12] Funding in the RTP/SCS Project List refers to if there are identified projects and investments in the financially constrained project list that support the SCS strategy.
[13] N/A means not applicable.
[14] SACOG Program Funding Available refers to if SACOG has resources to support the SCS strategy.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Shortened Passenger Vehicle Trips: Infill Development	-5% (When combined with all listed Shortened Passenger Vehicle Trips strategies)	SACOG will develop a Regional Housing Needs Plan with action steps and incentives that put member agencies in a better position to accelerate infill housing production. SACOG will secure funding and implement the Green Means Go Pilot Program to encourage infill development and revitalization of commercial corridors through transit-supportive infrastructure. The Regional Housing Needs Plan, in combination and coordination with SACOG's Regional Early Action Plan funding, Local Early Action Plan funding, and SB 2 housing planning grants will help local jurisdictions with planning and zoning activity. SACOG will secure funding to allow the region's jurisdictions and stakeholders to revisit and update the Blueprint, which is SACOG's regional vision for future growth and development.	Actions Identified: Yes Funding in the RTP/SCS Project List: N/A SACOG Program Funding Available: Some program funds are available for RHNA and other work, however, CARB staff is concerned that this strategy will not be successful in reducing emissions because the Green Means Go Pilot Program remains unfunded and that jurisdictions have to be nominated to participate in the program. The Green Means Go Pilot Program needs further development and funding to support implementation.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Shortened Passenger Vehicle Trips: Transit-Oriented Development	-5% (When combined with all listed Shortened Passenger Vehicle Trips strategies)	SACOG will continue to provide technical assistance to support urban, suburban, and rural community revitalization. Examples include Civic Lab Year 2, Rural Main Streets Technical Assistance, and the Transit-Oriented Development Action Plan. SACOG will partner with cities and transit operators undergoing updates to transit plans, service changes, and transit-oriented development efforts. Examples include SacRT Forward, Transit Asset Management Planning, and the Transit-Oriented Development Action Plan.	Actions Identified: Yes Funding in the RTP/SCS Project List: N/A SACOG Program Funding Available: Yes, SACOG has existing programs and resources to provide funding, research and technical assistance.

CARB staff also found that the 2020 SCS housing unit growth assumptions in the region's targeted infill areas are reasonably aligned with local general plan buildout capacities for 2035. Special attention was given to the region's place type, what SACOG refers to as "Community Types," and CARB staff focused on the categories of "Center and Corridor" and "Established Communities," as these are the areas where the SCS expects infill development to occur. Figure 1 is from SACOG's 2020 SCS and illustrates the Community Types being used to describe the region's land use forecast for the SCS planning period.

Figure 1. SACOG's 2020 SCS Community Types Map



CARB staff found that local plans for these "Center and Corridor" and "Established Communities" are nearly fully consistent, and allow for the SCS's forecasted total units to be built by 2035, with the exception of the Center and Corridor Community areas in El Dorado County, Sacramento County (Gold and Blue line Station Areas), the City of Davis Core Area, and the City of Woodland. In these areas, the 2020 SCS assumes a greater number of housing units by 2035 than is currently in local plan build-out estimates. In aggregate, however, the net difference in total assumed infill housing units in the 2020 SCS versus what is allowable based on local planning is less than one percent of the total assumed housing units, indicating that the SCS's infill land use assumptions are reasonably aligned with local land use plans.

While CARB staff's analysis supports a conclusion that SACOG's 2020 SCS would meet the target, if implemented, CARB staff has significant concerns with SACOG's capability to implement the 2020 SCS strategies to achieve the planned outcomes. CARB staff recognizes that one of the SACOG region's strengths is having local plans in place that support the 2020 SCS's preferred infill housing growth scenario. However, while local plan alignment is an important first step to implementing future needs, it does not guarantee this housing will be built. As shown in CARB's *2018 Progress* Report*: California's Sustainable Communities and Climate Protection Act*,[15] prepared pursuant to SB 150 (Allen, Chapter 646, Statutes of 2017), local housing planning is nearly fully compliant with Regional Housing Needs Allocation (RHNA) law, but actual permits issued are lagging, especially for affordable housing. In the four largest regions, according to local jurisdiction reports submitted to the California Department of Housing and Development (HCD), most regions are ahead of schedule in issuing permits for housing for the wealthiest, "above moderate-income" households but are falling short in housing that is affordable for households in the three lower-income categories: moderate-income, low-income, and very low-income.

SACOG's process for developing the 2020 SCS acknowledges that the region is not on track to meet the region's infill goals, and identifies additional strategies and action items within the 2020 SCS to address the challenge of implementing infill. However, CARB staff found that these additional strategies and actions rely on funding that has yet to be secured and partnerships that have yet to be formed. For example, CARB's review of available program documentation for Green Means Go confirms that SACOG is actively advocating for funding and partners, however, the program is not yet funded and it is not clear what funding source would be used for this purpose, particularly as

[15] SB 150 Progress Report to the Legislature on Sustainable Communities Implementation.

revenue to the Greenhouse Gas Reduction Fund (GGRF) is expected to decline over time.[16] Furthermore, it is unclear what criteria SACOG will use for the Green Means Go Program to direct funds toward projects that will best support the SCS's infill goals. In addition, CARB staff's review of SACOG's SCS submittal materials and publicly available information on SACOG's identified Blueprint Update work and the Regional Housing Needs Plan and incentive work found a lack of specificity about milestones and how these actions would contribute to reducing emissions. CARB staff finds this approach of relying primarily on unspecified incentive actions to carry a high risk that the SCS will not be implemented as planned, especially since SACOG has not identified alternative actions if funding is not secured.

Transportation Infrastructure and Network Strategy Commitments

SACOG has included four transportation-related strategies in the 2020 SCS. Three of the strategies seek to complement its land use and housing strategies, and focus on increasing non-SOV mode share by increasing available alternatives to driving, including transit supportive infrastructure & investment, bicycle & pedestrian infrastructure & investment, and transportation demand management (TDM). Another strategy, intelligent transportation system & transportation system management (ITS & TSM), is also included that focuses on smoothing stop-and-go traffic, which can reduce GHG emissions per mile traveled. Together these transportation strategies support SACOG's goal of building and maintaining a safe, resilient, and multimodal transportation system. Altogether, SACOG estimates these strategies will result in a 6.5 percent decrease in per capita GHG emissions.

SCS Planned Outcomes

These strategies translate into assumptions about changes to the transportation infrastructure and network that will serve the region between 2016 and 2035, [17] which include:

[16] Proceeds from the Cap-and-Trade Program help facilitate comprehensive and coordinated investments throughout California that further the State's climate goals through the GGRF. However, the Cap-and-Trade Program's cap on economy-wide emissions declines over time, making fewer allowances available to purchase, and thus less proceeds available for deposit into the GGRF.

[17] This subsection includes information based on the data table and compares transportation indicators from the 2016 base year to 2035. CARB staff also looked at changes between the SB 375 2005 target baseline year and 2035, where SACOG provided 2005 data. However, given greater 2016 data availability across the SCS land use and transportation metrics, CARB staff have summarized what the SCS says

- Increasing the region's total transit operational miles by 67 percent, compared to 2016.
- Increasing the region's total bike and pedestrian lane-miles by 79 percent, compared to 2016.
- Decreasing freeway/general purpose lanes (3 percent), collector lanes (1 percent) and rural roadways (8 percent); and increasing freeway HOV lanes (28 percent) and arterial/expressways (27 percent), compared to 2016.[18]

Supporting Actions

Per the 2019 Evaluation Guidelines, CARB staff checked for evidence that appropriate funding, other incentives, technical assistance, or other key actions were present to support the development of the transportation network in the SCS. In particular, CARB staff looked for alignment against the project list adopted with the 2020 SCS to see whether the projects are planned and funded within the target timeframe. CARB staff also considered whether SACOG identified other region-specific funding or technical assistance programs to support implementation of its transportation strategies. In addition, CARB staff evaluated the extent to which the projects included in the SCS complement its land use and housing strategies, with a particular focus on capacity-increasing projects that carry a high risk of inducing travel and therefore increasing VMT/GHG emissions.

CARB staff found that the 2020 SCS transit, active transportation, TDM, and ITS/TSM assumptions are supported by region-specific funding and planning program actions, as well as through direct investments in the project list adopted with the 2020 SCS. In particular, the 2020 SCS includes a number of positive project commitments that align with the Sacramento region's SCS land use strategy and help advance GHG emission reductions. As part of the project list adopted with SACOG's 2020 SCS, CARB staff found multi-modal projects that are intended to improve transit, bike and walk options in the region by the 2035 target year. Examples include:

- Extension of the Green Line light rail service to North Natomas Town Center ($390 million).

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needs to occur to meet the region's 2035 GHG emission reduction target compared to latest observed 2016 regional conditions.

[18] The decrease in freeway general purpose lanes is due to these facilities being converted to HOV lanes, while the reduction in collector lanes and rural roadways, typically two-lane roads with one-lane in each direction, is due to those facilities converting into multiple-lane arterials and expressways.

- Construction of phases 1 and 2 of the Downtown/Riverfront Streetcar in Sacramento and West Sacramento ($239 million).[19]

- SacRT Green Line Light Rail Loop and transit improvements along K and H streets in Sacramento. These improvements would accommodate a future Streetcar Project, as well as future Green Line service ($60 million).

- Construction of phases 3 and 4 streetscape improvements on West Capitol Avenue in West Sacramento, including wider sidewalks, new lighting, and planting treatments ($25 million).

- Construction of a Class 1 bike lane between Davis and Woodland ($10 million).

Table 3 shows CARB staff's summary of SACOG's 2020 SCS transportation infrastructure and network strategy commitments and associated supporting actions and investments.

[19] In September 2020, SacRT recently voted to move forward with a scaled back version of this project. Instead of being 4.4 miles long from Midtown to downtown West Sacramento, it will now only be 1.5 miles long and go from Sacramento Valley Station to Sutter Health Park (formerly Raley Field) in West Sacramento.

Table 3. SACOG's 2020 SCS Transportation Infrastructure and Network Strategy Commitments and Supporting Actions

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Increase Non-SOV Mode Share: Transit Supporting Infrastructure/ Investments	-6% (When combined with all listed Increase Non-SOV Mode Share strategies)	SACOG has allocated $10.1 billion to bus and rail operations and maintenance, paratransit services, strategic bus and rail infrastructure expansion and transit vehicle purchases. This is a slight reduction in investment of $0.5 billion compared to the 2016 SCS. SACOG is currently seeing a ridership decline compared to 2005. However, SACOG is projecting a tripling of ridership by 2035 from 120,500 in 2016 to 376,040. SACOG is working on its Next Generation Transit Study to help address the declines in transit and re-envision and explore new opportunities for transit. The SCS's actions support providing better traveler information for trip planning, reliable service and coordination between operators and supports ways for transit agencies to secure funding to improve frequency, span, and coverage of productive transit service.	Actions Identified: Yes Funding in the RTP/SCS Project List: Yes, but transit investment has declined compared to the 2016 SCS. CARB staff is concerned that transit ridership forecasts are overly ambitious and do not connect with on the ground realities of declining ridership and reduced investment. CARB staff would expect to see significant increases in transit investment that correspond with the SCS forecasted transit ridership increases. Additionally, if pricing strategies are not implemented then funding for transit improvements may be at risk. SACOG Program Funding Available: Yes, SACOG has existing programs and resources to provide funding, research and technical assistance.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Increase Non-SOV Mode Share: Improved Bicycle and Pedestrian Infrastructure/ Investments	-6% (When combined with all listed Increase Non-SOV Mode Share strategies)	SACOG has programmed and planned for $2.5 billion to go towards bicycle facilities, pedestrian improvements, and Americans with Disabilities Act (ADA) retrofits. This number reflects direct investments in bicycle and pedestrian improvements. However, some bicycle and pedestrian improvements are included as part of the costs of road and highway capacity projects. The exact costs for these elements as part of larger investments are not readily available for the planned projects in the 2020 SCS. The direct investment has decreased by $0.3 billion compared to the 2016 SCS. SACOG is currently seeing a slight increase in bicycle and pedestrian mode share compared to 2005, and is projecting a slight increase in bicycle mode share from 2.5% in 2016 to 2.8% by 2035, and in pedestrian mode share from 7.8% in 2016 to 9% in 2035. The total number of miles of bicycle infrastructure is projected to increase from 37% in 2016 to 79% in 2035.	Actions Identified: Yes Funding in the RTP/SCS Project List: Yes, but bicycle and pedestrian investment has declined compared to the 2016 SCS. CARB staff is concerned that mode share forecasts do not connect with reduction in investments. CARB staff would expect to see increases in bicycle and pedestrian infrastructure investments to correspond to increases in mode share. Additionally, if pricing strategies are not implemented then funding for bicycle and pedestrian improvements may be at risk.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Increase Non-SOV Mode Share: Improved Bicycle and Pedestrian Infrastructure/ Investments (continued)	-6% (When combined with all listed Increase Non-SOV Mode Share strategies) (continued)	SACOG encourages investment in bicycle and pedestrian infrastructure to support healthy, active transportation trips and provide recreation opportunities for residents and visitors. SACOG provides online resources regarding active transportation options for the use of local planning practitioners and stakeholders. SACOG also provides technical assistants regarding complete streets and active design, which promotes improved health outcomes by designing spaces that promote and facilitate regular physical activity.	(Continued) SACOG Program Funding Available: Yes, SACOG has existing programs and resources to provide funding, research and technical assistance.
Increase Non-SOV Mode Share: Transportation Demand Management (TDM)	-6% (When combined with all listed Increase Non-SOV Mode Share strategies)	SACOG has allocated $3.1 billion to program, safety, and systems management and operations, of which approximately $12.9 million goes to TDM strategies. These funds are used for outreach, education and incentives to drivers to reduce driving. SACOG will develop and implement new and innovative employer and residential-based TDM programs. SACOG's Civic Lab Innovative Mobility Accelerator Program will provide mini grants to fund this effort.	Actions Identified: Yes Funding in the RTP/SCS Project List: Yes, but CARB staff is surprised that TDM programs are not funded through 2035.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Increase Non-SOV Mode Share: Transportation Demand Management (TDM) (continued)	-6% (When combined with all listed Increase Non-SOV Mode Share strategies) (continued)	The project list includes a regional TDM program throughout SACOG, as well as a TDM Program through the Placer County Congestion Management Program, however, these programs are only for the 2020-2025 timeline.	(Continued) SACOG Program Funding Available: Yes, SACOG has existing programs and resources to provide funding, research and technical assistance.
Intelligent Transportation System & Transportation Systems Management (ITS & TSM)	-0.5%	SACOG is investing $3.1 billion in program safety and systems management and operations. A large portion of this funding goes to funding ITS & TSM strategies and used for intelligent technology and management systems to monitor traffic and incidents, to convey information to drivers, and to manage driver movements. The project list includes projects such as ramp metering, changeable message signs, and traffic signalization. SACOG plans to implement ITS and TSM through implementing and raising funding through tolling or pricing strategies, and prioritizing investments in transportation improvements that reduce GHG and VMT. SACOG has an Intelligent Transportation Systems Committee/Sacramento Region ITS Partnership that works to advance ITS in the region.	Actions Identified: Yes Funding in the RTP/SCS Project List: Yes, but if pricing strategies are not implemented then funding for ITS and TSM may be at risk. SACOG Program Funding Available: Yes, SACOG has existing programs and resources to provide funding, research and technical assistance

CARB staff also found that the 2020 SCS includes hundreds of millions of dollars in funding for roadway capacity expansion projects that are not well-aligned with the region's adopted SCS land use and housing strategy, including segments of the Capital Southeast Connector project. Capacity expansion projects, especially those that are not aligned with the long-term vision for accommodating new growth, increase VMT and work against achieving the State's climate and air quality goals.[20] [21] As part of its SCS submittal, SACOG conducted analysis on the anticipated long-term effects on VMT due to the roadway capacity expansion projects within the SCS by comparing its SACSIM19 model results with research-based elasticity calculations.[22] Based on SACOG's elasticity calculations, it estimates that all together these types of roadway projects are increasing the region's VMT as high as 12 percent and as low as 7 percent between 2016 and 2040, through induced travel.[23] SACOG included forecasted VMT increases from these projects as part of its overall 2020 SCS emissions estimate and determined that it will still be able to meet its SB 375 GHG reduction target, if implemented. CARB staff reviewed SACOG's approach to capturing the short- and long-term VMT/GHG impacts of its 2020 SCS roadway capacity expansion projects and found them to be reasonable in the context of aggregate impacts on SCS performance. However, for the next SCS, SACOG should evaluate and discuss the VMT impacts of individual capacity projects in comparison with the aggregate analysis used for the SCS. Results of this effort could be used to further refine how SACOG assesses the VMT impacts of capacity projects on its SCS.

While CARB staff's analysis supports a conclusion that SACOG's 2020 SCS would meet the target, if implemented, CARB staff has significant concerns with SACOG's capability to implement the 2020 SCS transportation system strategies and achieve its estimated GHG reduction benefits. CARB staff is especially concerned with the region's ability to fund and deliver the transit and active transportation projects that are needed to support the 2020 SCS planned outcomes. This is important given the fact that the region wants to overcome recent declines in transit ridership since 2012 and increase transit ridership 212 percent compared to 2016 levels. SACOG's 2020 SCS plans to achieve this, in part, through increasing transit service miles by over 67 percent

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[20] See CARB's Policy Brief: Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions.

[21] See the information regarding the relationship between reducing VMT and responding to the State's Climate Goals.

[22] See *SACOG MTP/SCS Appendix E: Plan Performance*.

[23] Through induced travel, or increases in travel due to changes in the number of trips and trip distances (destination changes); shifts in travel modes, the time-of-day travel occurs, and routes; as well as changes in residence and workplace locations.

compared to 2016. However, this is contrary to planned transit and active transportation project investments, which have declined between the 2016 and 2020 SCS, with $0.5 billion less in the 2020 SCS for total transit investment compared to the 2016 SCS. SACOG attributes this to a delay in the Green Line light rail extension to the airport to after 2040. Further delays or removals of transit and active transportation projects will prevent SACOG from meeting its regional targets.

This is particularly true for SACOG's 2020 SCS, which is estimated to only just achieve the GHG emission reduction targets, and contains roadway capacity-increasing projects that could undermine target achievement and are prioritized over other projects that are more likely to reduce GHG emissions.[24] SACOG will need to be vigilant about monitoring implementation of the particular balance of transportation projects through 2035, and funding transportation projects that support the region's adopted SCS land use and housing strategy prior to other projects in order to ensure net reductions are achieved.

Local and Regional Pricing Strategy Commitments

SACOG has included two new pricing strategies in the 2020 SCS. These strategies include facility-based congestion pricing through managed express lanes and a regional mileage-based user fee. The facility-based pricing program will charge drivers for use of managed express lanes by considering time of day and congestion level. Drivers in the region would be given the choice of purchasing their way into the managed express lane in exchange for a faster and more reliable trip. The regional mileage-based user fee, which SACOG calls the Pay Go Program, will charge drivers for use of all roadways across the region on a per-mile basis. SACOG estimates that these strategies will decrease congestion, increase transit, walking, and biking, improve road/highway conditions, generate revenue for funding transportation infrastructure in the region, and result in a 1 to 2 percent decrease in per capita GHG emissions.

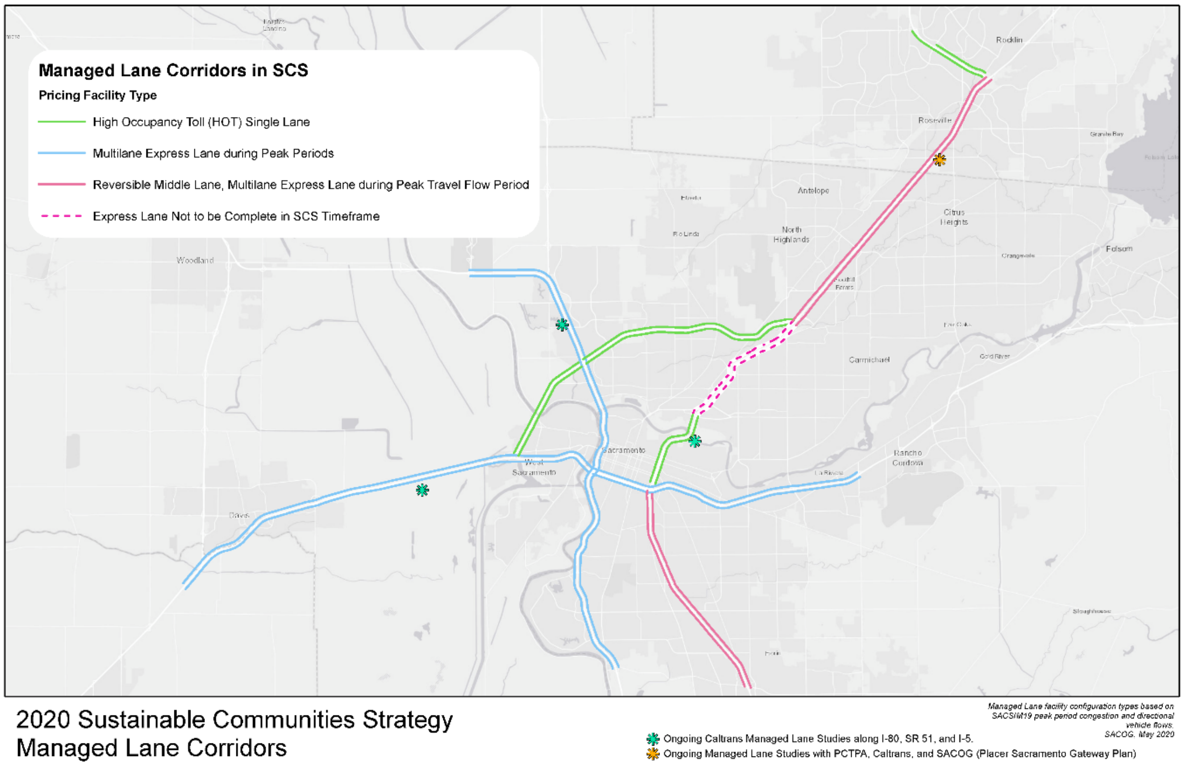
SCS Planned Outcomes

These strategies translate into assumptions about changes to the cost of transportation options, specifically, the cost to drivers for use of the roadway network in the region between 2016 and 2035, which include:

[24] CARB staff analyzed how projects that might erode VMT/GHG benefits are prioritized relative to projects that are more aligned with the SCS, see "Investments Analysis" for discussion

- Starting in 2031, decrease congestion and overall roadway travel demand with new priced managed lanes along two corridors with an estimated dynamic charge rate of $0.10 cents to $2.12 dollars per mile for passenger vehicles utilizing the lanes during peak period.[25] Figure 2 shows the proposed draft managed lane locations.

Figure 2. Proposed Managed Lanes in the SACOG Region



- Starting in 2030, decrease overall roadway travel demand and encourage increased transit, walking, and biking, with a new per-mile charge for drivers along all roadways throughout the region with an estimated charge rate of 3.5 cents per mile.[26]

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[25] SACOG, Toll Charges by Facility. July 2020.
[26] The SCS states that there is still much work to be done on identifying how this program will be implemented and does not provide details on how the fee would be collected. To estimate the GHG benefits for this program, SACOG assumed all drivers in the region would be charged this fee. This includes $0.012 California Mileage-Based User Fee, which equals the California State Fuel Tax, and $0.023 SACOG Mileage-Based User Fee.

Supporting Actions

Per the 2019 Evaluation Guidelines, CARB staff checked for evidence that appropriate funding, other incentives, technical assistance, or other key actions were present to support the assumed local and regional pricing strategies in the SCS. In particular, CARB staff looked for alignment against the project list adopted with the 2020 SCS to see whether the actions are planned and funded within the target timeframe. CARB staff also considered whether SACOG identified other region-specific funding or programs to support implementation of its pricing strategies. In addition, CARB staff looked for whether and how SACOG considered equity, which is a key implementation concern for pricing strategies.[27]

CARB staff found that the 2020 SCS local and regional pricing assumptions are supported by region-specific funding and planning program actions, as well as through direct investments in the project list adopted with the 2020 SCS. In particular, the 2020 SCS project list includes the same managed express lane corridor projects for funding by 2035 that SACOG assumed when quantifying the SCS's GHG benefits in 2035. The SCS also identifies some initial supporting actions to further support its two pricing strategies. One action is to work with Caltrans and other local partners to identify options for governance and administration of revenues from facility-based pricing, in coordination with ongoing managed lane studies. Another action is to work with regional partners to develop pilot programs and pursue funding for piloting roadway pricing mechanisms, such as facility-based pricing (e.g., managed express lanes) and mileage-based fees (e.g., Pay Go Program), in partnership with the State, federal, and local agencies and private sector organizations. SACOG recently applied, in partnership with SCAG and SANDAG, for a Caltrans planning grant to design a pricing pilot.

Table 4 shows CARB staff's summary of SACOG's 2020 SCS local and regional pricing strategy commitments and associated supporting actions and investments.

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[27] CARB staff also checked to see to what extent the proposed strategies were tied to the SCS's overall revenue and investment assumptions to see what if any impacts implementation could have on other SCS strategy commitments. See the "Investments Analysis" section for further discussion.

Table 4. SACOG's 2020 SCS Local and Regional Pricing Strategy Commitments and Supporting Actions

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
Facility-Based Pricing: Congestion Pricing/Manage d Express Lanes	-2% (When combined with all listed pricing strategies)	The project list adopted with the 2020 SCS includes express lane projects. SACOG has stated that revenue generated from facility-based pricing should be used to build and maintain a regional network of priced express lanes and, where surplus revenue is available, on strategic transit services (e.g., express buses) or other mobility solutions that can reduce VMT and provide multiple travel options along priced corridors. SACOG has stated that they want to work with Caltrans and other local partners to identify options for governance and administration of revenues from facility-based pricing. In 2020, as the lead applicant, SACOG applied for a Caltrans Sustainable Transportation Planning grant with SCAG and SANDAG. The grant has not been approved.	Actions Identified: Yes, SACOG has made some initial steps to plan and analyze facility based-pricing. CARB staff is concerned that this pricing program will not be implemented within the identified timeframe and that other SCS projects are at risk due to a lack of revenue if these facilities are not in place as anticipated. CARB finds that further action and buy-in from local jurisdictions, stakeholders, and the public is needed to advance implementation. Funding in the RTP/SCS Project List: Yes, for a few of the identified corridors.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
(Continued) *Facility-Based Pricing:* Congestion Pricing/Managed Express Lanes	(Continued) -2% (When combined with all listed pricing strategies)	SACOG also collaborated with Caltrans on managed lane studies.	SACOG Program Funding Available: Somewhat. SACOG can provide funding, research and technical assistance, however, more work needs to be done around program development and implementation, specifically around fee collection, and revenue allocation, that should include equity opportunities.
Mileage-Based: *User Fee*: Pay Go Program	-2% (When combined with all listed pricing strategies)	The project list adopted with the 2020 SCS does not include projects identified for mileage-based user fees. SACOG plans to implement pricing strategies by piloting roadway pricing mechanisms through implementing tolling or pricing of specific lanes, providing technical assistance to local jurisdictions (e.g. Civic Lab 2), working with Caltrans and other partners for administration of revenues, and supporting local agencies in implementing local fees and taxes for transportation improvements.	Actions Identified: Yes, SACOG has made some initial steps to plan and analyze implementation of mileage-based user fees. CARB staff is concerned that this pricing program will not be implemented within the identified timeframe, because this strategy requires congressional and state enabling legislation, as well as local action.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
(Continued) *Mileage-Based*: *User Fee*: Pay Go Program	(Continued) -2% (When combined with all listed pricing strategies)	SACOG assumed a mileage-based user fee would be implemented region-wide to replace gas taxes. The fees are estimated to generate $959 million. The facility-based and mileage-based fees have been identified as critical for SACOG to provide a sustainable revenue source for funding the region's transportation system. The SCS states that there is still much work to be done on identifying how this program will be implemented and does not provide details on how the fee would be collected.	CARB staff is further concerned that other SCS projects are at risk due to a lack of revenue if these facilities are not in place as anticipated. CARB staff finds that further legislative action and buy in from state and local agencies, stakeholders, and the public is needed to advance implementation. Funding in the RTP/SCS Project List: N/A SACOG Program Funding Available: Somewhat. SACOG can provide funding, research and technical assistance, however, more work needs to be done around program development and implementation, specifically around fee collection, and revenue allocation, and equity considerations.

CARB staff also found that SACOG analyzed and discussed the effects of roadway pricing on equity. This analysis included discussion of different options to mitigate the potential impacts of facility pricing on lower-income households. It also included analysis to compare the change in household auto operating cost with SCS pricing strategies by community type and income level. SACOG's Board also adopted a policy framework for its pricing strategies, that includes a provision to avoid negative impacts on lower-income and rural households.

While CARB staff's analysis supports a conclusion that SACOG's 2020 SCS would meet the target, if implemented, CARB staff has significant concerns with SACOG's capability to implement the 2020 SCS local and regional pricing strategies and achieve its estimated GHG reduction benefits. CARB staff acknowledges the significant leadership and partnership work needed to realize the 2020 SCS pricing strategies. Given that SACOG's application for a planning grant to pilot pricing was rejected and the planning grant was a primary supporting action necessary to implement this strategy, SACOG needs to identify and implement new supporting actions to advance these strategies along the timeline assumed in the 2020 SCS, and SACOG will need to demonstrate further progress to implement these strategies by its next plan cycle for SACOG to continue receiving the full amount of GHG emission reductions assumed.

Electric Vehicle and New Mobility Strategy Commitments

SACOG has included three strategies related to electric vehicles (EV) and new mobility services, which include EV infrastructure, EV incentives, bike share and micromobility. These strategies seek to accelerate the penetration of EVs and increase micromobility options like bike share and scooter share in the region. These strategies are intended to support SACOG's goal of providing additional clean travel options and induce mode shift away from driving. Altogether, SACOG estimates these strategies will result in a 0.5 percent decrease in per capita GHG emissions.

SCS Planned Outcomes

These strategies translate into assumptions about the availability of EV-supportive infrastructure, bike share and other micromobility fleets that will serve the region between 2016 and 2035, which include:

- Adding 150 new public chargers[28] by 2035 in the region.
- Increasing EV market penetration between 13.3 to 16.8 percent by 2035.

[28] SACOG Off-Model Assumption Calculation, May 1 2020 Table 3.

- Providing the same level of local EV incentives/rebates in 2035.
- Deploying a total of 25,000 to 50,000 electric bikes and electric scooters[29] through sharing applications around the majority of High Frequency Transit Areas. This represents an increase of between 20,500 and 45,500 new electric bikes and scooters (456 to 1,011 percent) by 2035.

Supporting Actions

Per the 2019 Evaluation Guidelines, CARB staff checked for evidence that appropriate funding, other incentives, technical assistance, or other key actions were present to support the assumed availability of EV-supportive infrastructure, bike share and other micromobility fleets in the SCS. In particular, CARB staff looked for alignment against the project list adopted with the 2020 SCS to see whether the actions are planned and funded within the target timeframe. CARB staff also considered whether SACOG identified other region-specific funding or technical assistance programs to support implementation of its EV and new mobility strategies.

CARB staff found that the 2020 SCS EV and new mobility strategy assumptions are supported by region-specific funding and planning program actions, as well as through direct investments in the project list adopted with the 2020 SCS. In particular, the 2020 SCS project list includes EV infrastructure installation projects that are expected to be completed by 2035. In addition, SACOG'S 2020 SCS carries over actions and programs from the 2016 SCS that will support innovative education and TDM programs in the region to pilot, test and scale new mobility options and programs. These include technical assistance for transit and local agencies to pilot these options and implement new employer- and residential-based TDM programs through the region's Civic Lab Innovative Mobility Accelerator Program; leading a collaborative effort to shape a vision of next-generation transit through SACOG's Next Generation Transit Study with strategies to integrate traditional transit services with new mobility options; and potential funding support through the region's Green Means Go Pilot Program.

Table 5 shows CARB staff's summary of SACOG's 2020 SCS EV and new mobility strategy commitments and associated supporting actions and investments.

[29] SACOG Off-Model Assumption Calculation, May 1, 2020 Table 4

Table 5. SACOG's 2020 SCS EV and New Mobility Strategy Commitments and Supporting Actions

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
EV and New Mobility: Electric Vehicle Charging Infrastructure	-0.5% (When combined with all listed EV and New Mobility strategies)	SACOG is planning to support local EV programs by pursuing new funding and planning opportunities to support EV infrastructure, and by implementing the Green Means Go Pilot Program. According to the project list adopted with the 2020 SCS, SACOG is allocating $36.8 million (to support charging infrastructure in the region. The project list includes a partnership with the City of Davis and Valley Clean Energy to install EV charging infrastructure at various locations such as between UC Davis, downtown Davis, and the Davis Amtrak Station. The project list also calls for the installation of 14 EV charging units and related equipment to facilitate the introduction of electric propulsion buses to the Unitrans bus fleet. Both of these projects are anticipated to be completed in the 2020-2025 timeframe. However, other EV charging infrastructure are expected to be complete in the 2036-2040 timeframe. Examples include adding new electric bus charging infrastructure for Sacramento Regional Transit District and for the Placer County Transportation Planning Agency.	Actions Identified: Yes Funding in the RTP/SCS Project List: Yes SACOG Program Funding Available: Some program funds are available, however, CARB staff is concerned that the Green Means Go Pilot Program remains unfunded and that jurisdictions have to be nominated to participate in the program. The Green Means Go Pilot Program needs further development and funding to support implementation.

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
EV and New Mobility: Electric Vehicle Incentives	-0.5% (When combined with all listed EV and New Mobility strategies)	The project list adopted with the 2020 SCS does not include projects identified for EV incentives. Incentives/rebates for EV purchase are provided in the SACOG region to accelerate and increase market penetration of electric vehicles. For example, El Dorado County Air Quality Management District's (EDCAQMD) Drive Clean! incentive program provides a $1,000 incentive to County residents who purchase EVs within El Dorado County. Another example is SMUD's Charge Free for 2 Years program, which provides a $600 incentive for EV purchasers, based on the approximate value of two years' worth of electricity for an EV. SMUD has contracted with the EV advocacy organization Plug-In America to perform outreach and training for car dealership staff to better advertise and educate prospective car buyers about the costs, benefits, and lifestyle considerations related to purchasing an EV. In addition, the program offers participating dealerships a $300 incentive for each EV they sell.	Actions Identified: Yes Funding in the RTP/SCS Project List: No SACOG Program Funding Available: No, SACOG relies on other programs to provide incentives. CARB staff is concerned that without a dedicated revenue stream these incentive programs may not continue to be available in the timeframe of the plan. CARB staff recommend that SACOG develop a plan to ensure incentives are available to support planned EV outcomes

SACOG's SCS Strategies	Estimated GHG Emission Reductions in 2035	SCS Supporting Actions and Investments	CARB Staff's Analysis
EV and New Mobility: Bike Share & Micromobility	-0.5% (When combined with all listed EV and New Mobility strategies)	The project list adopted with the 2020 SCS does not include bike share or micromobility projects. SACOG plans to continue to assist transit and local agencies in finding ways to develop, test, and pilot new mobility services such as micro-transit micro-mobility through the SACOG's Civic Lab Innovative Mobility Accelerator Program and TDM Program. SACOG will support piloting innovations in new mobility and transit service as part of its Next Generation Transit Study.	Actions Identified: Yes Funding in the RTP/SCS Project List: No SACOG Program Funding Available: SACOG has some funds available to encourage new mobility but the region is primarily relying on private investment from new mobility companies. CARB staff recommend that SACOG continue to work with and provide incentives to local jurisdictions and bike share and micromobility companies to ensure planned outcomes.

While CARB staff's analysis supports a conclusion that SACOG's 2020 SCS would meet the target, if implemented, CARB staff has significant concerns with SACOG's capability to implement the 2020 SCS EV and new mobility strategies and achieve its estimated GHG reduction benefits. CARB staff are concerned that the supporting actions for these strategies primarily rely on funding and partnerships outside of SACOG's control. In particular, the 2020 SCS assumes that these strategies will be able to rely on continuing previously available incentives and rebate programs through the region's air district and local utilities, building on the region's demonstrated partnerships with private micromobility providers, as well as continuing to further demonstration projects through the region's Civic Lab Program and Green Means Go Program without long-term dedicated projects or funding in the SCS through 2035. The nature of these programs is dynamic, and not always favorable or within the control of the region. For example, Jump, a major provider of electric bikes and electric scooters in the region, temporarily ceased operations, but has since returned at a smaller scale.[30] SACOG will need to be vigilant about monitoring implementation of these strategies through 2035 and making adjustments as necessary to ensure planned reductions are achieved.

Looking across all four policy analysis categories, CARB staff's analysis found that SACOG's 2020 SCS includes evidence of policy commitments for its strategies, that if implemented would meet the target. However, areas of concern for CARB staff are that many strategies still require identification of funding sources and/or legislative changes to be implemented.

Investments Analysis

CARB staff evaluated whether the 2020 investments support the expected GHG emission reductions, by looking for evidence within the project list adopted with the 2020 SCS for commitments to funding SCS-consistent projects by 2035. CARB staff also qualitatively assessed the risk of delay to delivering projects that advance SCS goals based on assumed available funding sources.

Based on CARB's review of SACOG's project list, CARB staff found that the 2020 SCS included a number of projects in the project list for funding that would advance implementation of the SCS, as discussed in the "Policy Analysis" section of this report. However, CARB staff also identified significant concerns with whether SACOG's overall

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[30] Jump ceased operations in March 2020 due to COVID-19. In May 2020, Uber, which owned Jump, sold the bikes to its competitor Lime. As of September 2020, Jump bikes are back in Sacramento.

investment plan would sufficiently support implementation of the 2020 SCS strategies to achieve its estimated GHG reduction benefits. Specifically, CARB remains concerned with the latest decrease in funding for transit and active transportation projects. A comparison between the 2016 and 2020 SCS investments by mode are shown in Figures 3 and 4. Total spending decreased from approximately $35.2 billion to $34.9 billion between the 2016 and 2020 SCSs. The largest increase in investment occurred in the category of road and highway capacity, which grew from $5.8 billion to $6.8 billion (17 to 19 percent), while the portion of the plan devoted to transit fell from $10.6 billion to $10.1 billion (30 to 29 percent). The category of active transportation also decreased from $2.8 billion to $2.5 billion (less than 8 to 7 percent). The decline in anticipated investments to transit, bike and pedestrian projects, is not well-aligned with SACOG's assumptions around increased non-SOV mode share, increased transit ridership, and forecasted declines in VMT and GHG emissions. CARB staff is particularly concerned with how the region will be able to implement the SCS's 212 percent increase in transit ridership compared to 2016 levels with a reduced transit investment.

Figure 3. Investments by Mode in SACOG's 2020 SCS Compared to the 2016 SCS (Total Dollars)

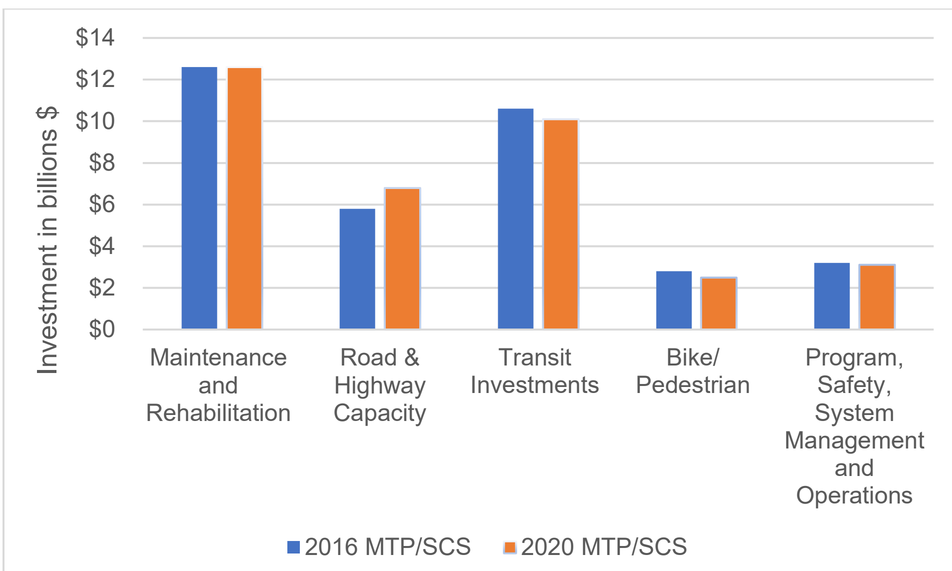
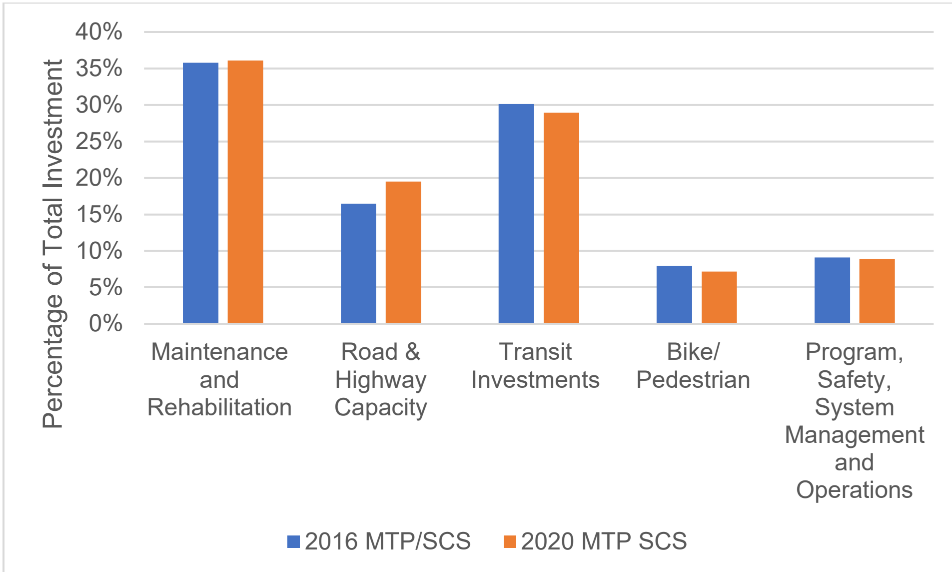


Figure 4. Investments by Mode in SACOG's 2020 SCS Compared to the 2016 SCS (Percent of Total Investment)



Furthermore, CARB staff is concerned with the risk of delivering SCS-supportive projects on the project list by 2035. As shown in Figure 5, almost every modal category has nearly half or more of total investments planned for the last 5 years of the plan (i.e., post 2035), and are not associated with any firm funding sources. The exception to this is the road and highway capacity category, which has 73 percent of total investments programmed by 2030.

Figure 5. SACOG's 2020 SCS Investments by Mode

Category	2020-2025	2026-2030	2031-2035	2036-2040
Bike & Ped	30%	23%	3%	44%
Road & Highway Capacity	27%	46%	11%	17%
Maint & Rehab	24%	15%	1%	60%
Programs & Plans	8%	1%	21%	71%
Transit	9%	6%	2%	82%
System Management, Operations and ITS	16%	16%	2%	65%

The 2020 SCS does include new revenue assumptions from its new roadway user fee strategies ($959 million 2031 to 2035). While these funds are not yet programmed toward specific projects, the SCS states that revenues generated from facility-based pricing should be used to build and maintain a regional network of paid express lanes. Where surplus revenue is available, revenues should be spent on strategic transit services (e.g., express buses) or other mobility solutions that can reduce vehicle miles traveled and provide multiple travel options along priced corridors. Additionally, the SCS includes the policy that new taxes and fees, including mileage-based fees, intended to raise additional funding for transportation purposes should prioritize closing the gap for system maintenance and state-of-good repair needs before investing in system expansion. While commitment of these potential funds toward SCS-supportive projects is helpful, CARB staff remains concerned that if the SCS pricing strategies are delayed or not implemented, the transit and active transportation projects tied to the 2031-2035 time period will not be delivered in time.

The 2020 SCS also includes revenue assumptions of yet to be adopted local sales tax measures.[31] For example, SACOG assumes voters will renew Measure A, a half-cent general sales tax in Sacramento County. Specifically, SACOG assumes that Measure A will be approved in November 2020 and generate approximately $2.9 billion by 2040 in nominal dollars. SACOG also assumes a proposed half-cent general sales tax in Placer County will be approved by voters in November 2020 and will generate approximately $1.2 billion by 2040 in nominal dollars. This is particularly concerning since both sales tax measures were not placed on the November 2020 ballot and it is unclear how this affects the projects in the project list approved with the 2020 SCS and the expected GHG emissions of the plan.

In addition, SACOG includes revenue assumptions around the Cap and Trade Program and GGRF. Specifically, SACOG assumes the region will capture 35 percent of auction proceeds that are allocated to Affordable Housing & Sustainable Communities, Intercity Rail, and Low Carbon Transit Programs, or approximately $817 million by 2040 in nominal dollars. The region's capture of these revenues assumes SACOG member agencies will receive revenues roughly equivalent to the region's share of statewide population and assumes 5 percent average annual growth. As of May 2020, the SACOG region has captured just 4.8 percent of all GGRF funds implemented. CARB staff is concerned with these assumptions, as these dollars would be applied to support SCS implementation, but are also not firm funding amounts as program dollars are competitive and total amounts available vary by time period. Further, as mentioned above, GGRF revenues are expected to decline over time. CARB staff's concern is further exacerbated when considering further anticipated impacts to available transportation revenues due to the COVID-19 pandemic.

[31] This section includes information from the 2020 MTP/SCS [Appendix B – Revenue Forecast].

On the whole, CARB staff finds that the 2020 RTP/SCS project investments do not sufficiently support the implementation of the 2020 SCS strategies and achievement of the SCS's estimated GHG reduction benefits. In particular, reduced transit investment does not support the SCS's strategy of growing transit ridership 212 percent from 2016 levels. CARB staff have also identified considerable risk to delivery of SCS-supportive projects on the project list by 2035, as they are not associated with any firm funding sources.

Plan Adjustment Analysis

The Plan Adjustment Analysis evaluates whether and what measures are being taken, as necessary, to correct course to meet an MPO's target if the region is falling behind on implementation of its SCS strategies. CARB staff reviewed how the implementation of SACOG's SCS has performed to date using observed land use and transportation system data.[32] CARB staff found that SACOG is not on track to achieve SACOG's previous, 2016 SCS planned outcomes for 2020 and 2035. Observed land use and travel data for the region shows declines in transit ridership and significant unrealized new development within infill areas in the region, which are inconsistent with the trends and values assumed in the 2016 SCS to meet the region's GHG reduction targets.

Given this finding, CARB staff looked for evidence that SACOG's 2020 SCS considered these challenges and either changed its SCS strategies, or put additional measures in place to accelerate implementation of its SCS strategies in order to stay on track to meet its GHG reduction target.[33]

CARB staff's review of the 2020 SCS found that the plan maintains phased and coordinated land use development and transit as its key strategies for achieving an even more aggressive 2035 GHG reduction target. SACOG adjusted the 2020 SCS's[34] transit ridership assumptions down 25 percent compared to what was assumed in the 2016 SCS; for land use, it assumed a 26 percent decrease in housing within a ½-mile of transit. In addition, 65 percent of new growth is assumed to occur in infill areas such as center/corridor and established communities, which is even higher than the 58 percent

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[32] See "Tracking Implementation" section of Appendix C: MPO Reporting.
[33] See "Incremental Progress" section of Appendix C: MPO Reporting for SACOG's quantitative assessment of how changes to its SCS strategies between the 2016 SCS and 2020 SCS contributed to achievement of its 2035 target.
[34] This section compares performance indicators from its 2020 SCS data table to its 2016 SCS data table.

of new growth in infill areas it assumed in its 2016 SCS. Adjustments to the plan's transit and housing near transit assumptions, while less supportive of GHG emissions reductions, directionally align with declining and stagnant transit service and ridership findings from SACOG's Regional Progress Report[35] (Progress Report), which was prepared in 2017 to inform the policy focus of the 2020 SCS. Increased infill assumptions in the 2020 SCS that support the region's GHG reductions, however, are identified as a challenge area based on housing permit data trends shown in the Progress Report. At the same time, SACOG has added new assumptions and strategies to its 2020 SCS regarding the implementation of new and shared mobility travel options, as well as regional roadway pricing that are anticipated to also support the region's GHG reductions. Taken as a whole, these adjustments suggest that the region is doubling down on land use strategies, reducing reliance on transit uptake, and further diversifying the strategies it plans to use to help meet the region's more aggressive 2035 target.

Specifically, CARB observed the following policy changes and adjustments to SACOG's 2020 SCS compared to its 2016 SCS.

Land Use and Development

- Green Means Go Pilot Program initiative is added to help catalyze the development planned in the region's infill areas.

- Regional Housing Needs Plan with action steps and incentives is added to put member agencies in a better position to accelerate infill and affordable housing production.

- Blueprint update effort is added to allow the region's jurisdictions and stakeholders to revisit and update the region's growth and development vision.

Transportation

- Transit assumptions are adjusted for the 2035 target year. Transit ridership is assumed to decreased from 499,800 to 376,040 average daily boardings (25 percent) between the 2016 SCS and 2020 SCS.

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[35] SACOG. Sacramento Area Regional Progress Report. June 2017.

- Bike and pedestrian lane miles are adjusted for the 2035 target year and decrease from 3,508 to 1,565 (55 percent) between the 2016 SCS and 2020 SCS.

Roadway Pricing:

- Two new pricing strategies are added to help address concerns about transportation funding sustainability, while also helping to support VMT reduction.

- Coordination with Caltrans, and other local partners, on managed lane studies is added to help support implementation of the new facility-based pricing strategy.

- Work with regional partners to develop pricing pilot projects is added to support implementation of the new pricing strategies.

Electric Vehicle and New Mobility:

- Assistance for transit and local agencies to develop, test, and pilot new mobility services such as micro-transit, bike share, and micro-mobility through SACOG's Civic Lab Innovative Mobility Accelerator Program is added to support incorporation of new mobility options into the region.

- Next Generation Transit Study development is added to support strategies to integrate traditional transit services with new mobility options.

- New employer- and residential-based transportation demand management program development is added through SACOG's Civic Lab Innovative Mobility Accelerator Program to support further incorporation of new mobility options in the region in a way that supports the SCS goals.

- EV charging strategy is adjusted to assume 150 additional public chargers will be deployed by 2035. SACOG previously included an EV charging strategy in the 2016 SCS, which assumed future deployment of over 120 public charging stations by 2020, and over 200 by 2035. As of 2020, SACOG had over 280 public chargers.

CARB staff finds that the 2020 SCS shows evidence of changes and adjustments made that are intended to help meet the region's more aggressive targets and are based on lessons learned from previous SCS performance.

CARB's Determination

ACCEPT

(WITH CONCERNS REGARDING IMPLEMENTATION)

Based on a review of all available evidence and in consideration of CARB's 2019 Evaluation Guidelines, CARB staff accepts SACOG's determination that its 2020 SCS would meet the target of a 19 percent reduction by 2035, compared to 2005 levels, when fully implemented.

CARB staff commends SACOG and its member jurisdictions for the innovative thinking and leadership shown in adopting new pathways for the region to address smart growth and increase mobility choices in its 2020 SCS. Furthermore, the region's addition of roadway pricing mechanisms in the 2020 SCS, both paid express lanes and mileage-based fees/Pay Go, demonstrate needed leadership on tough-to-implement strategies that can help provide mobility benefits to residents and achieve the region's GHG target. CARB staff's policy evaluation of the 2020 SCS concludes that the plan includes: sufficiently supportive indicator trends; near-term policy support actions; active transportation, transit, and other SCS-supportive project investments; and adjustments in response to observed implementation challenges that when fully implemented, will lead the Sacramento region to achieve its 2035 GHG reduction target.

CARB staff, however, continue to have serious concerns with the 2020 SCS, regarding the absence of a 2020 target determination and whether SACOG and its local members are putting in place the actions necessary to fully implement the region's SCS strategies by 2035. Specific to the 2020 target determination, SACOG did not make a determination as to whether the 2020 SCS meets the 7 percent GHG reduction target by 2020 compared with 2005 levels. Statute requires MPOs to show how they will meet the CARB-set targets for years 2020 and 2035. The overarching intent of SB 375 was to enact the magnitude of change that would lead to actual GHG reductions from passenger vehicles and light trucks in line with the targets set by CARB. Failing to evaluate and determine whether the strategies would meet the 2020 target could hinder this goal by allowing backsliding on GHG reductions achieved or backloading of strategies to meet the 2035 target, both of which threaten the ability of the region to meet the targets. This would be counter to the intent of SB 375 and frustrates California's ability to meet its climate commitments, which depend on local land use and transportation actions to reduce transportation GHG emissions. For these reasons, SACOG and every MPO should submit a determination as to whether or when it will meet the 2020 target in every SCS based on latest observed data and SCS strategy implementation progress.

While SACOG's plan forecasts bold changes to the region's future land use and transportation system by 2035, the implementation actions identified concern CARB staff. For example, these actions rely heavily on SACOG and its local members securing new funding sources and State legislative changes in the near-term to pilot and eventually launch some first-of-a-kind regional programs. CARB is concerned that any underperformance in the region's current and planned advocacy efforts to bring new programs and authorities to timely fruition means that the Sacramento region will not meet the targets. SACOG has already missed anticipated milestones for key supporting actions in the 2020 SCS, which raises concerns about the viability of fully implementing its included strategies by 2035. In addition, SACOG anticipates reducing funding for transit and active transportation projects and, the SCS appears to backload those critical projects, while prioritizing projects such as capacity expansion roadway projects that are known to encourage more people to drive.[36]

To support successful implementation of the SCS, and to continue fully supporting the GHG benefits claimed in the 2020 SCS, SACOG and its local members will need to undertake additional actions to deliver and monitor its SCS strategies, as well as quickly adjust its strategies for any lost opportunities that need to be replaced or mitigated. To address these concerns, CARB staff has the following recommendations and requests that SACOG set up regular monitoring of the implementation actions associated with its SCS strategies in consultation with CARB and other relevant agencies.

Recommendations

- Prioritize Funding for Transportation Projects that Advance SCS Implementation and Goals

  SACOG should adjust regional transportation funding award programs, like its Regional and Community Design Programs to target and prioritize certain projects. Specifically, projects with the best demonstrated performance outcomes for implementing the SCS strategies and goals of reducing VMT per capita, accelerating infill, and providing cleaner, multi-modal travel options should be prioritized.

[36] CARB - Research on Effects of Transportation and Land Use-Related Policies

SACOG should prioritize projects that meet the regional GHG reduction targets when seeking funding through the Solutions for Congested Corridors Program (SCCP) and Trade Corridor Enhancement Program (TCEP), under SB 1. SACOG and its member jurisdictions should align project nominations with the region's SCS by ensuring that all project nominations will support growth in the region's location-efficient infill areas, particularly in areas that already include a mix of uses and transportation options that foster lower VMT.

To help maintain the years of regional collaboration that informed SACOG's SCS and both the region and the State's ability to meet respective climate and air quality targets, future local sales tax measures in the region should limit funding roadway capacity expansion projects that are not well-aligned with the region's adopted SCS land use and housing strategy. Local sales tax measures comprise approximately 17 percent of the Sacramento region's projected transportation revenues. These measures list specific projects, locking them in for years or decades. Often, these measures do not fully fund their listed projects, and go on to capture a region's otherwise flexible State and federal funds. Within the SACOG region, some of these measures have been supportive of SB 375 goals, while other projects have not. Considering projects' impacts on VMT is more important than ever. Going forward, investments should focus on transit, active transportation, transportation electrification, and increasing mobility options that discourage solo driving and reduce VMT.

- Monitor Implementation of the Adopted Transportation Project List

SACOG will need to be vigilant about monitoring the balance of transportation projects through 2035 to ensure planned reductions are achieved. Delays or removals of transit and active transportation projects will prevent SACOG from meeting its GHG emission reduction target. Amendments to the project list should be accompanied by recalculation and discussion of whether and how SCS target achievement is maintained.

- Accelerate Infill to Further SCS Implementation and Goals

Given that Green Means Go is a key strategy that SACOG is pursuing and anticipates will contribute significantly to helping address previous challenges with implementing its SCS's infill assumptions, it is imperative that the locations and policies within the program's "green zones" align with the planned outcomes assumed in the SCS. Furthermore, SACOG could assist with identifying priority locations for "green zones" that would result in more successful implementation. In addition, SACOG and its local jurisdictions may need to also explore other mechanisms to level the cost of infill to make it more financially attractive than greenfield development. Some areas that could be explored are local implementation of SB 743 and development of a regional mitigation bank to support catalytic infill project development in the region, and developing a regional site inventory and feasibility study for infill potential that aligns with the growth assumed in the SCS.

- State and Regional Partnership on Pricing Pilot Options

  SACOG will need to engage in close collaboration with State partners at Caltrans and CalSTA to ensure successful implementation of the pricing mechanisms identified in the 2020 SCS. Given that SACOG's pilot project grant application was not funded this round, SACOG needs to work with both Caltrans and CalSTA on identifying alternative joint actions for advancing pilot work in the next four years. CARB expects SACOG to identify further progress on implementing this strategy in its next SCS in order to continue receiving credit for the full GHG emission reductions assumed in this 2020 SCS.

- Provide All Trend Analysis Metrics

  SACOG's SCS submittal lacks data on transit seat utilization, which is one of the eight trends that CARB analyzes as part of the trend analysis. This information is important as it can be used to demonstrate how transit strategies in the SCS support growth in public transit ridership and GHG reductions. Providing more meaningful performance indicators like this may require SACOG to update its travel demand model and collect additional information. CARB requests that this metric be included in SACOG's next SCS.

- Improve Modeling and Data

  As new data emerge, CARB recommends that SACOG update its model and its components as new data such as travel surveys, transit boarding surveys, and big data become available. Among other updates, CARB recommends that the model incorporate TNCs and autonomous vehicles.

- Analyze Induced Travel Demand

Induced travel is a phenomenon that is caused by roadway expansion that increases VMT when drivers reroute from congested roads to longer, uncongested roads, shift from alternative modes to driving, or make more frequent trips. Road expansion projects can also lead to long-term induced travel in the region. Long-term effects may also occur if households and businesses move to more distant locations or if development patterns become more dispersed in response to the capacity increase. Induced travel is important to analyze as it can affect VMT and GHG emissions. SACOG has included several road expansion projects in its 2020 SCS. Currently SACOG is using an elasticity-based approach to assess the long-term effect of induced travel. While this approach can estimate the magnitude of VMT change, it cannot identify the geographic areas of induced travel or synergistic effects of induced travel with other strategies, and thus may not be directly helpful to future planning and mitigation actions. CARB staff recommends that SACOG continue to explore methods that analyze the long-term induced travel demands of road expansion more thoroughly in future SCSs, using an integrated land use and travel demand model that captures change in transportation investments or neighborhood changes (residential and employment locations). Further, this will improve the capability to analyze the impact of land use policies such as smart growth strategies, transit-oriented development, and bike/pedestrian-friendly developments on travel demand.

Appendix A: SACOG's 2020 SCS Strategy Table

This is a summary table based on SACOG's submittal that compares the key land use and transportation strategies between the 2016 and 2020 SCSs. This table also illustrates how GHG emissions were estimated for each strategy.

Strategy Category: 2020 SCS Strategy Name	New/Carryover Strategy from 2016 SCS	Analysis Type	Estimated GHG Emission Reduction in 2035
Land Use & Housing: Shortening Passenger Vehicle Trips: Jobs/Housing Balance, Infill Development, Transit-Oriented Development	Carryover	On-Model	-5%
Transportation: Increasing Non-SOV Mode Share: Transit Supportive Infrastructure & Investment, Bicycle and Pedestrian Infrastructure & Investment, Transportation Demand Management (TDM)	Carryover	On-Model	-6%
Local/ Regional Pricing: Managed Express Lane Pricing & PAYGO	New	On-Model	-2%
Transportation: Intelligent Transportation System & Transportation System Management (ITS & TSM)	Carryover	Off-Model	-0.5%
Electric Vehicles and New Mobility:	Carryover	Off-Model	-0.5%

Strategy Category: 2020 SCS Strategy Name	New/Carryover Strategy from 2016 SCS	Analysis Type	Estimated GHG Emission Reduction in 2035
Electric Vehicle Charging Infrastructure Electric Vehicle Incentives Bike Share/Micromobility	Carryover Carryover New	(Continued)	(Continued)
Aging Population[37]	Carryover	Exogenous Variable	-2%
Increase in Auto Cost[38]	Carryover	Exogenous Variable	-3%
Total Reduction	NA	NA	**19%**

Note:
NA means not available

[37] SACOG is claiming GHG reductions from there aging population, which is an exogenous variable.
[38] SACOG is claiming GHG reductions from increased auto operating cost, which is an exogenous variable

Appendix B: Data Table

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Modeled Population	2,139,955	2,376,311	2,482,749	2,903,090	2,996,832	MPO Estimated
Vehicle Operating Costs ($/mile)	$0.22	$0.19	n/a[3]	$0.24	$0.24	In 2017 dollars, Includes federal fuel tax assumed to remain constant for all future scenarios. Fuel, Maintenance and Tires
State Fuel Tax or Mileage Fee Price ($/mile)	$ n/a	$ n/a	n/a	$0.012	$0.012	In 2017 dollars, California State Fuel Tax or Mileage fee per mile range from ($0.012-$0.019) Assumed low range for SCS. Refer to 3d - Auto Operating Costs, Fuel Taxes and Mileage-Based Fees
SACOG Mileage Fee Price ($/mile)	$ n/a	$ n/a	n/a	$0.023	$0.023	2017 dollars, SACOG Mileage fee per mile may range from ($0.007-$0.023) Assumed high range for SCS. Refer to 3d - Auto Operating Costs, Fuel Taxes and Mileage-Based Fees

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Average Median Household Income ($/year)	$72,270	$61,970	n/a	$61,520	$61,500	In 2017 dollars
Total Number of Households	774,312	881,799	n/a	1,100,474	1,136,599	MPO Estimated
Total Number of Jobs	1,000,887	1,060,751	n/a	1,279,016	1,330,813	MPO Estimated
Total Developed Acres	n/a	686,847	n/a	728,790	733,247	MPO Estimated
Total Housing Units (DU)	n/a	921,123	n/a	1,144,694	1,181,251	MPO Estimated
Total Single-Family Housing Units (DU)	n/a	664,718	n/a	760,552	784,841	Refer Table C-4 in Appendix C, 2020 MTP/SCS
Share of Single-Family Housing Units (%)	n/a	72%	n/a	66%	66%	Refer Table C-4 in Appendix C, 2020 MTP/SCS
Total Multi-Family Housing Units (DU)	n/a	256,405	n/a	384,142	396,410	Refer Table C-4 in Appendix C, 2020 MTP/SCS
Share of Multi-Family Housing Units (%)	n/a	28%	n/a	34%	34%	Refer Table C-4 in Appendix C, 2020 MTP/SCS
Net Residential Density Regional Total	n/a	1.2	n/a	1.5	1.5	dwelling units/acre
Net Residential Density Center and Corridor	n/a	11.0	n/a	13.9	14.0	dwelling units/acre
Net Residential Density Established	n/a	2.4	n/a	2.5	2.5	dwelling units/acre
Net Residential Density Developing	n/a	1.4	n/a	3.0	2.9	dwelling units/acre

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Net Residential Density Rural Residential	n/a	0.2	n/a	0.2	0.2	dwelling units/acre
Total Housing Units Within ½-Mile of a High-Quality Transit Station	n/a	536,075	n/a	669,175	690,960	High Frequency Transit Areas are those areas of the region within ½-mile of a major transit stop (existing or planned light rail, street car, or train station) or high-quality transit corridor. A high-quality transit corridor is a corridor with fixed route bus service with service intervals no longer than 15 minutes during peak commute hours (Pub. Resources Code, § 21155).
Total Employees Within ½-Mile of a High-Quality Transit Station	n/a	553,756	n/a	641,088	658,323	High Frequency Transit Areas are those areas of the region within ½-mile of a major transit stop (existing or planned light rail, street car, or train station) or high-quality transit corridor.

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Total Employees Within ½-Mile of a High-Quality Transit Station	n/a	553,756	n/a	641,088	658,323	A high-quality transit corridor is a corridor with fixed route bus service with service intervals no longer than 15 minutes during peak commute hours (Pub. Resources Code, § 21155).
Freeway and General Purpose Lanes - Mixed Flow, auxiliary, etc. (lane miles)	1,401	1,705	n/a	1,648	1,670	General purpose + auxiliary lane miles.
Freeway Express Lanes (lane miles)	0	0	n/a	273	273	Express Lanes during AM peak hour. Includes taking a lane from GP and implementing reversible lanes.
Average Express Lane Price ($/mile)	n/a	n/a	n/a	$ 0.83	$0.68	Based on dynamic demand corridor pricing rollup of average SOV + commercial vehicles across only priced corridors during peak hour periods only, off peak hours is free for all vehicle types. All other freeway and other roadway lanes not along Express Lane are free. 2017 dollars

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Freeway HOV Lanes (lane miles)	64	124	n/a	159	171	HOV lanes miles during AM peak period lane configuration.
Arterial/Expressway Lanes (lane miles)	2,935	3,392	n/a	4,324	4,477	Expressways, Major, Minor Arterials, and American River Crossings
Rural Roadway Lanes (lane miles)	3,203	3,103	n/a	2,849	2,854	Rural Highways and Rural Arterials
Collector Lanes (lane miles)	2,336	2,425	n/a	2,410	2,414	MPO Estimated
Average Transit Headway (minutes)	n/a	n/a	n/a	n/a	n/a	MPO Estimated
Total Transit Operation Miles	4,916	5,558	n/a	9,308	9,368	Vehicle Service Miles
Transit Total Daily Vehicle Service Hours	3,588	3,994	n/a	8,212	8,223	MPO Estimated
Bike and Pedestrian Lanes (class I, II, & IV) Miles	639	876	n/a	1,565	1,576	MPO Estimated
Household Vehicle Ownership	1.92	1.82	n/a	1.81	1.80	MPO Estimated
Average Trip Length (miles/day) Drive Alone	8.04	7.85	n/a	7.35	7.33	Average trip length for all trips by mode.
Average Trip Length (miles/day) Shared Ride	6.73	6.89	n/a	6.78	6.78	Average trip length for all trips by mode.
Average Trip Length (miles/day) Public Transit	5.39	5.83	n/a	6.24	6.24	Average trip length for all trips by mode.
Average Trip Length (miles/day)Bike & Walk	1.63	2.3	n/a	2.37	2.37	Average trip length for all trips by mode.

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Average Travel Time by Trip Purpose (minutes) Commute Trip	25	24	n/a	25	25	Half of work tours
Average Travel Time by Trip Purpose (minutes) Non-Commute Trip	17	19	n/a	19	19	Half of non-work tours
Average Trip Travel Time Drive Alone (minutes)	15	14	n/a	14	13	Average trip travel time for all trips by mode.
Average Trip Travel Time Drive Alone (TNC)	n/a	n/a	n/a	n/a	n/a	TNC not a mode in the MTP/SCS
Average Trip Travel Time Shared Ride	12	12	n/a	12	12	Average trip travel time for all trips by mode.
Average Trip Travel Time Shared Ride (pooled TNC)	n/a	n/a	n/a	n/a	n/a	TNC pool not a mode in the MTP/SCS
Average Trip Travel Time Public Transit	40	46	n/a	40	40	Average trip travel time for all trips by mode.
Average Trip Travel Time by Mode (minutes) Bike	21	28	n/a	29	29	Average trip travel time for all trips by mode.
Average Trip Travel Time by Mode (minutes) Walk	23	30	n/a	32	32	Average trip travel time for all trips by mode.
Average Travel Time for Low-Income Populations	14	15	n/a	16	16	Low Income Population defined as households less than 200% the U.S. Poverty Line.
Mode Share (%) Drive Alone	43.7%	42.1%	n/a	41.5%	41.5%	MPO Estimated
Mode Share (%) Drive Alone (TNC)	n/a	n/a	n/a	n/a	n/a	TNC not a mode in the MTP/SCS

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Mode Share (%) Shared Ride	43.8%	45.1%	n/a	43.3%	43.2%	MPO Estimated
Mode Share (%) Shared Ride (pooled TNC)	n/a	n/a	n/a	n/a	n/a	TNC pool not a mode in the MTP/SCS
Mode Share (%) Public Transit	1.3%	1.2%	n/a	2.4%	2.4%	MPO Estimated
Mode Share (%) Bike	1.9%	2.5%	n/a	2.8%	2.8%	MPO Estimated
Mode Share (%) Walk	7.3%	7.8%	n/a	9.0%	9.0%	MPO Estimated
Mode Share (%) Other	2.0%	1.2%	n/a	1.0%	1.0%	MPO Estimated
Seat Utilization	n/a	n/a	n/a	n/a	n/a	MPO Estimated
Transit Ridership (Average daily boarding's)	138,460	120,500	n/a	376,040	385,901	MPO Estimated
Total VMT per weekday (all vehicle class) (miles)	57,820,351	58,442,986	60,832,404	67,499,956	69,812,811	MPO Estimated
Total VMT per weekday for passenger vehicles (CARB vehicle classes LDA, LDT1, LDT2, and MDV)	51,543,000	51,440,387	53,449,298	59,052,790	61,073,845	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
SB 375 vehicle population vehicles (CARB vehicle classes LDA, LDT1, LDT2, and MDV)	1,916,792	1,356,213	1,410,022	1,579,658	1,634,419	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
GHG Emissions Per Person Vehicle VMT	0.986	0.948	0.948	0.950	0.951	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Total II VMT per weekday for passenger vehicles (miles)	39,714,178	40,775,623	n/a	46,522,031	48,125,117	MPO Estimated
Total IX/XI VMT per weekday for passenger vehicles (miles)	10,746,419	9,584,515	n/a	11,054,439	11,421,881	MPO Estimated
Total XX VMT per weekday for passenger vehicles (miles)	1,082,403	1,080,248	n/a	1,476,320	1,526,846	MPO Estimated
SB 375 VMT per capita	24.09	21.65	21.53	20.34	20.38	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
Total CO2 emissions per weekday (all vehicle class) (tons/day)	32,970	31,417	32,924	36,905	29,021	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
Total SB375 CO2 emissions per weekday for passenger vehicles (CARB vehicle classes LDA, LDT1, LDT2, and MDV) (tons/day)	25,410	24,373	25,404	28,051	29,045	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
Total II CO2 emissions per weekday for passenger vehicles (tons/ days)	19,579	19,320	n/a	22,099	22,887	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
Total IX / XI CO2 emissions per weekday for passenger vehicles (tons/day)	5,298	4,541	n/a	5,251	5,432	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Total XX CO2 emissions per weekday for passenger vehicles (tons/day)	534	512	n/a	701	726	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
SB 375 CO2 per capita (lbs./day) (Through Trips removed with factors 0.979 for 2005/2016/2020 and 0.975 for 2035/2040)	23.25	20.00	20.03	18.84	18.90	2005 from EMFAC 2007, all other scenarios are from EMFAC 2011.
EMFAC Adjustment Factor	n/a	n/a	3.50%	3.7%	n/a	Applied to SB375 CO2 per capita. This is the adjustment factor for EMFAC version 2007 to 2011
Off-Model CO2 Emissions Reductions RTP/SCS Strategy 1: ITS/TSM	n/a	n/a	-0.15%	-0.36%	n/a	2020: Estimates of actual off model adjustment. 2035: Applied midpoint of low-high forecast range.
Off-Model CO2 Emissions Reductions RTP/SCS Strategy 2: TDM + Car Sharing	n/a	n/a	-0.80%	-2.00%	n/a	2020: Estimates of actual off model adjustment. 2035: Applied midpoint of low-high forecast range.
Off-Model CO2 Emissions Reductions RTP/SCS Strategy 3: EV	n/a	n/a	-0.05%	-0.55%	n/a	2020: Estimates of actual off model adjustment. 2035: Applied midpoint of low-high forecast range.

Modeling Parameters	2005	2016 (base year)	2020 With Project [1]	2035 With Project	2040 With Project	Notes for CARB
Off-Model CO2 Emissions Reductions RTP/SCS Strategy 4: Bike Share	n/a	n/a	-0.10%	-0.42%	n/a	2020: Estimates of actual off model adjustment. 2035: Applied midpoint of low-high forecast range.
Off-Model CO2 Emissions Reductions RTP/SCS Strategy : Average Combined	n/a	n/a	-1.10%	-3.33%	n/a	2020: Estimates of actual off model adjustment. 2035: Applied midpoint of low-high forecast range.
Total RTP Expenditure ($ in billions) **[2]**	n/a	n/a	n/a	n/a	n/a	n/a
Road & Highway Capacity expansion ($)	n/a	n/a	n/a	n/a	n/a	n/a
Roadway Maintenance & Rehabilitation ($)	n/a	n/a	n/a	n/a	n/a	n/a
Transit Investments ($)	n/a	n/a	n/a	n/a	n/a	n/a
Transit operations ($)	n/a	n/a	n/a	n/a	n/a	n/a
Bike and pedestrian projects ($)	n/a	n/a	n/a	n/a	n/a	n/a
Other (Program, Safety, System Management & Operations) ($)	n/a	n/a	n/a	n/a	n/a	n/a

[1] 2020 forecast based on an interpolation between 2016 and 2027. No land use scenario was prepared for 2020.

[2] SACOG did not provide investment information in the data table provided to CARB. SACOG referred CARB to the 2020 MTP/SCS DEIR Table 2-16 Summary of Proposed Investments in the Plan Area for the Proposed MTP/SCS, and Appendix A Transportation Project List for investment information.

[3] n/a means not available

Appendix C: MPO Reporting Components

This section will focus on discussing the three reporting components of the 2019 Evaluation Guidelines: tracking implementation, incremental progress, and equity. The three reporting components are included to identify the effectiveness of prior SCS implementation and increase overall transparency of the SCS for the public and other stakeholders. These reporting components will demonstrate the efforts put forward by MPOs and the progress made towards meeting their SB 375 GHG targets.

Tracking Implementation

The purpose of this section is to report on the progress the SACOG region has made implementing its SCS. Specifically, staff compared observed data for transportation, housing, and land use performance metrics to plan performance to determine whether the region is on track to meet its targets. Performance metrics used in this analysis were chosen based on the availability of observed data and plan performance indicators provided by SACOG and represent a snapshot of where the region is currently. Metric trends that are not heading in the right direction relative to expected plan outcomes are areas that CARB staff look at in the Plan Adjustment analysis, to understand whether the current SCS modifies or adds its strategies or actions to get the region on track with expected plan outcomes.

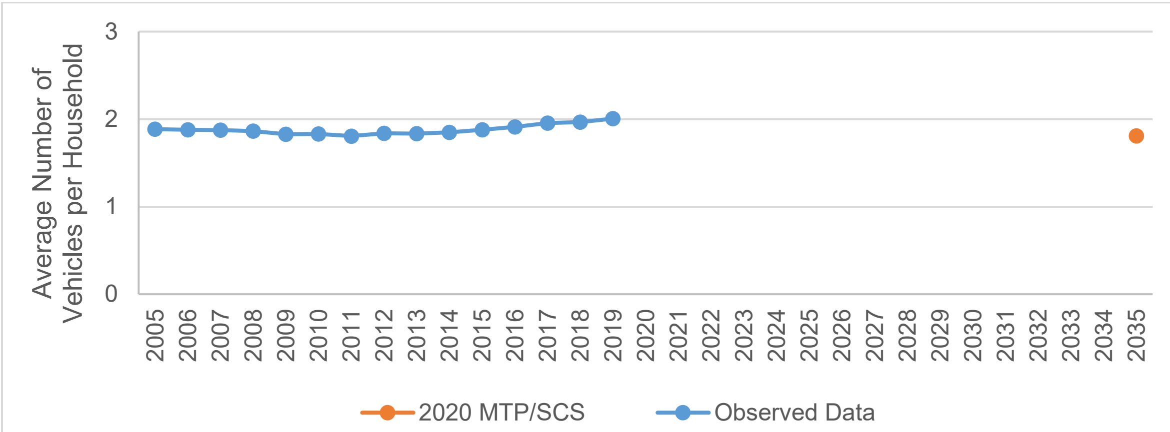
Regional Average Household Vehicle Ownership

CARB staff analyzed the trend in household vehicle ownership for SACOG from 2005 to 2019. This indicator reports the average number of private vehicles owned by each household in SACOG (i.e., the total number of household vehicles divided by the number of households). Total county-level, privately owned vehicle and household data for 2005 to 2016 were obtained from the American Community Survey (ACS) reports[39] and Department of Finance,[40] respectively.

Figure 6 shows historical SACOG average household vehicle ownership from 2005 to 2019 in comparison to SACOG's 2035 forecasted household vehicle ownership from its travel demand model (See Appendix B: Data Table). While average household vehicle ownership increased by 6.4 percent in SACOG from 2005 to 2019, there was a decline between 2005 and 2012, with a subsequent rebound. The 2035 forecasted SCS household vehicle ownership is 4 percent below 2005 levels and the trend in observed data from 2012 forward is heading in the wrong direction relative to expected plan outcomes.

[39] U.S. Census Bureau, American Community Survey, 2005 – 2019 ACS 1-year Estimates.
[40] Department of Finance, Demographics.

Figure 6. SACOG Region Average Household Vehicles



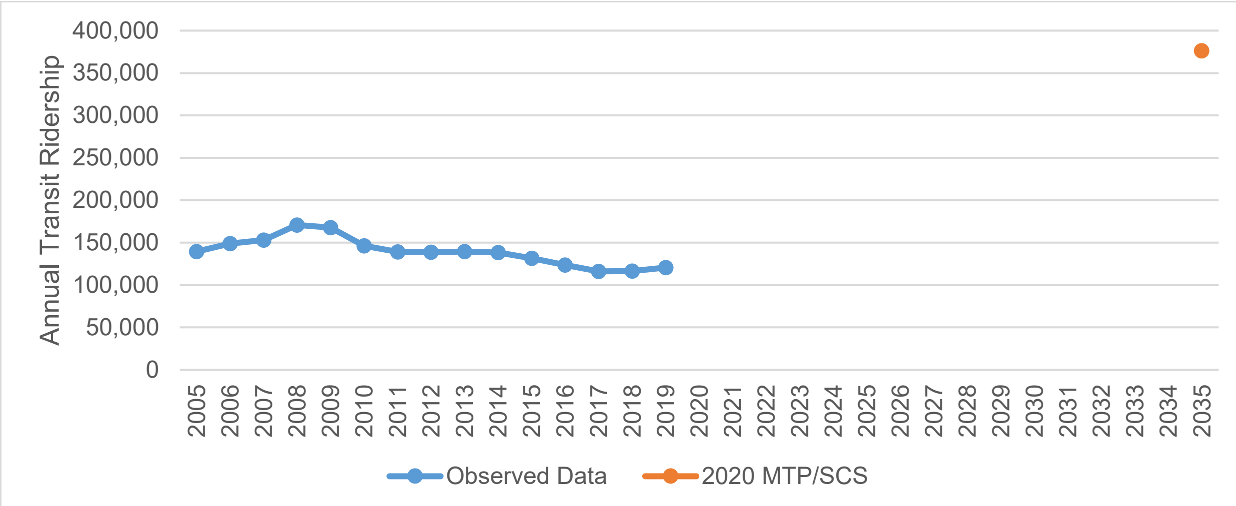
Annual Transit Ridership

CARB staff used the National Transit Database (NTD)[41] published monthly transit boarding numbers (unlinked trips) reported by local transit agencies to determine the historical monthly and annual boarding numbers in the SACOG region. This dataset cover 2005 to 2017.

Figure 7 shows observed annual transit ridership in SACOG in comparison to 2035 plan performance. The observed data generally increase from 2005 throughout 2008 and then generally decrease through 2019, while SACOG's MTP/SCS forecasted transit ridership is twice that of historical levels. The trend between 2008 and 2019 is heading in the wrong direction relative to the expected plan outcomes.

[41] Federal Transit Agency, National Transit Database.

Figure 7. SACOG Region Annual Transit Ridership



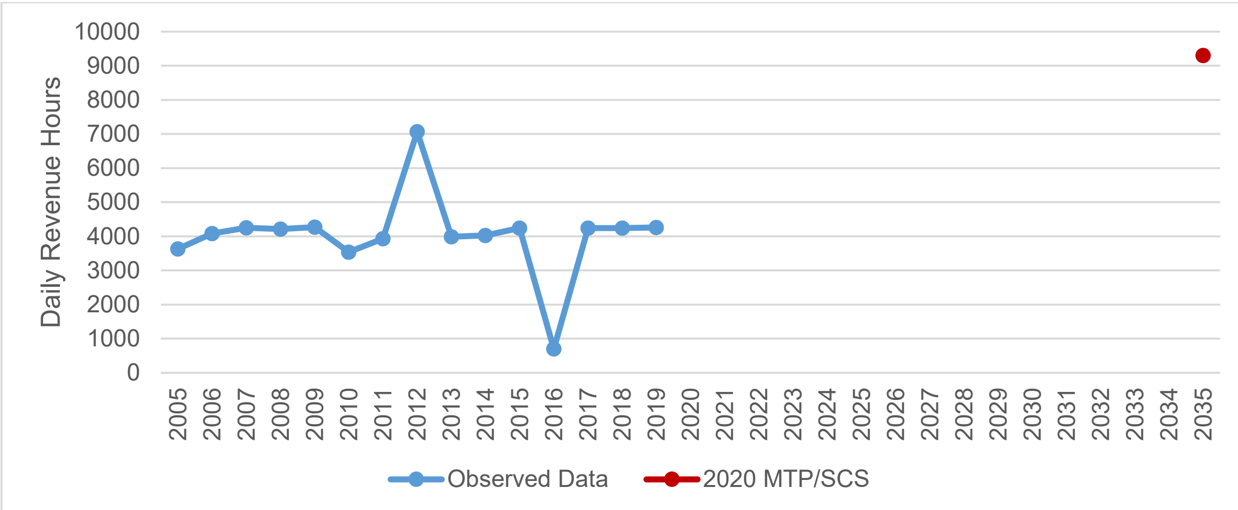
Daily Transit Service Hours

The National Transit Database (NTD) publishes monthly boarding numbers (unlinked trips) reported by local transit agencies. CARB staff calculated the monthly and annual revenue hours in the SACOG region based on this NTD dataset from 2005 to 2019[42]. Total transit revenue hours in SACOG were then adjusted to daily transit revenue hours.

Observed NTD transit revenue hours shows slight increase from 2002 to 2006, and then remained relatively steady through 2019. SACOG's 2020 MTP/SCS forecasts transit revenue hours to more than double from 2019 observed transit revenue hours.

[42] National Transit Database (NTD).

Figure 8. SACOG Region Transit Revenue Hours



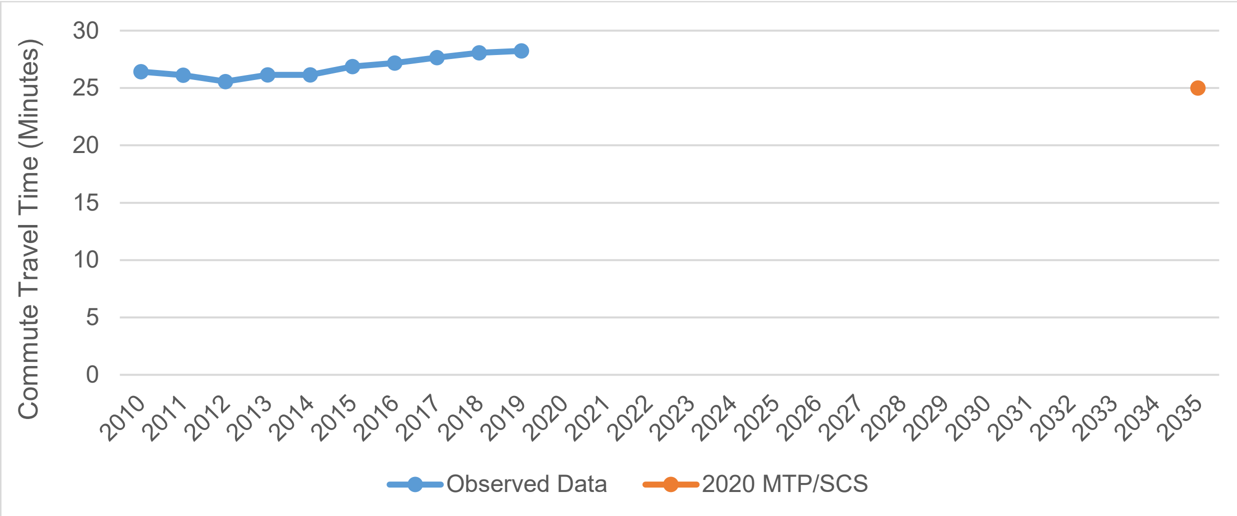
Commute Trip Travel Time

CARB staff analyzed commute trip travel times from 2010 to 2019 using data from the American Community Survey[43] data. A population weighted approach was used to calculate total travel times by county and then aggregated to the SACOG region.

Figure 9 shows historical commute time in comparison to SACOG's 2020 MTP/SCS average commute time. SACOG's 2020 MTP/SCS forecasts a 3-minute reduction in commute time for the region by 2035, while the observed data slightly increase from 2010 to 2019, away from the expected plan outcomes.

[43] U.S. Census Bureau, American Community Survey

Figure 9. SACOG Commute Time



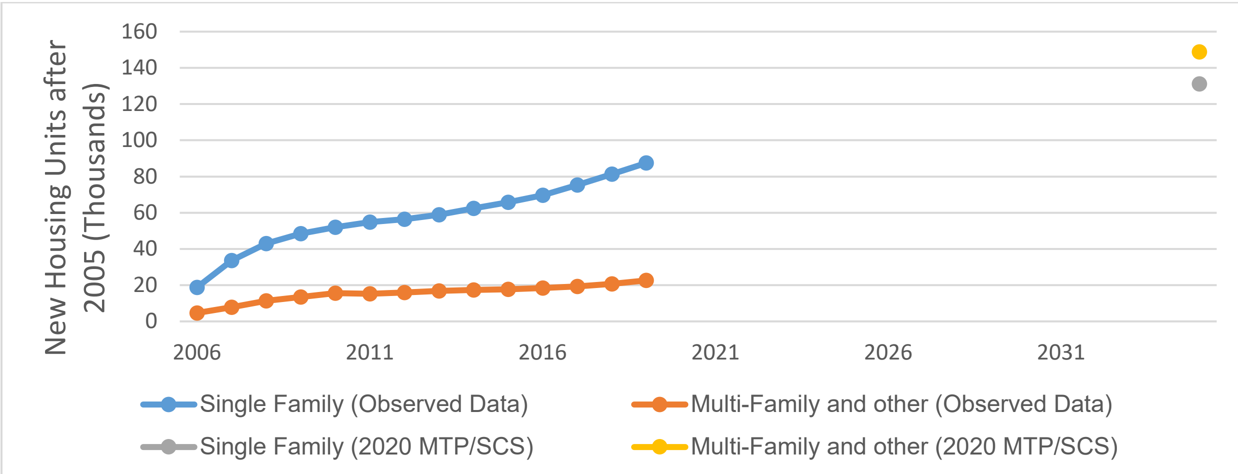
New Homes Built By Type

CARB staff analyzed the rate of new homes being built by type in the SACOG region from 2005 to 2016 using the California DOF datasets including E-5 (for years 2011 to 2016) and E-8 (for years 2005 to 2010)[44]:

Figure 10 shows the historical number of new single-family and multi-family housing units in the SACOG region. Since 2005, there have been 808,214 new single-family and 217,011 new multi-family housing units built in the region. During this period, single-family housing has represented a much greater share of the new housing units built and that share has risen rather than declined. In 2019, 87,470 new single-family housing units and 22,630 new multi-family housing units were built. The 2020 SACOG MTP/SCS forecasts 131,241 new single-family housing units and 148,842 multi-family housing units to be built in 2035, with multi-family housing units representing a greater share of housing than single-family housing units. While the total number of observed housing units is increasing consistent with the plan, the share of single-family is heading in the wrong direction relative to the expected plan outcomes.

[44] California Department of Finance, rate of new homes being built by type.

Figure 10. SACOG Region Housing Units Mix



In summary, CARB staff compared the observed data for regional average household vehicle ownership, annual transit ridership, daily transit service hours, commute trip travel time, and new homes built by type with the projected plan performance indicators provided by SACOG. Based on the analysis none of the observed data heading in the right direction toward the expected plan outcomes. CARB staff concluded that SACOG is not on track to meet its GHG targets.

Incremental Progress

CARB staff reviewed the incremental progress of SACOG's 2020 SCS compared to its 2016 SCS in place in October 2018, in accordance with Board direction and the 2019 Evaluation Guidelines.[45] As background, during the 2018 target update process, some of the MPOs reported to CARB that, due to external factors, even greater effort would be required to achieve the same level of per capita GHG emissions reduction reported in the current SCSs. According to the MPOs, simply staying on course to achieve the previously demonstrated SB 375 GHG emission reduction targets will be a stretch of current resources, let alone achieving the more aggressive targets adopted by the Board in 2018. For example, in 2018, SACOG determined that the 2016 SCS would achieve approximately 3 to 5 percent less than when it was adopted in 2016 simply due to changes in exogenous assumptions (e.g., auto operating cost and growth forecasts)[46]. In other words, if during the target setting process, SACOG updated its 2016 SCS with exogenous assumptions current at the time, it would only achieve 11 to 13 percent per capita GHG reduction in 2035, well below its target of 16 percent. At that time, SACOG communicated that in order to meet its new target of 18 to 19 percent, it would need to include another 5 to 8 percent GHG reductions in new and/or enhanced SCS strategies (i.e., incremental progress) in its 2020 SCS.

To determine whether SACOG is achieving the level of incremental progress consistent with what it reported during the target setting process, CARB staff compared[47] GHG emissions for both the 2016 SCS to the 2020 SCS under varying assumptions using data and information provided by SACOG.[48] Figure 11 illustrates the incremental progress between SACOG's 2016 and 2020 SCSs when controlling for as many exogenous factors as possible. As you can see, the 2016 SCS achieves a 16 percent GHG reduction from 2005 levels in 2035, with 5 percent coming from exogenous variables and the remaining 11 percent from the plan's land use and transportation strategies along with the related demographic assumptions. When adjusting the 2016 SCS with exogenous assumptions from the 2020 SCS, the 2035 per capita GHG reductions are approximately 18 percent, with 3 percent coming from exogenous variables and 11 percent from the plan's land use and transportation strategies along with the related demographic assumptions. Lastly, under the 2020 SCS, the 2035 per capita GHG reductions are approximately 19 percent, with 3 percent coming from exogenous variables and 16 percent from the

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[45] Board Resolution 18-12 (March 22, 2018).

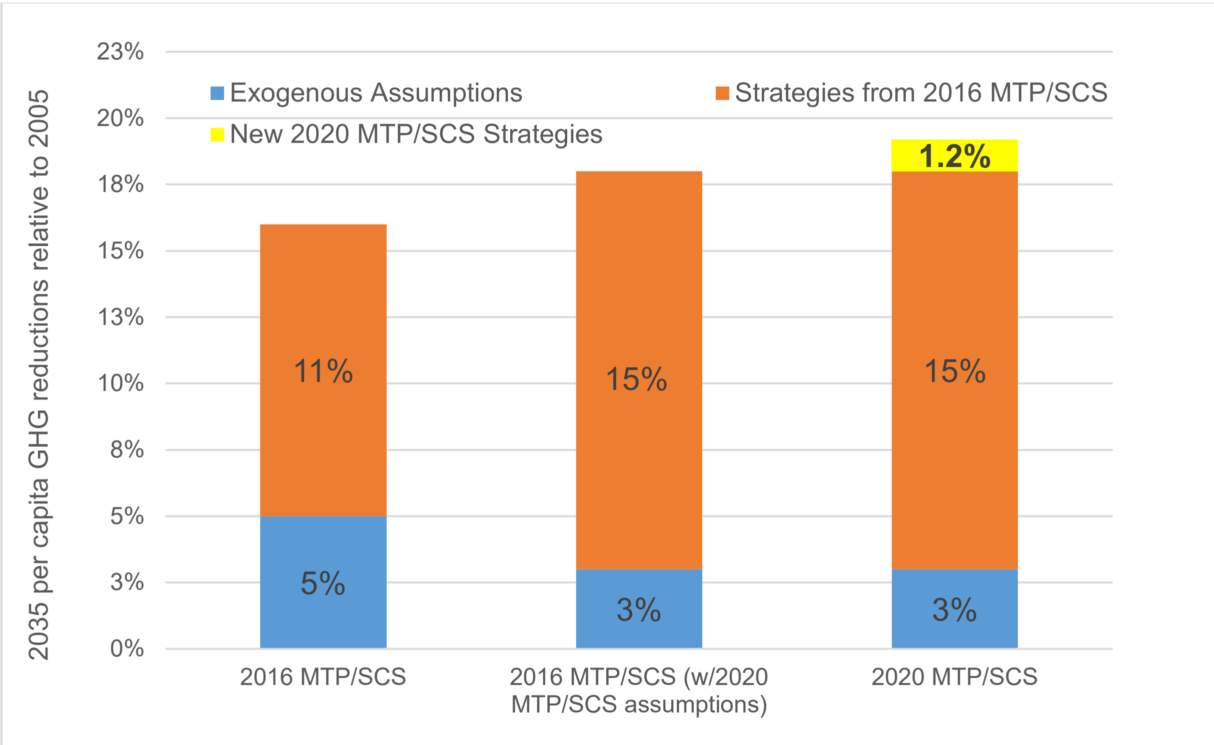
[46] California Air Resources Board. Final Staff Report Proposed Update to the SB 375 Greenhouse Gas Emission Reduction Targets: Appendix B. MPO Scenario and Data Submittals. October 2017.

[47] For a detailed description of CARB's analysis approach, please refer to: California Air Resources Board. *Final Sustainable Communities Strategy Program and Evaluation Guidelines*. November 2019.

[48] For a detailed description of SACOG's approach to demonstrating incremental progress, please refer to SACOG's 2020 SCS Submittal to CARB for Technical Review: 1c. Analysis of Incremental Progress, April 15, 2020.

plan's land use and transportation strategies along with the related demographic assumptions.

Figure 11. SACOG's Incremental Progress



When adjusting the 2016 SCS with exogenous assumptions from the 2020 SCS, the contribution of exogenous assumptions went from 5 percent down to 3 percent primarily due to lower auto operating cost, while the contribution from land use, transportation and demographic characteristics went from 11 percent to 15 percent. This change in the contribution from land use and transportation strategies is in the opposite direction from what CARB expected given the information SACOG shared during the 2018 target update process. CARB expected the contribution from these strategies to go down instead of up. SACOG staff indicated that this change is due to improvements they made to the sensitivity of its travel demand model, SACSIM19, to various variables such as regional auto and transit accessibility, residential density, proximity to transit, street pattern, and mix of land uses. However, CARB staff found this increased sensitivity (elasticities) to be higher than the existing literature would suggest (e.g., regional accessibility, mix of use and residential density).[49] This

[49] SACSIM 19 is more sensitive (i.e., model elasticities) to land use and transportation factors when compared to SACSIM15 used in SACOG's 2016 SCS. Some of the elasticities are higher than elasticities in the existing literature, which may result in an overestimation of land use and transportation

oversensitivity may overestimate the contribution of the plans land use and transportation strategies. Finally, when comparing the 2016 SCS adjusted with exogenous assumptions from the 2020 SCS to the 2020 SCS SACOG plan performance of 19 percent, you can see the new plan has achieved an incremental 1.2 percent per capita GHG reductions in 2035.

While incremental progress is not used for CARB's SCS determination, CARB expects MPOs to achieve incremental progress due to its SCS land use and transportation strategy commitments from its second SCS to its third SCS consistent with information shared during the GHG emission reduction target setting process. Information SACOG submitted during the target setting process indicated it would achieve 5 to 8 percent incremental progress as part of the 2020 SCS, however, it only achieved 1.2 percent. As such, SACOG did not include new/enhanced strategies consistent with the information they shared during the 2018 target setting process.

SACOG did not include enough new/enhanced strategy reductions to show incremental progress consistent with the information they shared during the 2018 target setting process.

strategies. For example, elasticities for regional accessibility in SACSIM 19 are -0.38; mix of use -0.31; residential density -0.27; street pattern -0.31. While the literature suggests reasonable elasticities are in the range of -0.05 to -0.25 for region accessibility; -0.01 to -0.17 for mix of use; -0.05 to -0.12 for residential density, and -0.005 to -0.2 for street pattern. For a more detailed description of SACOG's sensitivity test results, please refer to SACOG's 2020 SCS Submittal to CARB for Technical Review: 3b. SACSIM19 Sensitivity Test Report, April 15, 2020.

Equity

MPOs may report to CARB a summary of how they conducted equity analyses as part of the development of their SCSs in accordance with the *CTC's 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations.*[50] Appendix H of SACOG's 2020 SCS documented SACOG's equity analysis. CARB staff reviewed this appendix and prepared this section to summarize SACOG's 2020 SCS equity work, including identified communities of concern, equity performance measures, equity analysis, and public participation efforts.

Identifying Vulnerable Communities

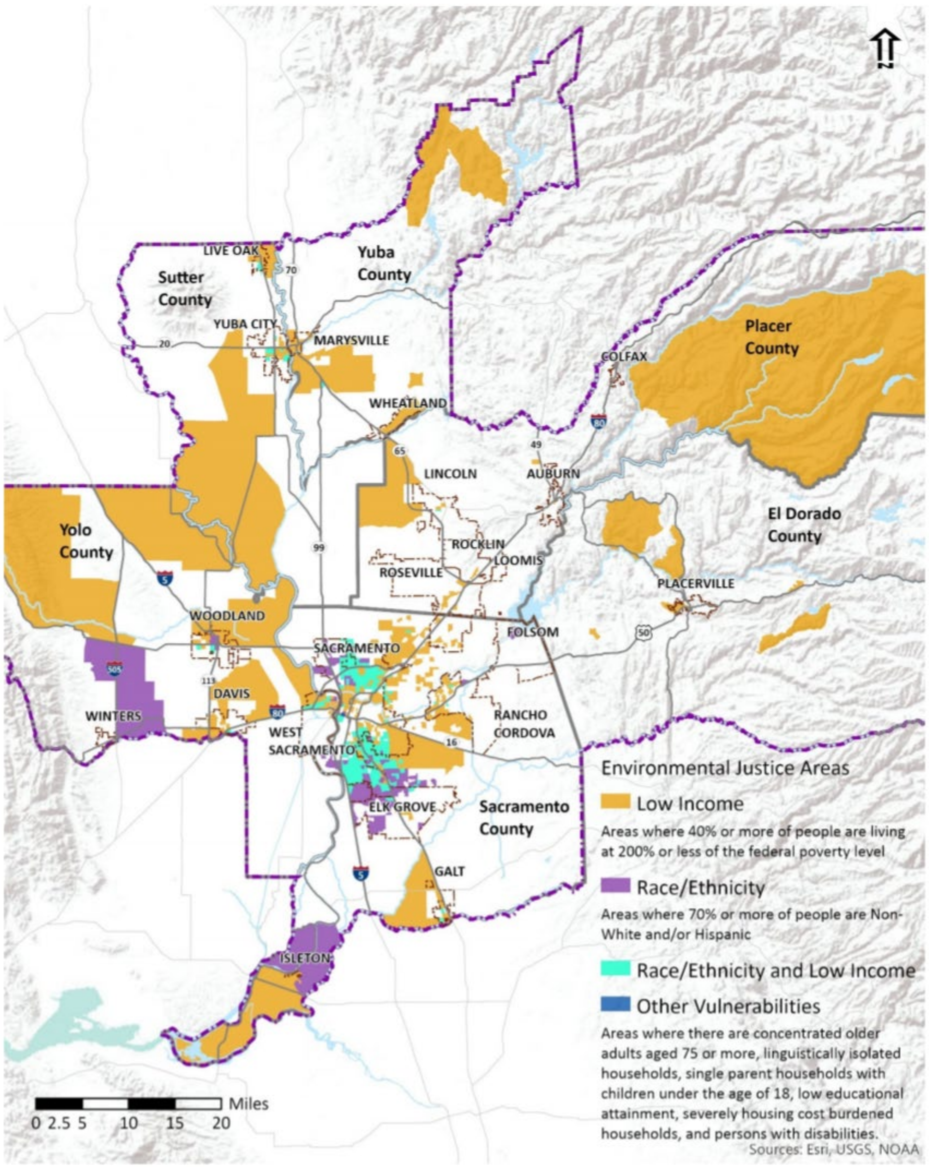
SACOG's 2020 SCS states that its environmental justice (EJ) and Title VI analysis strives to go beyond its federal and State legal requirements in addressing the actual needs within the MPOs most vulnerable communities and of its residents. While SACOG identified and addressed EJ areas in its previous two SCSs, for the 2020 SCS, SACOG convened an equity working group to review and refine its methodology for defining EJ areas. Through this process, EJ communities were developed for areas within each SACOG county (excluding the Tahoe Basin portions of El Dorado and Placer Counties). Criteria for establishing these EJ areas included[51] race/ethnicity, low income status, and vulnerability criteria, such as the concentration of older adults aged 75 years or older, concentration of linguistically isolated households, concentration of single parent households with children under the age of 18, concentration of low educational attainment with less than a high school diploma or GED for the population aged 25 or more, concentration of severely housing cost burdened households, and concentration of households with at least one person with a disability. In addition, another criterion for identifying EJ areas considered CalEnviroScreen 3.0, a screening tool that evaluates the burden of pollution from multiple sources in communities while accounting for potential vulnerability to the adverse effects of pollution. Based on these criteria, key characteristics of the region's EJ analysis areas included:

- About 38 percent of the region's population lives in one of the defined EJ communities. See Figure 12 for Environmental Justice Areas within the SACOG Region.
- People in the EJ communities are nearly twice as likely to be classified as low income as people in other areas.
- The number of EJ block groups increased from the 2016 plan.

[50] California Transportation Commission. 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations. January 2017.
[51] SACOG, Appendix H: 2020 MTP/SCS EJ Analysis, Page 5

- Households in EJ Communities tend to use transit, walk, and bike at significantly higher rates than non-EJ households — more than twice the rate for transit use and a 65 percent greater rate for walking and bicycling region-wide.[52.]

Figure 12. Environmental Justice Areas in the SACOG Region



SACOG, 2020 MTP/SCS, Appendix H Environmental Justice

52 SACOG, Appendix H: 2020 MTP/SCS EJ Analysis, Page 6

Equity Performance Measures

SACOG's EJ analysis attempted to determine if the SCS has a disproportionate negative impact on the low-income population and/or people of color living in the community or the region and if there are any disparate impacts specifically based on race, color, or national origin. SACOG's EJ analysis examined the effect of the SCS on access by both transit and auto from both EJ and non-EJ communities to key destinations.

Accessibility Performance Measures

SACOG assessed changes in transit and auto access to a variety of destinations over the SCS timeframe, such as job sites, medical services, higher education, and parks, for residents of both EJ and Non-EJ communities. For both transit and auto accessibility performance measures, SACOG used a 30minute travel time to destinations as a benchmark.

The trends of SACOG's performance measures for both the EJ and Non-EJ communities appeared generally to improve. Throughout the duration of the SCS, accessibility by transit or auto to job sites, medical services, higher education sites, and parks seemed to increase.

Health and Environment Performance Measures

SACOG's EJ analysis also looked at human health and environmental effects of EJ and non-EJ communities. One measure SACOG analyzed was the number of people in EJ and non-EJ communities that would live within 500 feet of major roadways. SACOG used this as an indicator of risk of exposure to toxic air contaminants. SACOG also looked at the number of people in EJ and non-EJ communities that get at least 30 minutes of physical activity from active modes of transportation.

SACOG's EJ analysis identified that approximately two percent of the MPO's population lives within the 500-foot Sensitive Receptor[53] buffer, with EJ communities even slightly higher at about three percent.

SACOG's analysis of its active transportation measure showed the SCS resulting in increased use of active transportation modes and more physical activity, especially in EJ communities.

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[53] ARB, 2005 Sensitive Receptors guidance: 500-foot buffer (homes, schools, day care centers, parks, hospitals, etc.) of major roadways, defined as freeways or urban roads with traffic volumes of 100,000 or more vehicles per day or rural roads with 50,000 or more vehicles per day.

Public Outreach and Engagement

SACOG held eight outreach meetings for the SCS. SACOG used the locations and times of the meetings as a significant way to reach out to the community, where workshops were hosted at locations that already convened people and focused on communities of color and lower-income residents. In addition, an online survey was conducted that reduced barriers of having to attend in person to participate.

SACOG also convened an Equity Working Group (EWG) to vet ideas and receive feedback on its EJ Analysis. Additional EWG tasks included analysis on the existing travel behaviors, updating the existing methodology for the required EJ analysis, identifying an accessible public workshop format, and developing inclusive outreach strategies.

In addition, SACOG developed "EJ Fact Sheets" as a resource for local agencies as they consider the infrastructure needs of their communities.[54] The EJ fact sheets were prepared for each city, county, and unincorporated area in the region and contain baseline demographics and transportation trend comparisons between the EJ and Non-EJ communities within the jurisdiction.

[54] SACOG, Appendix H: 2020 MTP/SCS EJ Analysis

Exhibit E

Congestion Pricing Home
About Congestion Pricing
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Contacts

Home > About Congestion Pricing

Benefits of Congestion Pricing

Congestion pricing benefits drivers and businesses by reducing delays and stress, by increasing the predictability of trip times, and by allowing for more deliveries per hour for businesses. It benefits mass transit by improving transit speeds and the reliability of transit service, by increasing transit ridership, and by lowering costs for transit providers. It benefits State and local governments by improving the quality of transportation services without tax increases or large capital expenditures, by providing additional revenues for funding transportation, by retaining businesses and expanding the tax base, and by shortening incident response times for emergency personnel and thus saving lives. By preventing the loss of vehicle throughput that results from a breakdown of traffic flow, pricing maximizes return on the public's investment in highway facilities. By revealing where and how much motorists are willing to pay for highway use, it provides signals to better identify where to make new investments in transportation. And it benefits society as a whole by reducing fuel consumption and vehicle emissions, by allowing more efficient land use decisions, by reducing housing market distortions, and by expanding opportunities for civic participation.

Benefits to Transit Riders and Carpoolers

Pricing in combination with transit services provides bus riders with travel time savings equivalent to those for drivers and reduces waiting times for express bus riders due to more frequent service.

The 95 Express project in Miami and Ft. Lauderdale, Florida, introduced new Bus Rapid Transit in January, 2010. By November 2011, total ridership had increased by 145 percent. While the addition of new routes had a significant impact upon ridership, so did the dramatic improvement in express lane travel speeds along the corridor utilized by transit (Average speeds in AM Peak increased from 20 mph on the original HOV lanes to 62 mph on the 95 Express Lanes).

Introduction of pricing in central London and Stockholm has resulted in significant shifts of commuters to transit, particularly buses. Bus delays in central London dropped by 50 percent after the pricing scheme was introduced. There was a 7 percent increase in bus riders (Transport for London - *Central London Congestion Charging: Impacts Monitoring Fifth Annual Report* (PDF, 2.4MB)). In Stockholm, 200 new buses were put into service in August 2005, several months in advance of the pricing trial, which began in January 2006. After the pricing scheme was implemented, daily public transportation use compared to the same month in 2005 was up by 40,000 riders daily. Ridership on inner-city bus routes rose 9 percent compared with a year earlier (2Transek - Cost-benefit analysis of the Stockholm Trial (PDF, 547KB)).

Within three months of the opening of the priced express lanes on California's SR-91, a 40 percent jump occurred in the number of vehicles with more than three passengers. Ridership on buses and a nearby rail line have remained steady (Edward Sullivan - SR 91 Value-priced Express Lanes). On San Diego's I-15 HOT lanes, revenues generated by toll-payers financed transit improvements that contributed to a 25 percent increase in bus ridership (San Diego Association of Governments (SANDAG) - I-15 Fastrak Lanes).

After the HOV lanes were converted into HOT lanes on I-15 in San Diego, carpooling increased significantly, even though there was no change in incentives to carpool - carpoolers continued to use the lanes free of charge, as they did before the lanes were converted. Similar effects were observed (although to a lesser extent) when the HOV lanes on I-25 in Denver were converted to HOT lanes in June 2006. Carpooling increases have not been experienced by all of the HOT lane conversion projects. However, none have observed dramatic declines, which had been projected on some of the early projects, as drivers could now opt to pay a fee instead of creating and maintaining a car pool. It's not clear why observed carpooling increases have occurred - it could be a result of the extra publicity by the media, coupled with assigning a “value” (i.e. toll rate) to the time savings.

Benefits to Drivers

On the State Route 91 priced lanes in Orange County, California, traffic during rush hours moves at over 60 mph, while the traffic in adjacent lanes crawls at average speeds of 15 mph or less. Commuters on the priced express lanes thus save as much as half an hour each way on the 10-mile trip, or as much as an hour a day (Lee County's variable pricing project, Institute of Transportation Engineers. ITE Journal, April 2002 by Burris, Mark W; Swenson, Chris R; Crawford, George L).

If we could use pricing to restore free-flowing traffic conditions on other metropolitan freeways during rush hours, similar results could be achieved. An average commuter using a 5-mile freeway segment twice each day (i.e., once in each direction) would save about half an hour each day, or 120 hours annually - equal to three weeks of work or leisure time!

The day-to-day variation in travel times is now understood as a separate component of the public's and business sector's frustration with congestion. An important benefit of pricing is that it guarantees toll-paying vehicles a reliable trip speed and travel time.

Benefits to Businesses

Growing congestion and unreliability threatens truck transportation productivity and ultimately the ability of sellers to deliver products to market. Additionally, when deliveries cannot be relied upon to arrive on time, businesses must keep extra "buffer stock" inventory on hand, which can be expensive. Pricing of the nation's major thoroughfares to guarantee free flow of traffic will ensure that reliability is restored to the transportation system, keeping business and transportation costs low. Lower costs will increase the competitiveness of U.S. businesses in international markets and boost the U.S. economy.

You may need the Adobe Acrobat Reader to view the PDFs on this page.

Exhibit F

Our communities. Our transportation. Our future.

A Report and Toolkit to Help Communities Advance a More Equitable and Affordable Transportation System

PRICING **ROADS,** ADVANCING **EQUITY**

PRICING **ROADS**, ADVANCING **EQUITY**

TransForm promotes walkable communities with excellent transportation choices to connect people of all incomes to opportunity, keep California affordable, and help solve our climate crisis. With diverse partners we engage communities in planning, run innovative programs, and win policy change at the local, regional, and state levels.

www.transformca.org

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Document design: Alan Hoffman

Contents

INTRODUCTION

Pricing Roads, Advancing Equity Report and Toolkit

Inequities have long been ingrained in our transportation system. Vulnerable communities—which include low-income households, people of color, and those disadvantaged due to ability, age, or other factors—have long borne the brunt of negative transportation impacts while paying a proportionally larger share of their income to get where they need to go.

Meanwhile, in response to worsening road congestion, inadequate funding for transportation, and the climate crisis, cities and regions across North America have begun implementing road pricing programs, primarily on highways. While equity issues are often analyzed when setting up these programs, the primary focus has been on minimizing negative and disproportionate impacts on vulnerable communities as opposed to maximizing benefits and redressing historic or systemic inequities.

A host of major US cities, including New York and several on the West Coast, are now considering "congestion pricing," as it is commonly called, in or around their downtowns. Many of them will undertake major studies in 2019 where equity will be considered a cornerstone of the program. These cities want a clear focus on social and racial equity, based on concerns that road pricing programs may burden low-income drivers with new costs, potentially deepening existing inequities.

These concerns are both valid and helpful. TransForm believes that if public agencies prioritize equity goals and deep community engagement to guide road pricing studies from the beginning, the ultimate programs can greatly benefit vulnerable communities. Road pricing and smart investment strategies can lead to more frequent and affordable public transit, safer pedestrian and bicycle routes, and improved health outcomes for vulnerable communities. Discounts and exemptions for low-income households can create progressive pricing structures. In short, pricing can deliver a wider range of mobility options that are fast, frequent, and affordable, improving access to economic, recreational, social, and other opportunities.

The goal of this report is to challenge policymakers and equity advocates to act on this key proposition: that structural inequity in our transportation system may be remedied in part by effective, equitable road pricing. The companion toolkit complements the report and is designed to help planners implement equitable road pricing strategies.

Chapter 1 of this report explains the need for road pricing and the forms it can take, as well as the equity concerns involved. It looks especially at HOT (High-Occupancy Toll) Lanes and Cordon or Area Pricing. HOT lanes are free for carpools, while any excess capacity may be used by solo drivers willing to pay a toll, which typically varies based on supply and demand. Cordon or Area Pricing, is where autos pay a charge to enter and/or circulate within a defined zone. This is often referred to as congestion pricing, but recent nomenclature includes "decongestion pricing" (Vancouver, Canada) and "Go Zones" (California). Cordon or Area Pricing has not yet been implemented anywhere in North America but is of growing interest as a means of decongesting city centers and similarly dense zones. London, Stockholm, and Singapore have used this kind of pricing to achieve positive transportation, public health, and even equity outcomes.

Chapter 2 looks at examples of cities in the U.S. and Canada that have studied road pricing, both as an alternative to road expansion and to manage downtown congestion, and further looks at how equity concerns were incorporated into these studies.

Chapter 3 examines a range of strategies to achieve equitable outcomes, focused on full participation in the planning process as a way to achieve greater affordability, access to opportunity, and community health. There is no shining example, yet, of road pricing done as a way to redress transportation inequities. Still, the report provides examples of strategies that are being implemented in cities in the US and around the world that can form the building blocks of an equitable road pricing program.

Chapter 4 introduces the companion toolkit, which outlines five key steps for implementing a pricing program. Each step includes questions to ask, sample performance measures, and references to additional resources. While the toolkit is primarily intended for policymakers and equity advocates that are actively considering a road pricing strategy, it includes many case studies and tools that are interesting and useful in their own right for a variety of audiences.

Road pricing is increasingly being looked at to help solve the interrelated problems of traffic congestion, climate change, transit sustainability, and economic vitality. The *Pricing Roads, Advancing Equity* report and toolkit offers a roadmap to ensure that vulnerable populations can derive real, tangible benefit from road pricing projects—no matter what the other goals of these projects may be.

CHAPTER 1

How Can Road Pricing Advance Equity?

Transportation has reinforced inequality

America's transportation investments and policies have helped to create—and reinforce—racial and social inequities. Since the 1950s, the emphasis on moving cars quickly, combined with sprawling land use patterns, has imposed real costs on *vulnerable communities*. Those within such communities—which include low-income households, people of color, immigrants, and those disadvantaged due to ability, age, or other factors—are less likely to own cars and are more reliant on walking and public transit. Yet the combination of unsafe walking and bicycling conditions and inadequate public transportation has limited access to opportunities for those who need it most.[1] A recent Harvard study found that such access (measured as commuting time) was the *single strongest factor* shaping whether people can escape poverty.[2]

Transportation investments have not only favored those with the resources to own, operate, or otherwise gain access to a motor vehicle; they have often funded roads that ripped right through vulnerable communities. Many of these investments have left multi-generational scars that include physical division of the community, safety issues due to high-speed traffic, and lower property values. Vulnerable communities have also borne the brunt of air quality impacts, with elevated rates of asthma and other illnesses triggered by air pollution.[3] Racial inequities, in particular, are deep, pervasive, and persistent in the United States, and the transportation sector is no exception.

Lower-income families also spend a much higher percentage of their income on transportation.[4] Transportation spending will likely continue to increase for these families, as low-income renters are increasingly priced out of walkable neighborhoods near public transit. This displacement itself can decrease access to opportunities and increase costs as families rely on private vehicles for more and longer trips.

The right transportation policies and investments, along with real and effective participation of vulnerable communities in decision-making, are critical to overcoming some of the most important barriers that limit too many people from finding and keeping a good job, getting an education, and being healthy.

Regions are searching for new transportation strategies

Planning agencies increasingly acknowledge transportation inequities. Cities and metropolitan regions, however, face a host of other transportation challenges that demand attention and investment, such as traffic congestion, flat or declining transit ridership, growing maintenance costs, and the need to reduce greenhouse gas emissions.

Traffic congestion often tops the list of public grievances and it is getting worse in almost every region.[5] New roads and wider highways don't solve the problem—they just invite more driving.[6] Even the massive Katy Freeway in Houston has seen congestion levels return to what they were before its expansion to 23 lanes, with afternoon commute times on the 29-mile stretch from Pin Oak to Downtown increasing 55% between 2011 and 2014.[7]

Many investments in public transit over the past few decades have also not fully realized their potential. Most bus and some light rail systems get caught in congestion, leading to higher operating costs. Most U.S. systems are losing ridership—and fare revenue—as passengers opt for faster options.[8] It is worth noting, though, that in places like Seattle that are working to get buses out of traffic, bus ridership is growing.

Building our way out of these transportation challenges is an increasingly dim prospect. Almost every city and region in North America is struggling with higher costs to operate and maintain aging road and transit infrastructure (and maintenance backlogs often play out inequitably, hitting vulnerable communities hardest). It is also increasingly expensive to add highway lanes and new rail lines, especially in areas that are already developed.

More recently, the threat of climate change is motivating action. Transportation is now the country's largest source of climate pollution and continues to be a top source of local air pollution, especially in urban areas and areas adjacent to freeways.[9] In transportation planning, climate considerations are rising on the policy agenda.

To overcome these challenges, planning agencies across North America are desperately searching for tools – and few are as powerful as road pricing.

What is road pricing?

The U.S. already has over 5,000 miles of tolled roadways.[10] While tolling has traditionally been applied to whole roads, bridges, and tunnels, two relatively new forms of pricing, aimed specifically at managing demand, are taking center stage in North America: *HOT lanes* and *cordon and/or area pricing*.

HOT lanes are quickly expanding across the country. These "High-Occupancy Toll" lanes, often called express lanes, are essentially carpool lanes that also allow solo drivers in for a fee, when there is unused capacity. The revenue from express lanes is often used to fund the highway expansion needed to create the lane, although sometimes existing carpool or HOV lanes or road shoulders are converted to create the HOT lane. These lanes can be more efficient overall than carpool lanes since there is a way to make use of unused capacity.

Cordons are a form of pricing that charge a fee every time a vehicle enters or exits a defined area or zone. ***Area pricing*** is similar, except that vehicles are charged for circulating *within* that zone as well. Cities such as Stockholm, Milan, and Singapore have cordon pricing to enter their downtowns, while London employs area pricing for driving within its central zone.

Types of Road Pricing	
Cordon pricing	Cordon pricing is typically applied to a Central Business District or other similar traffic-congested zone; motorists pay a charge to enter the zone, typically using an electronic transponder in the vehicle or license plate readers at entry points.
Area pricing	Similar to cordon pricing, except vehicles that travel *within* the designated zone also pay a fee.
Congestion point charging	Vehicles pay a charge or toll when crossing select key points.
Distance-based charging	Vehicles are charged based on distance traveled. Sometimes referred to as a VMT (vehicle miles travelled) fee.
Full-facility tolling	All users of the facility pay the toll. A "facility" may be a highway, a bridge, a tunnel, or any other roadway.
Managed lanes	Typically located within freeways, a lane or lanes for which access is restricted to HOVs or those paying a toll. Toll pricing on managed lanes may vary in response to changing congestion conditions, and HOVs may travel free or at discounted tolls.
HOT lanes	"High Occupancy/Toll" lanes are for use by carpools, with excess capacity available to single-occupancy cars that pay a toll. HOT lanes use electronic toll collection and traffic information systems to provide variable, real-time toll pricing. Drivers decide whether or not to use the HOT lanes or the general-purpose lanes based on price levels and travel conditions received via message signs.
Express lanes	Express lanes are toll lanes, available for any car paying a toll which varies with demand. Unlike HOT lanes, Express lanes charge all vehicles (including HOVs) for passage. In some cases, discounts may be given to HOVs. Enforcement is simpler and less costly than HOT lanes because there is no need to enforce vehicle occupancy. (Note that some places like the Bay Area now use the moniker "express lanes" for their HOT lanes, conflating these two definitions).
Flat rate tolls	These are toll rates that do not change, such as $5 to cross a toll bridge regardless of time of day or demand.
Dynamic or variable pricing	Rates vary with demand: when the tolled facility is lightly used, rates are low; as the lane begins to fill, rates rise to ensure that fewer cars enter the facility (usually to maintain free-flow speeds).

London exempts many vehicles from paying the congestion charge, including those belonging to and/or driven by people with disabilities, low-emission vehicles, and for-hire-vehicles such as taxis and ride-hailing services. Rapid growth of the latter, though, has contributed to new congestion and is forcing a reevaluation of the pricing strategy to keep it current and effective.[11]

Both New York and San Francisco have considered cordon pricing as a way to reduce congestion, but neither has yet moved forward, in part due to equity concerns.[12] Vancouver

(Canada), Seattle, Auckland (New Zealand), and Los Angeles are also starting to consider congestion pricing in or around their downtowns and other congested zones.

Pricing strategies are gaining traction

Road pricing can be a powerful tool for helping achieve transportation system goals; it can simultaneously reduce demand during peak times, make more efficient use of infrastructure, and create a new source of funding for more equitable transportation solutions. It can significantly improve the efficiency of a transportation system that is reeling from overuse and severe capacity constraints.[13]

Road pricing is based on a fundamental economic principle: ***when people have to pay the true cost for something, they use it more efficiently.*** The true costs of driving are not just reflected in construction and maintenance costs, or what people pay in taxes; they also include the *external* costs of congestion, pollution, collisions, etc. When road pricing reflects some or all of these costs, some people make changes to at least some of their trips. They may move some to off-peak times, choose different destinations, switch modes (whether occasionally or regularly) or consolidate their trip-making, reducing the pressure on roadways.[14] Those that pay enjoy a faster, more reliable trip. Even a relatively small reduction in the number of vehicles on a congested road can improve a road's throughput, significantly reducing delays for *everyone*.

Yet pricing can generate its own set of issues. ***If implemented without a clear focus on social and racial equity, it can deepen existing inequities in our transportation system and in society at large.*** It can burden low-income commuters with new costs, just when skyrocketing housing costs are forcing some to move out of transit-rich urban centers and rely on private vehicles for more and longer trips. If the revenue raised by road pricing is used primarily to build new roads, pricing could end up inviting yet more driving, increasing emissions and climate pollution, and limiting the potential to support alternatives.

It is important to evaluate the impact and efficacy of road pricing not in a vacuum, but in comparison to viable alternatives or the status quo. For example, sales taxes and parcel taxes—which we often use to fund transportation—are not only *regressive,* but also *inefficient,* since they make it seem like use of the roads is free, and thus induce excess driving.[15] Road pricing charges are paid only by users, rather than the entire public, so they don't impose an unfair burden on non-driver households (which are often low-income people of color).

Equity and sustainability concerns with road pricing

Some equity concerns are common to road pricing strategies. The most potent is that they might be regressive. Another is whether the mechanics of toll payment (such as requiring users to front sums of money or have bank accounts to link to their transponders) limit access for low-income people.

Perhaps the biggest affront for many people is that road pricing can appear to create a two-tier transportation system. For HOT lanes that means those who can afford it are able to drive quickly while those on limited budgets are relegated to sit in traffic congestion (hence the moniker "Lexus Lanes" that has stuck in some areas). While people of all incomes do use the lanes and surveys show that people of all incomes appreciate the choice of using the lanes when needed, it is also true that middle- and upper-income drivers use them more frequently.

For cordon or area pricing, there is often concern that people from vulnerable communities might be unable to afford to make trips they currently make, especially their regular commute. For some people this may lead to detours, shifting modes or their time of travel, or even changing their designation to avoid the new charges. It may also create new costs with regard to both time and increased gas and vehicle use.

London's program has received the most attention in the U.S. London has conducted regular analyses of equity impacts both before and after implementing area pricing. Concerns about the equity of the London program center on whether it is *progressive* overall (due to the focus on expanding and improving public transit links) or *regressive* (as low-income drivers who drive into the central zone pay the congestion charge).[16]

Cordon and area pricing have generally reduced driving by 15-20% and congestion by 30% or more.[17] Several of these programs started as pilots since they were not popular when first proposed. In Stockholm just a third of the public was in favor of the program before the pilot. After the pilot was implemented, support eventually rose to two-thirds as people came to understand the policy and enjoy the benefits.[18]

In some cases, HOT lanes have reduced average vehicle occupancy as some carpoolers opt to drive solo and pay the charge—especially when there is a conversion of HOV-2 (HOV lanes open to cars carrying at least 2 people per vehicle) to HOT-3 (lanes open to cars carrying at least 3 people or to those in other vehicles willing to pay the toll).[19]

These concerns are all valid. Yet it is also possible to design a system that overcomes them. It is possible to harness the efficiency of road pricing to move public transit more quickly, support new mobility choices, and decrease driving and pollution. With targeted discount and exemption programs, it is even possible that people from vulnerable communities who still need to drive can *benefit* from the decrease in congestion and increase in reliability.

CHAPTER 2

More Regions Are Considering Pricing

Most road pricing projects implemented in North America, to the extent they truly considered social equity, have focused on mitigating harm. Out of all the projects reviewed, Los Angeles' HOT lane implementation took equity issues most seriously and this report's companion toolkit features several of Los Angeles' strategies.

Discussed below are six efforts that suggest a new model for using the efficiency of pricing as a tool to advance social and economic equity. While the examples are all in coastal states, some of the good work being done in places like Dallas/Fort Worth (featured in the toolkit) points to the potential for a wide range of geographies and political environments.

One thing is certain, though: ***we will not effectively resolve inequities in our transportation system unless improving equity is a major project goal for road pricing proposals.*** Such concerns need to help drive and lead the agenda, not follow it. This report focuses on two major ways road pricing can advance an equity agenda: as an alternative to highway widening and as a tool for managing congestion in downtowns and similarly dense urban areas.

Pricing as an alternative to highway widening

Portland, Oregon, offers an interesting example of the potential for road pricing to serve as an alternative to highway expansion—and some of the obstacles. When the Oregon Department of Transportation (ODOT) proposed expanding capacity on the I-5, I-205 and 217 freeways, a broad range of groups, spearheaded by the Nature Conservancy with the Oregon Environmental Council (and including business groups, Metro, and the Port of Portland), recommended that ODOT look into congestion pricing as a way to manage demand. This recommendation was incorporated into the state's $5.3 billion transportation funding package which passed in April 2017.[20] In addition to various fees and taxes, it directs the Oregon Transportation Commission to develop a proposal for congestion pricing on I-5 and I-205.[21]

To advise the pilot pricing projects on the two freeways, ODOT formed a 24-member advisory committee including representatives of local governments, business, highway users, and equity, transit, and environmental advocates.[22] The group made a host of recommendations in 2018, aimed at expanding public transportation and other travel choices as well as asking for a more detailed set of equity mitigations for low-income commuters, to be studied in future phases.

In addition, a group of organizations came together as the No More Freeways Coalition to oppose the widenings with a particular focus on a 1.7-mile section in the Rose Quarter. The added capacity would run right past a historically black middle school and cost over $450 million. Groups from the Sierra Club's Oregon Chapter to NAACP Portland Branch signed on.

Many of the coalition members argued that "decongestion pricing" should be tried as a way to manage demand. The group continues to battle this widening.

There is growing support for pricing at the city and regional level. The Portland City Council passed a resolution calling for implementation of congestion pricing and TDM options "as soon as feasible and prior to opening of this (Rose Quarter) project."[23] In a clear indication of how complex transportation-decision making can be, in February 2019, the Metro Council (Portland's regional planning agency) informed ODOT of its plan to move forward with a complementary pricing study—one that would consider a broader range of pricing strategies including cordon pricing and full freeway tolling.[24] Although Metro does not have the legal authority to implement road pricing at this time, several of their planning documents seek to "expand use of pricing strategies to manage travel demand."

As the Oregon studies move forward, they are faced with a paradox: while many of the agencies see pricing as a way to reduce the need for future road widenings, the State's constitution requires that toll funds be spent on roadway projects (though there can be exceptions for rebates to fund transportation allowances).[25] For equity groups, there may be a strong benefit in working to amend the constitution, or at least in ensuring that pricing is part of a larger package of transportation measures that has overall equity benefits.

San Francisco Bay Area. TransForm has led a multi-year campaign in the Bay Area to fight the proposed widening of eight-lane Highway 101 between San Jose and San Francisco, and instead promoted the conversion of an existing general purpose lane in each direction to HOT-3.

TransForm made the case that the financial savings from converting rather than widening, in addition to HOT lane revenues, should be used to expand and improve transit options and to provide incentives for vanpooling and carpooling. TransForm also pushed for an equity strategy to expand successful programs like free transit passes for service workers. The regional transportation planning agency, MTC, performed a study in 2015 that confirmed the effectiveness of this approach: a convert and optimize strategy had strong mobility benefits, but without the negative impacts of widening. [26]

While the Environmental Impact Report (EIR) that began in 2015 included the conversion alternative, the lead agencies couldn't model all of the interrelated elements of TransForm's proposal, such as the transportation demand management and new mobility strategies, only including some new express bus service in the model. Another critical component of the alternative, San Francisco's study of lane conversion all the way to their downtown, was not far enough along in the planning process to include. As a result, the EIR's conversion alternative routed the express buses through highly congested lanes once they neared San Francisco, resulting in too little improvement in mobility and reducing the apparent viability of the alternative. The conversion alternative was thus rejected by planning staff (even though congestion would also increase significantly in the widening alternative that was adopted).[27]

While that particular proposal for conversion rather than widening on 13 miles was rejected, three elements of TransForm's framework for equitable pricing are moving forward:

- Both San Mateo and San Francisco counties will soon initiate equity analyses for the Highway 101 corridor.

- Two of the agencies are analyzing conversion of general purpose lanes along the corridor; SamTrans for the Dumbarton Bridge[28] and the SFCTA for the San Francisco portion of the corridor. MTC is also now analyzing the potential for lane conversion to create a complete regional express network. [29,30]

- Six transportation agencies have agreed to develop a 101 Mobility Action Plan to optimize the use of the lanes. Equity-driven solutions and the potential for social mobility are key parts of the project mission.

Congestion pricing for downtowns

Congestion pricing for downtowns is not yet practiced in North America, but as big cities get more congested and as climate concerns rise on their policy agendas, it is of growing interest. The authors' review of downtown pricing proposals suggests that these have greater potential to advance equity than HOT lanes—in part because the vast majority of low-income commuters into city centers are not driving their personal vehicles, but would gain mightily from expanded, faster, and more reliable transit. Four current efforts to implement congestion pricing are briefly described below.

New York City has seen several congestion pricing proposals since 2006. In 2014, former Traffic Commissioner Sam Schwartz—looking to overcome opposition to Mayor Bloomberg's pricing plan that drew the ire of the outer boroughs—proposed a "Move NY" plan that focused on both geographic and income equity. The chart on the next page is adapted from Move NY's infographic explaining the proposal; it highlights how the charge could produce real and significant benefits to low-income New Yorkers through support of transit and travel discounts. State-level legislation to implement Move NY was introduced in 2016 but did not pass.

In response to continued overcrowding and delays on subways and buses another plan was developed in 2018.[31] The Fix NYC Advisory Panel Report directly linked congestion pricing to new investments in transit, particularly for the outer boroughs and suburbs—recommending that such investments begin even before the implementation of a cordon charge.

The phased approach included a proposal, adopted by the state legislature, to charge $2.50 for taxis, $2.75 for Uber, Lyft or other for-hire vehicles, and 75 cents for app rides that are shared. This charge was first levied in February, 2019. The final phase of the plan included a new congestion charge for other vehicles entering downtown and was expected to raise between $810 million and $1.1 billion annually, much of which would be invested in the public transit system where it would provide benefits for many of the city's low-income residents.[32]

At the end of 2018, the bipartisan city/state Metropolitan Transportation Sustainability Advisory Group released a report recommending a congestion pricing zone in the Manhattan commercial district with all proceeds going to the MTA for transit capital and operations.[33] Governor Cuomo, in his 2019 state budget proposal, has called for congestion pricing to be finally adopted for New York City.[34] In February 2019, Mayor de Blasio also came out in support of congestion pricing, greatly increasing its odds of passage.

<table>
<tr><th colspan="4">Move NY's Solution to Get NY Moving Again[35]</th></tr>
<tr><td rowspan="2">THE PROBLEM</td><td colspan="3">For far too long transportation needs of New Yorkers have gone unanswered.</td></tr>
<tr><td>Our roads
are clogged with traffic and ridden with potholes.</td><td>Our transit
is outdated and buses are overcrowded, service is scarce in parts of the city.</td><td>Our tolls & fares
are skyrocketing with little return on our investment.</td></tr>
<tr><td rowspan="2">THE SOLUTION</td><td colspan="3">Create a sustainable, dedicated revenue stream for our transportation system.</td></tr>
<tr><td>Adopt
A fairer tolling system that reduces tolls where there's less traffic and fewer transit options and adds them where traffic is heaving and transit options are plentiful.</td><td>Empower
communities and their representatives to make local transit investment decisions.</td><td>Safeguard
the revenue through bond covenants to avoid robbing Peter to pay Paul.</td></tr>
<tr><td>INVESTMENTS</td><td>PayGo
Total: $1.465 billion per year</td><td colspan="2">Bonded
Total: $15 billion</td></tr>
<tr><td>CITYWIDE BENEFITS</td><td>Extend citywide commuter rail discounts for 7 days a week
Create new discounted monthly pass for combined commuter rail, subway, and bus rides
$2.8 billion per year in increased economic activity
Fair Fares (discounted metro cards for low-income New Yorkers)</td><td colspan="2">Faster travel inside & outside the Central Business District
New ferry service
30,000+ new, local jobs
Improved roads and bridges
Toll relief on 7 MTA bridges
$1 off all Express Bus fares</td></tr>
<tr><td>THE NUTS & BOLTS</td><td colspan="3">Reduce tolls up to 48%
Toll savings on Triboro, Throgs Neck, Gil Hodges, Henry Hudson, Cross-Bay, Whitestone & Verrazano
Equalize entrance into CBD (Central Business District)
Tolls on East River Bridges and across 60th Street same as Brooklyn Battery and Midtown Tunnels
Treat "For-Hire Vehicles" equally
Uniform surcharge within Manhattan taxi zone; CBD toll exemption
Protect small businesses
Tolls capped at one round-trip per day; 2-3 more daily deliveries or service calls possible per business due to less traffic
Adopt variable pricing
Drivers avoid higher tolls by opting to travel during off-peak hours</td></tr>
</table>

San Francisco completed a study of downtown cordon pricing in 2010, and with congestion rising quickly since then, the San Francisco County Transportation Authority (SFCTA) is again studying the strategy. The 2010 study found that a cordon around the city's northeast quadrant, encompassing the Central Business District (CBD) as well as several congested neighborhoods, would be the most practical. The study found that less than six percent of peak period travelers to the focus area were low-income drivers. SFCTA proposed a 50% discount for those commuters as well as for people with disabilities. The vast majority of low-income travelers would be accessing the area by other modes and would benefit significantly from expanded, faster, more reliable transit, as well as better walking and bicycling infrastructure.

SFCTA is also moving forward with another tolling strategy for Treasure Island, an ex-naval base in the middle of San Francisco Bay. Massive development is proposed for the island, even though the only way to *drive* on and off the island is via the heavily congested Bay Bridge. SFCTA plans to charge all vehicles coming onto Treasure Island beginning in 2021. Details of their equity strategy for the project are described in the next chapter.

Vancouver has been exploring regional congestion pricing through a careful and deliberate process, which has identified two potential road pricing alternatives for further consideration—distance-based charges and congestion point charges, the latter a form of cordon pricing.

Three overarching objectives are guiding their process: reducing traffic congestion, promoting fairness, and supporting transportation investment. Equity considerations are embedded in the principle of promoting fairness and have been a primary part of the planning process from the beginning. Impacts on vulnerable communities are among the core issues being addressed, including estimating the level of revenues that would need to be reinvested in low-income communities so that the pricing element of any plan would not be regressive.

Seattle is exploring the use of pricing to reduce congestion, address climate change goals, and generate new revenues. At the same time, the City of Seattle has embraced equity as central to transportation planning, having established a Transportation Equity Program in 2017. This program "provides safe, environmentally sustainable, accessible, and affordable transportation options that support communities of color, low-income communities, immigrant and refugee communities, people with disabilities, people experiencing homelessness or housing insecurity, LGTBQ people, women and girls, youth, and seniors..."[36]

Funded through the Seattle Transportation Benefits District, the Transportation Equity Program allocates up to $2 million annually to support equity programs, including:

- Subsidized and youth transit passes;
- Partial rebate on vehicle licensing fees;
- Discounted car-share memberships and driving minutes; and
- Ongoing community consultation.

Funding from a road pricing project could be used to help maintain or expand these programs, as well as enhance transit services.

CHAPTER 3

Achieving Equitable Outcomes

Defining equity outcomes

To understand how road pricing strategies can drive an equity agenda, the desired outcomes need to be clearly understood. There are dozens of papers describing different types of equity outcomes in relation to congestion pricing.[37] These include overall ideas of fairness, such as by geography, not just those related to vulnerable communities. ***This report focuses on two dimensions of equity: Process Equity and Outcome Equity.***

For **Process Equity***,* the key measure is the full participation of vulnerable communities in planning, implementation, and project follow-up. Process Equity is central to the long-term task of making transportation systems more equitable for all people while addressing *historical inequities* that continue to affect vulnerable communities. For **Outcome Equity***,* TransForm identifies three key measures: affordability, access to opportunities, and community health. Step #2 of the Toolkit has more detailed explanations of each measure as well as sample indicators for each.

Type of Equity:	*Key Measures:*
Process Equity	Full Participation
Outcome Equity	Affordability
	Access to Opportunity
	Community Health

This chapter lists sample strategies for each of these four measures. Many of these examples are taken from existing pricing programs, while others could easily be introduced as part of a pricing program.

The solutions for each city and region will vary. Some of the most relevant strategies may have been identified previously in local or regional plans, or in recommendations made by community groups for other projects. In such cases, road pricing may become the means to fund promising strategies that otherwise might not get implemented.

Step 4 of the toolkit suggests specific performance indicators that can measure progress towards each of these four outcomes.

Full participation

There are countless resources available for supporting strong public participation from vulnerable communities. The chart below indicates the kinds of participation efforts that are more or less likely to empower communities.

Increasing Degree of Participation[38] →					
Level	**Minimal**	⟷			**Optimal**
Public Participation Goal	Vulnerable Communities are provided information on the project.	Vulnerable Communities provide feedback to the goals.	Solicitation of public concerns and aspirations is ongoing	Agencies closely partner with community groups throughout the project.	Vulnerable communities have a seat at the decision-making table.
Sample Outreach Strategies	• Fact sheets • Websites • Open houses	• Public meetings • Public comment • Focus groups • Surveys	• Workshops • Deliberative polling	• Advisory committees comprised of residents • Consensus building • Participatory decision-making	• Citizen juries • Ballots • Delegated decisions • Formal representation on decision-making groups

The expectations for the level of engagement are somewhat different for different pricing proposals. HOT lanes seem to get the least scrutiny and carry the lowest expectations. This may be because drivers can opt to use the free lanes some or all of the time, and because carpooling, vanpooling, and transit are not charged for entering the lanes.

For cordon or area pricing proposals—like those described above for San Francisco, NYC and Seattle—the bar is typically very high. In part this is because all drivers (unless there are exemptions) would have to pay for something that had been "free." In addition, elected leaders and residents in these cities are increasingly prioritizing social equity, especially as inequality widens. Finally, cordon pricing is still a new and untested concept in the U.S., so there are no domestic examples of its benefits for transit and pollution or direct examples of mitigation measures for its costs.

For cities and agencies engaged in pricing studies, an important consideration is the degree to which they've already developed an effective approach to operationalizing equity in community participation processes. These measures include:

- Having equity experts on staff;

- Developing or adopting general racial and social equity tools;
- Training staff in equity issues and processes; and
- Contracting with members of vulnerable communities as consultants in community participation work.

A major concern with achieving full participation is ensuring that representatives from vulnerable communities are present *from the beginning* on project advisory boards, sharing local knowledge and concerns. Their input is vital at the earliest stages of project visioning to help determine equity needs and community desires and concerns, as well as to identify metrics to help determine project success.

Vancouver: Community engagement around outcomes and indicators. In exploring the use of road pricing in the metro Vancouver region, the Mobility Pricing Independent Commission engaged in extensive community consultation, making a notable effort to reach out to vulnerable communities (see graphic below). Their engagement identified a number of issues related to equity concerns with road pricing, including the need for improved infrastructure for transit and safe bicycling and walking; finding equitable ways to mitigate impacts on seniors, lower income, and/or differently abled people; providing discounted transit fares; and general affordability concerns.[39]

Vancouver's Mobility Pricing Study Public Participation Results[40]

- Conducted **2** rounds of public opinion polling in September 2017 and March 2018 with **2,000** residents across the region
- Launched **2** multilingual public education campaigns on the Commission's work and mobility pricing in the region in **16** local distribution and **11** non-English newspapers and reaching **898,099** residents on Facebook and **65,752** website page-views
- Conducted online public engagement and in-person workshops to inform the principles, hearing from **6,078** residents and **176** stakeholders and government officials in Phase 1 and hearing from **11,474** residents and **130** stakeholders in Phase 2
- Increased accessibility by translating the online platforms into Traditional Chinese, Simplified Chinese, and Punjabi (the region's largest non-dominant languages), receiving **310** completed paper surveys from over **16** regional community offices, and conducting outreach with social service organizations
- Convened a citizen-based User Advisory Panel of **15** members representative of Metro Vancouver (selected through an external recruitment firm) to advise and provide input at key stages of the project

New York City DOT: Street Ambassadors Program. The New York City Department of Transportation created its Street Ambassadors Program to help improve process equity in its planning efforts by stimulating broader public participation in the planning process. Street

Ambassadors are recruited through external temporary employment programs that support the "diversity pipeline" in order to bring in a range of language skills and cultural backgrounds.[41]

The program was designed to be:

- *Equitable*, by intentionally hearing from as many affected people as possible, actively seeking out underrepresented groups, and speaking with them in multiple languages;
- *Flexible*, by meeting people where they were, including at rush hour, in the evenings, and on weekends; and
- *Respectful*, by honoring people's time and not making people go out of their way to participate.

As a measure of the success of the program, in 2016 the program supported 82 street improvement projects with over 32,000 conversations with the public.[42]

TransForm's companion toolkit has a section on full participation that includes indicators to show whether the program is achieving strong participation.

Affordability

At the heart of the affordability question is: Will the proposed pricing project make transportation *more expensive* for some members of vulnerable communities, and by how much*?* **It is just as important, however, to ask if there are ways transportation can be made *more affordable* through such projects.**

How can road pricing make transportation more affordable, when it seemingly adds a new expense? There are several ways.

- Unlike sales taxes, fuel taxes, and many other *regressive* sources of revenue, pricing programs can offer means-based affordability options that reduce costs for low-income drivers. Sample strategies for this are described below under "Subsidies, discounts, caps, and exemptions for drivers."

- Pricing programs can also provide lower cost options or subsidies and discounts for people who are already using alternatives (for example, by distributing free or discounted transit passes). Sample strategies for this are described below under "Affordability for transit riders and other mobility options" and "Bike share discounts."

- Finally, an improved set of alternative choices—funded by pricing revenues or simply by speeding up public transit—may allow people to save money on gas, car maintenance, and parking, and even reduce the need for vehicle ownership for some.

One way to understand impacts on affordability is to look at *overall* household expenditures on transportation. What percent of a household's income goes to all transportation expenses? The Oakland-based Greenlining Institute, in its *Mobility Equity Framework*, recommends a general target that households in vulnerable communities devote no more than 20% of their income to transportation.[43] This figure will necessarily vary by region/city, but is a good starting point.

Subsidies, discounts, caps, and exemptions for drivers

The most direct way to mitigate the cost of a pricing program on low-income drivers is to consider a range of subsidies, discounts, credits, caps (the maximum amount that someone might need to pay, usually over a certain period of time), and toll exemptions. While these may benefit those drivers, such discounts, caps, and exemptions need to be carefully weighed against other program goals such as moving traffic more efficiently or reducing greenhouse gas emissions. It is essential to define, up-front, the process for identifying and harmonizing these potential conflicts, including programs to transparently monitor, evaluate, and adjust program elements to ensure that all goals are met.

Some planners have proposed comprehensive transportation subsidies, applicable not only for driving fees or tolls, but for transit and other sustainable options as well. Sometimes referred to as a "mobility wallet," these subsidies could address equity without creating an incentive to drive. While the concept may face implementation hurdles it is worth pursuing as a way to achieve both equity and efficiency outcomes.

Usually, a single threshold is set to qualify for discounts, but it doesn't need to be that way. A Seattle focus group in 2014 suggested tolling should be different for drivers under 30% AMI (Annual Median Income) and those earning 30-60% AMI, to maximize benefits.[44] The following are two examples of existing programs and two that are proposed.

Los Angeles: Transponder Credits. L.A. Metro provides a one-time $25 transponder credit and waives the monthly maintenance fee for L.A. county residents who fall below an income threshold (about twice the Federal Poverty Level).[45] Their transit rewards program, the first of its kind, gives transit riders a $5 credit to use the express lanes for every 16 transit trips during peak hours using the I-10 El Monte Busway or I-110 Harbor Transitway.[46]

London: Exemptions. London offers various discounts and exemptions to disabled drivers. Notably, the London congestion charge includes a 'Blue Badge Program' for drivers with disabilities, which offers a 100 percent discount to them and those driving them. Participants may register up to two vehicles in the program.[47] Refunds are also available for certain people traveling to hospital appointments.[48]

In order to make the congestion charge more politically acceptable, the transportation authority offered many different exemptions. For instance, residents within the charging zone received a 90 percent discount, and there were exemptions for alternative fuel vehicles.[49] The number of exemptions has muted the traffic and emissions reduction benefits, especially as ride hailing services grow. As a result, London has been reviewing and restructuring some of these benefits.

New York City: Caps on Tolls. The Move NY cordon pricing program proposed a cap on tolls for small businesses, essentially permitting multiple crossings of the cordon line in any given day after the first toll is paid. With the expected reduction in traffic delays, it is estimated that the average business could add an additional two to three deliveries or service calls per day.[50]

San Francisco: Treasure Island Transportation Affordability Program. Beginning in 2021, SFCTA will implement a program that has many characteristics of a cordon price. The Treasure Island Mobility Management Program merges the concepts of cordon pricing and road tolling by charging all vehicles that drive onto Treasure Island, a former naval station that is being redeveloped.[51] The program, to be funded in part by the tolls, will provide new residents of Below-Market Rate (BMR) units a discount on a variety of modes through a multimodal Transportation Affordability Program (TAP), which includes transit and car-sharing. Combined with new or improved transit services and lower transit costs, the program is expected to benefit many more residents than a toll credit of any kind. Longtime households and existing BMR residents would also receive one non-tolled daily round-trip (or an equivalent TAP benefit) until July 2026.[52] The program is expected to both reduce costs and improve mobility for low-income residents of the island, while also reducing congestion, air pollution, and time spent driving.

Affordability for transit riders and other mobility options

New York City "Fair Fares." Means-based fare reductions were proposed as part of the Move NY program in 2015. Implementation started in January 2019, even though the full pricing program has yet to be approved. The program offers half-priced MetroCard transit passes for city residents whose incomes are below the Federal Poverty Line, potentially covering up to 800,000 New Yorkers.[53]

Seattle ORCA fares*.* After passing a Transportation Equity Resolution, Seattle adopted a number of programs to increase transportation access and equity. Seattle built on the already-established King County ORCA Lift program, which offered half-price transit fares for those who qualify based on income, with the ORCA Opportunity program, providing free, unlimited transit for high school students, income-qualified middle school students at Seattle Public Schools, and Seattle Promise Scholars.[54] Finally, Seattle is starting a low-income car-share program to provide income-eligible residents with discounted car share memberships and driving minutes.[55] While currently funded through other sources, many of these equity programs could be funded through a congestion pricing plan. Places like Seattle that already have such programs in place can more readily expand or deepen them with funds from congestion pricing.

Bike share discounts

As bike share increases in reach and popularity, discounted and improved bike share programs can be an important benefit to vulnerable communities that may be funded, at least in part, through congestion pricing revenues. Bikeshare isn't just an alternative mode on its own; it can be an important element of a transit program, offering people a convenient "first mile/last mile" solution for accessing transit from beyond a comfortable walking distance, extending the reach of a station significantly.

Chicago's bike share program, Divvy, provides a $5 annual membership that allows for cash payment for Chicago residents below 300% of the Federal Poverty Line. The cost goes up every year, reaching a $75 annual membership in year four. Members can add money to their account using cash at participating 7-Eleven, CVS, and Family Dollar stores.[56]

In the Bay Area, a similar Bike Share for All discount, combined with a regionally coordinated equity outreach program, helped increase the number of low-income members from 3% to 20% in the span of a year.[57]

The City of Portland, Oregon, offers highly discounted rates on its bike share program. Low-income residents who qualify can purchase a monthly pass under the Biketown-for-All program for just $3/month (with the first month free), compared to the standard fee of $19/month. Low-income residents can further earn credits to reduce their out-of-pocket costs to zero.[58]

Vancouver, British Columbia, has recently launched its "Vancity Community Pass" bike share program for low-income residents, offering a year of bicycle access for just $20. Qualification piggybacks off other low-income passes, including those offered through the transit agency and community centers, as well as third party referrals from partner organizations, and no credit card is required.[59]

Access to opportunity

Transportation affordability is a central issue, but just as critical of an issue is *access*—can people get to the many and diverse places they need or want to go?

Transportation systems should connect people to *opportunities*, including employment sites, retail centers, medical services, recreational destinations, schools and libraries, social services, friends and family, gathering spots, places of worship, and entertainment sites. When access is limited, people may find fewer jobs within reach, their retail options may be more limited and expensive, and they might incur greater expense, both in time and money, to access important destinations.

A transportation system looking to improve equitable outcomes must provide greater access to opportunities for low-income households and members of historically marginalized groups. Equity advocates should be thinking in terms of an overall strategy to address transportation equity in which road pricing plays a role. This can range from the direct benefits of pricing, such as faster bus service, to a better mix of transportation choices funded by the potential revenue from road pricing.

Bus users, for example, are some of the biggest winners from congestion pricing in London and Stockholm. Both cities increased the number of buses in advance of implementing cordon or area charges, increasing accessibility. In central London, bus wait times fell by 30% and delays due to traffic congestion fell by 60%.[60] In New York City, a recent study suggests that congestion charging would provide significant time savings to riders of express buses.[61]

Los Angeles uses revenues from its Metro ExpressLanes to fund a range of improvements, including express transit routes, commuter routes, and walking and bicycling projects, all targeted within three miles of the two existing ExpressLanes.[62] The transit routes improve access for residents of the corridor to reach major employment centers. Los Angeles is also considering the use of revenues from the ExpressLanes to help convert lanes on additional freeways to express operations.

Twin Cities. Minnesota state legislation requires that one-half of "remaining" money generated through tolled express lanes be dedicated to the expansion and improvement of bus transit services in the related corridors.[63]

Pierce County Transit and Lyft. Ride-hailing services like Lyft and Uber have increasingly started to work with transit agencies to help improve access to and from transit, often referred to as "first- and last-mile solutions." These services could help provide connections to residents of suburban and rural areas who would otherwise have the hardest time accessing public transportation.

Washington's Pierce College Puyallup, for example, partnered with Pierce County Transit and Lyft to bridge first-last miles gaps to both bus and light rail stations. In addition, the project will also provide students at Pierce College Puyallup a grant-funded Lyft ride home from some locations near campus in the evening after transit services have ended. This program demonstrates that there is no one-sized fits all solution, and that creativity is needed to serve a wider range of people that would otherwise be largely car-dependent.[64]

Lyft also recently started working directly through community groups to give qualifying members free-rides.[65] This could help in areas not well served by public transit.

Making sure tolled facilities are accessible

Road pricing programs often assume that people will have the ability to use the priced roads or the transit options, discounts etc. Electronic tolling and transit cards make it efficient to use those facilities, but only if one has the resources to participate. Such systems often depend on:

- *Transponders* that automate the toll collection process;
- *Credit cards* that may be tied to transponders or accounts;
- *Languages* required to understand instructions;
- *Bank accounts* that may be tied to transponders or accounts; and
- *Smartphones* that run the apps used for some services (such as shared rides).

Since many low-income households may not have bank accounts or credit cards, be able to afford the initial deposit on a transponder, or be sufficiently fluent in English, they might not be able to take advantage of either the newly tolled facility or many of the alternatives. It is critical to overcome these barriers (the Los Angeles program described in this report is an example).

All of the examples in this chapter raise the question as to *where and how* the decisions about road pricing programs are made. The answer varies by locale; a good guide to the types of decisions and requirements that apply to different governmental agencies and stakeholders may be found in the National Cooperative Highway Research Program's *Assessing the Environmental Justice Effects of Toll Implementation or Rate Changes: Guidebook and Toolbox*.[66]

Community health

Transportation systems too often impose negative health impacts on vulnerable communities. Major roads and freeways are often built in or adjacent to such communities, subjecting them to higher levels of air pollution and the various serious health problems that accompany it. Projects that end up increasing road traffic in vulnerable communities also increase safety hazards for pedestrians and bicyclists. Chronic disinvestment in these communities often means that likely destinations are not within safe walking distance, limiting physical activity and increasing emissions, contributing further to negative health outcomes.

Healthy communities are a clear and major equity goal. Road pricing should reduce overall driving and result in improved air quality when effectively implemented. A clear-cut example of improvements in air quality comes from Sweden, where a Johns Hopkins study found that improvements in air quality in the central zone due to reduced traffic led to a 50% decrease in asthma attacks among young children.[67]

Funding can go to clean air buses as well as improved conditions for walking and bicycling. Even though community health benefits are likely, it is important to analyze the potential (and actual) diversion of traffic so that vulnerable communities do not see an increase in traffic.

Los Angeles: Clean Air Buses. Purchased in part with $1.4 million from the Metro ExpressLanes program, Foothill Transit recently acquired two double-decker electric buses. The buses can hold up to 80 passengers and provide a quieter, less bumpy ride than traditional articulated buses, while reducing GHG emissions by 80-90% compared to diesel buses.[68] L.A. has also invested revenues in bicycle and pedestrian infrastructure along the corridor.

King County, Washington: Prioritizing clean air buses for vulnerable communities. In March 2017, King County Metro released a feasibility plan to achieve a zero-emission fleet. The goals included climate and racial and social equity objectives. The report adopted a methodology for identifying the areas with the greatest vulnerabilities based on air quality, health, and social conditions (such as demographics, linguistic isolation, and rates of high school completion). The analysis revealed where zero-emission bus routes would have the greatest positive impact on equity. The results were meant to both inform near-term decisions and provide an analytic framework that could be used in the future. Since most pricing programs will direct revenues to expanding and potentially cleaning the bus fleet, this methodology provides a strong example of how to maximize equity and health benefits.[69]

CHAPTER 4

Putting It All Together

Equitable pricing can support equitable transportation

This report has outlined many possibilities to work with impacted and vulnerable communities to design systems that make transportation more fast, affordable, and healthy than it is today. So why do road pricing strategies, especially congestion pricing in downtowns, often fail based on concerns about social equity? There are at least three reasons.

First, is the lack of an exemplar for road pricing. That is why our implementation strategies do not highlight just one region, and why the report pulls ideas from places that are implementing pricing as well as some which are considering doing so.

Second, there are usually many layers of decision-making and approvals that are needed to implement pricing strategies, making defeat possible at the local, regional, and state level.

The third is suggested by Professor Michael Manville of UCLA's Department of Urban Planning: that we have a strong human tendency to strictly scrutinize the potential implication of changes.[70] Changes are noticeable and they require an act of commission. The status quo of free roads, with all of their inefficiencies, congestion, and pollution that disproportionately harms vulnerable communities, persist with little or no scrutiny—that's the privilege of the status quo. The failure to act (omission) carries less weight than acts of commission. As a result, people strictly scrutinize harms that arise from changing the status quo, and downplay or overlook harms that arise from the status quo itself.

To counter that, Professor Manville posits a future where all freeways are priced:

> Maybe the best way to think about congestion pricing's fairness is to imagine a world where the roads are already priced—a world where we allocate road space like we already allocate water or electricity or other infrastructure. In this world, drivers would pay for the valuable public land they used; congestion would be far lower and so would pollution; transit would run faster; and governments would use some of the toll revenue to mitigate congestion pricing's burden on low-income drivers.
>
> Now imagine a proposal to make all roads free. Free roads would let the poor and rich drive free, but the rich drive much more than the poor. Congestion would rise, buses would slow, and pollution would increase. The pollution would fall most heavily on the poor, but without tolls, there would be no revenue to redistribute and compensate the people it fell on. Making the roads free would undermine efficiency (the transportation

system would work less well) and equity (free roads would harm the disadvantaged and reward the more advantaged).

In the real world, this unequal proposal is not a proposal at all. It's the status quo, and its normalcy prevents us from thinking about its fairness. It is appropriate to worry that priced roads might harm the poor while helping the rich. But we should also worry that free roads do the same, and think about which form of unfairness we are best able to mitigate. People who worry about harms to the poor when roads are priced, and not when roads are free, may be worried more about the prices than the poor.[71]

We don't live in that future where equitable road pricing is widespread. But it is not far-fetched. In both London and Stockholm, pricing was not popular when first proposed. Once people experienced the benefits, including transit riders who got expanded service and faster rides, pricing became an accepted—even popular—component of the transportation system.

While road pricing is not a panacea, it can be an important piece of the transportation equity puzzle. If we listen to community voices, engage community expertise, and work collaboratively to develop more affordable, accessible, and healthy transportation options, road pricing can contribute to a more just, sustainable world where everyone has the opportunity to thrive.

Pricing and investment strategies: equity impacts

We can sum up the general impacts on equity of a variety of pricing and investment strategies. The following two charts should be useful as a means of understanding the relative impacts of different alternatives.

PRICING STRATEGY EQUITY MATRIX		
PRICING STRATEGY	***EQUITY IMPACTS***	
24 hour **Flat-rate pricing**		Likely to be most regressive strategy, charging low-income drivers who often don't commute at peak commute hours. Least efficient at reducing congestion. Used on many tolled facilities.
Dynamic pricing varies with time or congestion		Efficient charging system but may be regressive (though likely less regressive than gas and sales taxes).
Dynamic pricing with some means-based discounts or rebates		Less regressive due to discounts.
Means-based pricing with targeted caps and/or exemptions		System designed specifically not to be regressive. Some loss of efficiency as plentiful discounts, caps and exemptions may limit the congestion and climate benefits.

REVENUE INVESTMENT EQUITY MATRIX	
INVESTMENT STRATEGY	*EQUITY IMPACTS*
Road expansion	Does not add more affordable options.
Mix of road expansion and transit	Some drivers can shift to new, more affordable modes. Transit users also benefit.
Transit, walking, and bike infrastructure with targeted carpool, vanpool, and new mobility options where needed	Allows greater shift to more affordable and sustainable modes.
Transit, walking, and bike infrastructure with an **intensive focus on vulnerable communities**	Significant expansion of commute options and a reduction in user costs (if fares are reduced on transit and other mobility options).

Five steps to equitable outcomes: TransForm's companion toolkit

While this report is the "why," the toolkit that accompanies this report is the "how." It lays out a roadmap of five primary steps to help ensure that road pricing studies improve the equitability of the transportation system.

1. Identify Who, What, and Where
2. Choose Equity Outcome and Performance Indicators
3. Determine Benefits and Burdens
4. Devise Programs to Advance Transportation Equity
5. Provide Accountable Feedback and Evaluation

With several cities and regions considering progressive programs, this is an important time for policymakers and equity advocates engage in road pricing studies to see if we can use road pricing as tool to advance racial and social equity. The toolkit lays out a process for fulfilling this vision.

Notes

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TransForm

Our communities. Our transportation. Our future.

A Companion to the *Pricing Roads, Advancing Equity* Report

TOOLKIT

PRICING **ROADS,** ADVANCING **EQUITY**

EQUITY TOOLKIT

Contents

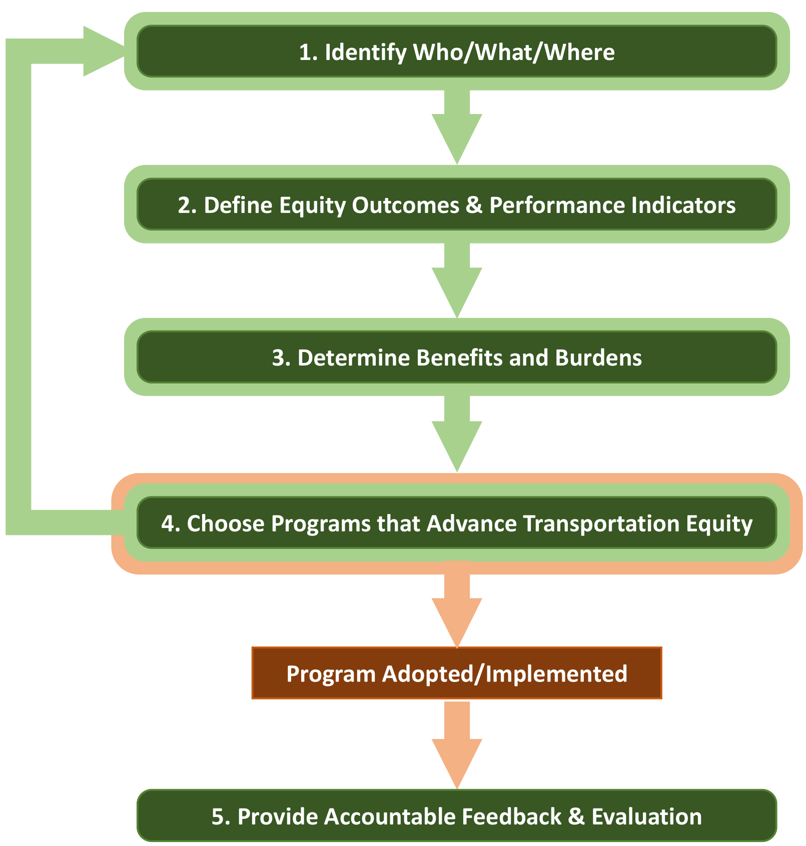
EQUITY TOOLKIT

Introduction

Five Steps Toward Equitable Outcomes

TransForm's report, *Pricing Roads, Advancing Equity,* suggests that road pricing strategies have the potential to produce notable benefits for vulnerable communities by addressing historic inequities (such as slow, infrequent, and unreliable bus transit). For these benefits to happen it is important to develop a clear sense of what a more equitable system might look like and then understand how a road pricing project can help get our communities closer to that system.

This toolkit is designed to help both equity advocates and decision-makers better understand how to effectively engage at key steps in the planning process. The toolkit is built on five *iterative* steps that form a conceptual framework, as shown in the graphic below.



As a pricing and investment strategy advances, it will be necessary to revisit earlier steps. For example, once a comprehensive strategy emerges from Step #4, it will be necessary to test it against the three earlier steps with an eye to further *refining* and *optimizing* the program along key indicators. In some cases, especially with cordon or area pricing proposals, as many as 5-10 iterations may be required to arrive at a solution worth implementing.[1] For HOT lanes and similar projects, fewer iterations are typical.

Strong participation and deep engagement from the most vulnerable communities is critical throughout the process, from inception through implementation and beyond. That's why this toolkit does not have a stand-alone step for "public participation." Indeed, the focus of the toolkit is to support equity advocates and decision-makers in achieving full participation at each step. Equity advocates can help planners reach vulnerable communities by helping develop the Public Involvement Plan component of the study, which is discussed in greater detail in this toolkit's companion report. Equity advocates should ensure that representatives of vulnerable communities are incorporated at every phase of a road pricing project.

An excellent guidebook and toolbox for planners that are leading road pricing studies is the National Cooperative Highway Research Program's (NCHRP), *Assessing the Environmental Justice Effects of Toll Implementation or Rate Changes.* With an intended audience of practitioners such as agency staff and consultants, the document is long and can be quite technical. Yet it has many excellent examples of where a particular tool, analysis, or strategy has been used to help advance equity.[2]

NCHRP's Tool #4, "Preparing, Implementing, and Assessing a Public Involvement Plan," for example, has a useful table with strategies that can address challenges to participation. While many of these strategies may be obvious to community members, they may not be as obvious to planners and other public officials. It can very useful to delineate these strategies in chart form to help create a common template for advocates and project planners to walk through ideas for the Public Involvement Plan.

Since we encourage equity advocates who dive deep into planning to reference the NCHRP guide, it is important to know how TransForm's five steps line up with the steps they propose. The following chart shows TransForm's five steps and how they correspond with steps in the NCHRP guidebook.

TransForm's Five Steps		NCHRP Planning Steps
1. Identify Who, What, and Where	➔	1. Frame the Project 2. Identify the Applicable Requirements Governing Decisions 3. Recognize the Relevant Decision-Makers and Stakeholders

2. Define Equity Outcome and Performance Indicators	➔	4. Scope Approach to Measure and Address Impacts
3. Determine Benefits and Burdens	➔	5. Conduct Impact Analysis and Measurement
4. Choose Programs that Advance Transportation Equity	➔	6. Identify and Assess Mitigation Strategies
5. Provide Accountable Feedback and Evaluation	➔	7. Document Results for Decision-Makers and the Public 8. Conduct Post-Implementation Monitoring

For road pricing projects, the agencies leading the studies should consult both TransForm's Toolkit and NCHRP's. The "additional resources" box at the end of each of TransForm's five steps can help with that deeper dive.

Format of the Toolkit

For each of the five steps outlined above, the toolkit has five components:

- Purpose
- Discussion
- Case studies or example (where appropriate)
- Questions to ask
- Additional resources

In addition, a worksheet template for recording your answers to the questions may be downloaded from www.transformca.org/pricing-equity-worksheet.

To make it easier to flip through to a specific component, the toolkit has color-coded text boxes, as follows.

CASE STUDIES	Case studies are displayed on a light blue background.
QUESTIONS TO ASK	Questions to consider asking are listed on a light pink background.
ADDITIONAL RESOURCES	Additional resources are described on a light green background.

EQUITY TOOLKIT

Step #1

Identify Who, What, and Where

Purpose

The early stages of a pricing equity study are where several key decisions are made, namely:

***Who*?**	The *populations* that need to be considered from an equity perspective.
***What*?**	The type and nature of *pricing* to be considered, along with any viable alternatives.
***Where*?**	The *geographic reach* of the study area, including key destinations accessed by vulnerable populations.

In planning terms, this stage is where the study's *scope* is developed.

Discussion

Who: Populations to be Studied

Any equity study is required to look at the impacts of major transportation projects on vulnerable populations—low-income communities and minorities. Under U.S. federal guidelines, *minority* populations include Black, Hispanic or Latino of any race, Asian American, American Indian and Alaskan Native, Native Hawaiian, and Other Pacific Islanders. It also includes individuals with limited English proficiency of any race. Low-income populations are any whose household incomes are at or below Federal poverty guidelines, though advocates may seek higher poverty thresholds for purposes of a pricing study since Federal thresholds are so low.

From an equity perspective, it is often important to consider other vulnerable populations such as seniors, persons with disabilities, immigrants and refugees, local small businesses, and even services like non-profit meal delivery services.

Federal policies also outline the fundamental principles of Environmental Justice:[3]

- To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.
- To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.
- To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations.

A key first step is to identify the data sources that can give you the demographic characteristics of the populations in the study area, and to parse this demographic data at different geographic scales. To start with, check if the regional planning agencies, county, or city may already have produced maps and datasets identifying communities of concern and travel patterns. Another first stop will be census data.

These sources all have limitations. They may be supplemented with a survey of key transportation destinations, such as schools, hospitals, and senior centers. In addition, it is critical to tap into local knowledge through interviews with community leaders, focus groups with residents, and possibly surveys to understand community concerns and travel patterns.

One of the key issues is what minimum population size merits an analysis of impacts. It is often typical, for example, for agencies to focus on census block groups (all urbanized regions in the U.S. are divided into these units) in which at least 50% of residents are low-income or minority. In areas that have a large percentage of minority residents, the 50% threshold may not be as useful, so agencies can use a "meaningfully greater" threshold to identify areas that have greater concentrations relative to the surrounding communities or region. In some cases, it might be useful to create an index that assigns points based on several criteria in order to select the zones that score highest on the combined criteria, such as was done in Dallas/Forth Worth.[4]

The population frame of reference can have a notable impact on the predicted outcomes. For example, the standard practice for estimating *regressivity* in road pricing projects looks at the toll's potential impact only on households with workers who would drive on those tolled facilities. One study made this estimation for the Puget Sound region of Washington State and found the toll to be quite regressive. If the study looked at all commuters (e.g. transit riders), not just those who paid the toll, it was less regressive. When the analysis was extended to the whole population, whether or not they commuted, regressivity fell even further.[5]

None of these levels of analysis is right or wrong by itself. Rather, it depends on the question you are trying to answer. If you want to study discount or exemption programs—how much they would cost and how they might be structured—then you need to focus on likely users of the tolled facility or zone. If you are trying to understand whether pricing would be less regressive than other funding mechanisms like sales or property taxes that are distributed across the whole population, then this broader analysis of the toll's cost is the correct reference.

Any community can have environmental justice concerns, even if they don't meet a given threshold. The NCHRP provides guidance that environmental justice determinations are made based on effects, not population size.[6] Page 95 of that guide also has an excellent table outlining the various methods to get data about populations.

QUESTIONS TO ASK:	
1.1	Are all populations adequately addressed in the study? *Should priority be given to certain populations? Why?*
1.2	Does the way groups are defined capture all relevant people?
1.3	Are the criteria used to identify groups fair and accurate? *For example, does the measure of household income adequately capture the target population? In some metro areas households earning up to twice the Federal poverty level may still be economically disadvantaged and in need of more equitable policies.*

CASE STUDY
Los Angeles[7]

In framing the objectives of its study of the impact of freeway HOT lanes on low-income populations, Metro (the L.A. transportation agency) chose as its primary focus "group equity"—ensuring that low-income commuters as a group are not being disadvantaged by the toll lanes by mitigating any excessive burdens. Additionally, Metro noted its concern for "market equity"—ensuring that shares of benefit are in proportion to the charges paid *because the financial burden of tolls should not exceed the value of travel time savings.*

Metro first described how "low-income" was defined. Then, using four distinct methods to understand the potential range of outcomes, they estimated the likely demand for the ExpressLane corridors by low-income commuters.

The authorizing legislation (SB 1422) explicitly mandated that eligibility requirements for "low-income" toll credits be set at a level no lower than five other referenced state and local programs serving the needs of low-income populations. In response to this requirement, Metro compared existing eligibility thresholds set by these programs and benchmarked other Los Angeles County programs, planned or in use, such as the Metro Rider Relief Program for low-income transit users.

Following this review, Metro set a threshold of $35,000 (in 2009 dollars) based on an annual income for a household of three persons, which was double the federal poverty level.

What: The Proposal and Viable Alternatives

Like with many transportation studies, road pricing studies may begin with a specific “favored” proposal, such as building a toll lane or converting an HOV lane to HOT. The projected *impacts* of this proposal are then compared with the projected impacts of one or more alternatives, as well as a scenario in which no action is taken.

Some highway widening studies may put road expansion into each of the alternatives (except the “no action” scenario). Like with the Portland and Bay Area examples in Chapter 2 of this toolkit’s companion report, a road pricing alternative can be used as a way to question the assumption that widening is required, and whether a “no widening” alternative can better meet *both* transportation and equity goals.

In other cases, a large number of mechanisms could be considered from the beginning. This is especially true when congestion pricing is being considered for downtowns and the areas surrounding them. The following table, derived from one created for Seattle’s current congestion pricing study, is a useful summation of a number of pricing tools that may be considered.

Pricing Tools Summary

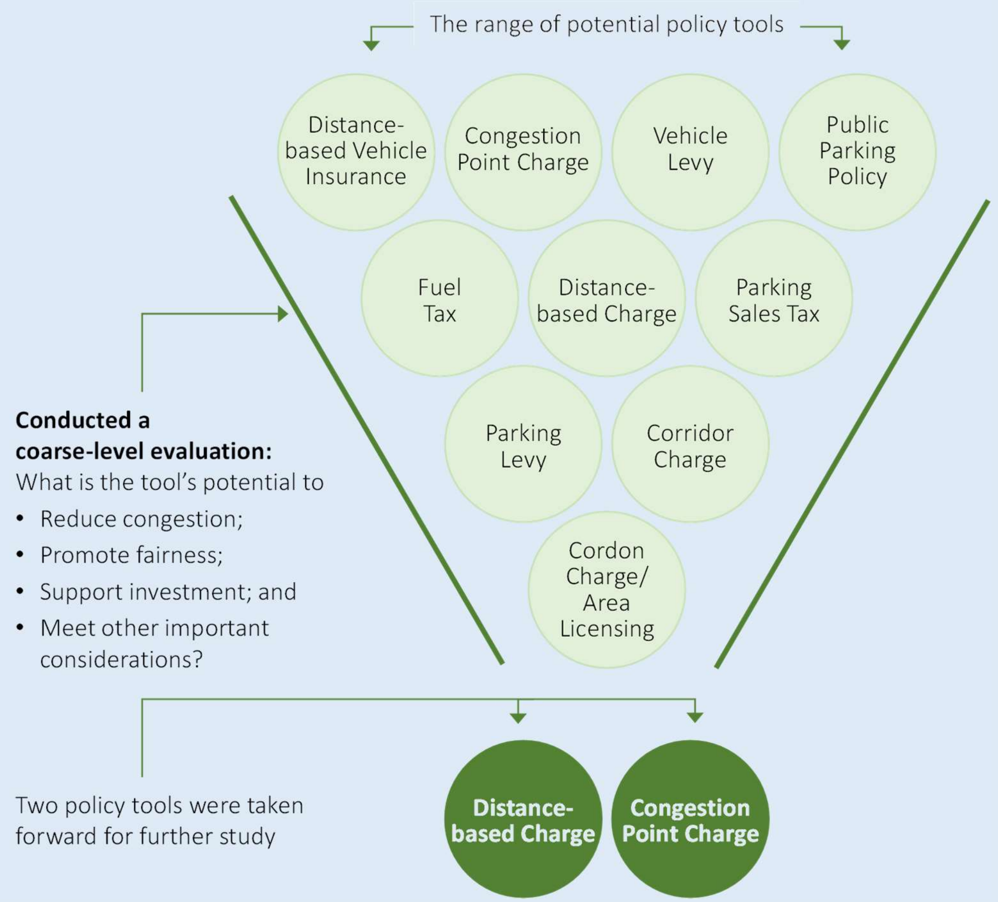
PRICING TOOL:	DESCRIPTION:
Cordon Pricing	Charge vehicles crossing the boundary into a cordon pricing zone.
Area Pricing	Charge vehicles crossing the boundary into *as well as driving within* an area pricing zone.
Fleet Pricing	Apply targeted pricing to specific vehicle types entering a zone, such as ride-hailing fleets or commercial vehicles.
Road User Charge (RUC)	Restrict access to a zone to vehicles enrolled in an RUC program that replaces fuel taxes with payment per mile traveled.
Arterial Toll Roads	Price entire arterial road(s).
Arterial Express Lanes	Convert or add lanes on arterial roads as tolled lanes, such as by converting bus-only lanes or an existing general-purpose lane.
On-Street Parking Pricing	Vary street parking prices to control demand.
Off-Street Parking Pricing	Apply a fee/tax to off-street parking facilities.
Vehicle Occupancy (HOT)	“High Occupancy Toll” lanes give free or discounted access to vehicles carrying a specified number of people (2 or 3 is typical), while charging a toll to all others.

During the first step, or at least after going through the first three steps, it is possible that the types of pricing to be studied are narrowed down to a manageable number by conducting an initial screening of the impacts and benefits of the options. The most promising options will then be subject to a more detailed analysis.

This is illustrated by the process Vancouver, British Columbia, is employing, as described in the case study below.

CASE STUDY
Vancouver[8]

Vancouver has mounting congestion, continued population growth, and two bridges that are tolled while others are not, leading to concerns about the fairness of the system. While some type of bridge tolling or congestion charging seemed a likely outcome, Vancouver created an Independent Pricing Commission that studied a broad range of alternatives. They first adopted a set of transportation goals that included promoting fairness in transportation costs and impacts. They then evaluated which alternatives, if any, could best achieve their goals. After detailed analysis and community input, they settled on the two potential alternatives that seemed to be the best fit: distance-based charges and congestion point charges (similar in principle to cordon charges).



QUESTIONS TO ASK:	
1.4	Are there any additional pricing strategies which should definitely be considered? *Put another way, does the list of project alternatives include all the options that best serve vulnerable communities? Have representatives of vulnerable communities provided input on measures, strategies, and goals?*
1.5	Do the scope and budget of the planning study allow for a number of iterations so as to maximize the equity outcomes of identified actions?
1.6	Have we identified community priorities from existing studies that may be relevant?

Where: The Geographic Reach of the Study

Road pricing can affect people who might live or work at some distance from the roadway or from downtown pricing zones. It is important at an early stage to set the project boundaries so that vulnerable populations which may be impacted are included within the study area or project scope.

For example, a city considering cordon pricing or a region considering conversion of an HOV lane to HOT will need to have a sense of which drivers will be affected, where they're coming from and going to. While it's not possible for a study to include *every* commuter or traveler that uses the road—some might be passing through from distant cities, for example—it is desirable to include as many as possible. These initial geographies are also important because they help determine who should be the focus of the public engagement plan.

Decisions about the geographic reach of a study should follow a "macro-level" analysis of the potential effects on access to opportunities for vulnerable populations. It should describe the location and function of the project relative to the existing transportation network, the location of vulnerable populations, and the destinations (work, healthcare, religious, educational, retail, and public services) served by the facilities or areas being studied for pricing. The geographic reach may shift or expand once the first rounds of analytical results come in; some openness in redefining boundaries might be useful.

In practice, many studies adopt multiple geographic "levels" of analysis. For example:

- For commute impacts and predicting costs by population, a very large *travelshed* or "extended impact area" may be studied;
- A "direct impact area" is most likely to experience the potential direct impacts (such as noise, emissions, and traffic) from project construction or operation, and would typically be within a short distance of the proposed toll facility or priced zone and likely alternative routes;

- For cordon pricing proposals, the impacts on other issues need to be identified (such as, but not limited to, parking just inside and outside the boundary).

QUESTIONS TO ASK:	
1.7	Are all potentially impacted and vulnerable populations within the project study boundaries?
1.8	Do we know the critical services (such as shopping, medical care, education, and recreation) that are regularly used by the relevant populations? Are these included within the study boundaries? *Examples of such services include shopping, medical care, education, religious, and recreation.*
1.9	What are the growth projections for the city or region and should the planning process be using current population for the study, or projections for a future year?

ADDITIONAL RESOURCES

NCHRP's *Assessing the Environmental Justice Effects of Toll Implementation or Rate Changes: Guidebook and Toolbox* has a good introduction (pp. 9-18) to the eight kinds of road tolling or pricing actions that are typically considered, the kinds of impacts these are most likely to generate, and the initial identification of environmental justice issues. The checklists on pp. 366-372 are also useful summations of the important points to be considered in framing an impact study. It does not deal directly, though, with cordon or area pricing.

In addition, Tool #1, "Developing a Socioeconomic Profile and Community Characteristics Inventory for Environmental Justice Assessments," explains how the census can be used, including the kind of metrics available and the data tables that report those variables.

Two other equity toolkits are also worthwhile for the insights they provide. The Race & Social Justice Initiative's *Racial Equity Toolkit* was developed to help implement the vision of the Seattle Race and Social Justice Initiative.[9] Likewise, the Greenlining Institute's *Mobility Equity Framework: How to Make Transportation Work for People* is a guide to creating a more community-centered transportation planning process.[10]

EQUITY TOOLKIT

Step #2

Define Equity Outcome and Performance Indicators

Purpose

Another important part of project planning is defining the primary goals, referred to here as *outcomes*. It is important to then match these outcomes with *indicators*—the measures that we will use to gauge success or failure, and how the program can be evaluated and improved. These more detailed performance indicators help us answer the core question: does this project advance equity?

There are dozens of papers describing different types of equity in relation to congestion pricing.[11] These include overall ideas of fairness, such as by geography, not just those related to vulnerable communities. TransForm recommends a focus on two types: *Process Equity* and *Outcome Equity*.

For *Process Equity,* the key measure is the full participation of vulnerable communities in planning, implementation, and project follow-up. Process Equity is central to the long-term task of making transportation systems more equitable for all peoples, and of addressing *historical inequities* that continue to affect vulnerable communities.

As discussed in *Pricing Roads, Advancing Equity*, TransForm's Outcome Equity framework focuses on three key measures, as shown in the following table.

Type of Equity:	***Key Measures:***
Process Equity	Full Participation
Outcome Equity	Affordability
	Access to Opportunity
	Community Health

Road pricing projects typically pursue goals such as congestion relief, revenue generation, and—for cordon pricing especially—impacts on greenhouse gas emissions and air quality. Social and racial equity concerns have never been at the top of the list in any of the U.S. projects implemented so far, though Seattle's recently-initiated process does prioritize such concerns.

It is important to be clear on outcomes as well as their relative priority, since some equity strategies (such as giving toll exemptions to different groups) may seemingly work against other project goals (such as reducing climate emissions and local air pollution).

This is where it is crucial to have equity advocates at the table and to build strong participation. Proposed outcomes should highlight key social equity objectives. These can then be matched with *performance indicators*—the measures that will be used to gauge success or failure, and how the program can be evaluated and improved (Step 5). These outcomes and indicators should not just be in the mix, they need to be clear and *prioritized*.

It is usually necessary to do *comparative analysis* in order to determine the real impacts of proposed changes in the transportation system. At its simplest, two kinds of comparative analysis are useful. The first compares impacts from the road pricing proposal with what may be expected if road pricing is *not* adopted. The second compares the impacts on vulnerable populations with the impacts on the general population. These projections are often made for when the project is first implemented and for one or more time points in the future (such as in 10 years and/or 25 years).

The following chart depicts these comparative analyses, with arrows showing where the comparisons take place:[12]

	Vulnerable Communities:		General Population:
No Toll Plan:	Impacts	⇔	Impacts
	⇳		⇳
With Toll Plan:	Impacts	⇔	Impacts

These aggregate or "big picture" analyses can help people understand what it would take to achieve certain goals. For example, Vancouver calculated how much low-income, medium-income and high-income households might spend on different kinds of congestion pricing. People in high-income households generally drive more, so were projected to pay more as an absolute dollar figure, but low-income households would pay a larger percentage of their income. Vancouver calculated that, in order to ensure everyone paid the same proportion of their income as the high-income households would, around 20 percent of the net revenues (between CD $170-345 million annually) would need to be returned to low-income households through rebates, discounts, or other measures. This kind of analysis can be used to compare how equitable—or inequitable—different kinds of road charges are.

These comparative analyses can be useful in highlighting unfair advantages or burdens at the group or "population" level. But, ultimately, it is also important to understand the real impacts—both benefits and burdens—on *individuals* in certain communities. How much will it cost for an individual who has no option but to drive during peak hours? Are reasonable alternatives like transit readily available and useful? What are the alternative routes, or times of day, that low-income travelers might use to avoid the extra costs and how burdensome would the lost time or change in schedule be? Even if the number of such individuals is not large, the tolls may be a real burden for them.

CASE STUDY
Los Angeles[13]

For its I-10 and I-110 ExpressLane pricing study, Metro identified several potential performance measures for considering effects on low-income users, including:

1. Number of low-income commuters [including percentage of Transit Access Program (TAP) users] who sign up for a transponder.
2. Number of peak-period low-income users of HOT lanes (and percentage of overall HOT lane users).
3. Usage of HOT lane credits for low-income drivers (credit redemptions).
4. Mode choice of low-income drivers (carpool versus single-occupant vehicle), compared with mode choice before the project is implemented.
5. Performance of transit service (average speed, trip time, time savings, and trip reliability) in the ExpressLanes corridors during the demonstration period.
6. General purpose lane speeds during the demonstration period.
7. Account balance problems of low-income commuters compared with non-low-income.
8. Share of time savings by low-income ExpressLanes drivers compared with the share of tolls and transponder costs they pay.
9. Trends in trip distance and trip time by low-income commuters compared with non-low-income.
10. Toll revenue investment.

Discussion

In this section we provide a short discussion of each TransForm's four equity outcomes. This is followed by a chart with some sample indicators for each outcome. Note that most of these indicators—such as changes in transit ridership or the percent of toll revenue spent to benefit vulnerable communities—can be predicted ahead of time using models and formulas; they can also serve as indicators to monitor, evaluate, and improve the program.

Full Participation

Process equity is focused on *participation* in the planning and decision-making process. In a road pricing program, process equity will continue to remain important during program implementation and evaluation.

Since low-income groups and communities of color have historically been disenfranchised from full participation, the issue is how to ensure that the views and concerns of these communities, *as community members understand and articulate them*, are fully solicited, valued, and reflected throughout the process, *especially by those making the final decisions on the project*.

A goal of full participation is to increase the level of positive impact and benefits for vulnerable communities.

Full Participation	
CATEGORY	*SAMPLE INDICATORS*
Activities	• Number of meetings and focus groups with vulnerable communities. • Dollar amount and/or percentage of project budget dedicated to equity outreach programs.
Communications	• Share of principal languages spoken in the community into which materials are translated. • Number of ethnic media outlets that receive information and publish articles about the proposal, or are targeted for advertising community meetings.
Organizations	• Staff time dedicated to technical support and funding for Community-Based Organizations (CBOs) to conduct/participate in needs assessment.
Participants	• Number of individual voices that have contributed to the community needs assessment.
Responsiveness	• Number of community-identified priorities that are being implemented as part of the program.

There are several best practices for full participation not noted in these indicators, such as having language translation at meetings, offering child care, and holding some meetings in the evenings and on weekends. This toolkit's companion report has a useful chart in Chapter 3 to show the degrees of participation.

QUESTIONS TO ASK:	
2.1	Where is the planning process on the "Degree of Participation" scale (found in Chapter 3 of this toolkit's companion report)? *Does it need more resources or political support to increase the degree of community empowerment?*
2.2	Are the efforts planned to reach vulnerable populations likely to reach people where they are, or do they expect people to come to planning events?
2.3	Are the comments and priorities of vulnerable communities being actively catalogued? *Are there plans to address these priorities in a clear and transparent way?*
2.4	Have equity outcomes been prioritized in the list of project goals?

Affordability

At the heart of the affordability question is: Will the proposed pricing project make transportation *more expensive* for some members of vulnerable communities, in both time and money? If so, by how much? Are there ways that transportation can become *more affordable* to some or most, for example through additional public transit discounts? Chapter 3 of this toolkit's companion report includes a section on affordability, with some examples of places that are working to directly address affordability as part of their pricing program.

It is especially important to capture the financial impact of *cordon pricing* and fully tolled roadways on vulnerable communities, since there may be no realistic alternative for some low-income travelers but to use those facilities. While it is useful to understand the financial impacts of HOT lanes, most of those highways also have general purpose lanes that are free to use. In surveys of HOT facilities, satisfaction is often similar between lower- and upper-income commuters, as there is widespread appreciation of the choice to avoid congestion for solo drivers, even if lower-income commuters use them less frequently.

The table on the following page illustrates sample indicators for assessing impacts on affordability.

Affordability	
CATEGORY	***SAMPLE INDICATORS***
Discounts	• Discount level on tolls for low-income and other populations. • Discounts on transit fares or other alternatives (subsidized by tolls).
Regressiveness	• Degree to which tolls are regressive, and how much revenue redistribution is needed to make them progressive (or neutral, as was calculated by Vancouver). • Household budget spent on transportation, by income level (total amount and percentage of income). • Change in share of household income spent on transportation and housing, by income category. • Change in generalized cost of transportation (time and money) for those switching mode/route/time of travel.
Participants	• Number of people from vulnerable communities participating in (or eligible to participate in) discounted tolls or transit fares. • Ratio of those who are eligible for equity pricing programs (both for car drivers and for non-driving strategies like discounted transit) to those that have actually signed up.
Subsidies	• Amount of toll revenue invested in transportation subsidies for vulnerable communities (and as a share of total net revenue).
Savings	• Total expected savings from toll and other subsidy programs for vulnerable communities.
Alternatives	• Cost of using transit or other modes instead of driving.

QUESTIONS TO ASK:

2.5 How will congestion pricing change the travel costs of low-income drivers and non-drivers?

2.6 How do we ensure that members of vulnerable communities have ways to overcome financial barriers to participation, including for the unbanked and for those who may have trouble putting up deposits for transponders or other required technologies?

2.7 Do we have enough data on travel patterns and the potential changes in travel behavior to understand the potential financial impact of the tolls?

Would it be useful to complement that data with focus groups or surveys?

CASE STUDY Greenlining Institute	In its 2018 *Mobility Equity Framework*,[14] the Greenlining Institute suggests, as a default, households spend no more than 20% of their budgets on transportation.

Access to Opportunity

The purpose of the transportation system is to link people to all kinds of opportunities: jobs, education, health care, and social, recreational, and commercial activities. So the question of how a proposed pricing (or infrastructure) proposal may change *access* to these places is critical. A well-designed pricing strategy should be able to increase access, especially for those who rely on public transit and for drivers who find it worth the expense to use the priced facility or zone.

There are two big areas of concern with regard to access. The first is for drivers from vulnerable communities who may decide to detour, shift modes or travel time, or even choose a different destination to avoid paying a toll or cordon charge. Pricing creates both a time cost (which essentially reduced access), and potentially increased costs for gas and vehicle use. A related issue, discussed in Step #1, is how trip diversion might impact affected roads and communities.

The second concern is whether the mechanics of toll payment restrict opportunity by creating barriers to use (for example, requiring users to front sums of money, such as for transponders or prepaid tolls, or to have credit card or bank accounts to link to their toll accounts).

Access to Opportunity	
CATEGORY	***SAMPLE INDICATORS***
Funding	• Absolute dollar amount invested in transit and mobility options that benefit vulnerable communities including: ➢ New transit routes ➢ Increased frequency ➢ Subsidies for vanpools, new mobility options, etc. • Percent of funds from tolls dedicated to supporting expanded mobility options that benefit vulnerable communities.
Service Quality	• Changes in transit speed, reliability, and quality that directly impact vulnerable communities. • Changes in travel speeds and/or reliability for cars, HOVs, and those paying tolls.
Service Levels	• Number of new transit miles, routes, or transit vehicle levels/frequencies that benefit vulnerable communities.

Transit Use	• Increase in target population's transit ridership attributed to transit investments. • Increase in the number of riders that use discounted fares each year.
Ratios	• Number of people from vulnerable communities paying the toll compared to those that change routes to avoid the toll (this information will require extensive surveys). • Amount of investment in vulnerable communities vs. other communities.
Access	• Change in the number of jobs, services, etc., that people from vulnerable communities can access within a 30, 45, or 60 minute window, by mode.

***CASE STUDY Dallas / Fort Worth*[15]**

The North Central Texas Council of Governments (NCTCOG), the Metropolitan Planning Organization for the Dallas–Fort Worth Metroplex, developed an Environmental Justice Index that rated "Traffic Survey Zones" (TSZs) based on population density, minority population, and low-income population, for use in its Regional Tolling Analysis.

TSZs were ultimately divided into Protected zones—those with significant environmental justice concerns—and Unprotected. Analysis then focused on the impacts to these two zones using measures of accessibility and mobility as follows:

Accessibility:

- Number of jobs accessible within 30 minutes by auto
- Number of jobs accessible within 60 minutes by transit
- Population within 30 minutes to special generators (e.g., universities, regional shopping centers, hospitals)

Mobility:

- Average level of congestion
- Average travel time

QUESTIONS TO ASK:	
2.8	Are key community destinations being analyzed and are any missing?
2.9	What alternative transportation choices (roads, transit, etc.) will be available to those who cannot afford the toll? For those who are likely to drive alternative routes, what is the time penalty? For those shifting to transit or other modes, what time penalties may be involved?
2.10	Are potential benefits being fully considered, such as the potential increase in bus speed, both when the project is implemented and at some future point?

Community Health

Vulnerable communities have historically borne a greater share of the negative health impacts of transportation systems. Freeways were often built through vulnerable communities, imposing higher levels of asthma and other health impacts of air pollution. Unsafe streets mean vulnerable communities also have higher death and injury rates from walking and bicycling.

Pricing strategies can be a way to minimize some of these impacts, by reducing the amount of overall driving taking place, by reducing the need to expand roads and freeways, and by creating revenue streams that can support transit improvements, bicycle and pedestrian infrastructure, and/or clean vehicles (serving the needs of workers as well as families, seniors, children, and those with special needs).

Another important issue to consider is access to health care. Transportation is frequently the top barrier preventing vulnerable residents from accessing medical facilities, especially for chronic and preventive care. This issue can be assessed in several ways including by noting the location of health facilities and whether they are inside or outside of a congestion pricing zone, and determining whether discounts and exemptions are feasible for trips to those destinations. There are also potential benefits of pricing strategies, such as improvements in speed and reliability for emergency vehicles and whether some revenues can be reinvested in shuttles or other modes that connect vulnerable communities to health facilities.

Community Health	
CATEGORY	***SAMPLE INDICATORS***
Infrastructure	• Miles of effective/safe bike lanes and sidewalks added or improved.
Funding	• Absolute dollar amount of funds spent on bike and pedestrian improvements in vulnerable communities. • Percent of toll revenues spent on bike and pedestrian improvements in vulnerable communities. • Absolute dollar amount and percent of toll revenues spent on clean air buses serving vulnerable communities.
Safety	• Change in collisions, death, and injury rates on facilities that receive investment.
Trips	• Change in the number of bicycle and pedestrian trips.
Air Quality	• Number/percentage of new clean air buses, funded as part of the toll investment strategy, in vulnerable communities. • Change in particulate matter or other criteria pollutants in identified impact areas.
Health	• Anticipated health benefits, disease reduction, and improvements in life expectancy (can be predicted using ITHIM or another model).

QUESTIONS TO ASK:	
2.11	Do the main health indicators include the ones that were prioritized by vulnerable communities?
2.12	Is data on health impacts detailed enough to ascertain impacts on residents within a short distance of the tolled facility and/or other impacted roadways?
2.13	What changes in air pollution are expected? *Where do these occur? Who do they affect?*
2.14	What impacts on bicycle and pedestrian safety are projected?
2.15	Will changes resulting from road pricing reduce traffic and bring more community cohesion? *May it further isolate some communities or populations?*

ADDITIONAL RESOURCES

NCHRP's *Assessing the Environmental Justice Effects of Toll Implementation or Rate Changes: Guidebook and Toolbox* has several lists that are useful for additional perspective:

- A checklist for understanding the role of quantitative and qualitative performance indicators (pp. 358-359).
- Table 3 (pp. 135-138), "Practical approaches for reaching low-income, minority, and other traditionally underserved populations," presents an agency-level perspective on reaching members of vulnerable populations.

The Greenlining Institute's *Mobility Equity Framework* identifies 12 indicators recommended for equity studies (pp. 11-13).[16]

EQUITY TOOLKIT

Step #3

Determine Benefits and Burdens

Purpose

Once a set of *performance indicators* is adopted, planners will conduct studies to determine the impacts of the proposed alternatives. There is no single approach to determining such impacts; several are discussed later. The analyses that will go into determining benefits and burdens should be tailored to:

- the *scale* of impacts,
- community *interest* in those impacts, and
- the *potential* of those impacts to help or hurt vulnerable populations.

Discussion

From an equity perspective, there are two fundamental ways to think about impacts. The first is whether the indicators are *relative* or *absolute*. The second is the *level of analysis*, whether at the individual, group/population, or geographic scale.

Relative impacts compare vulnerable populations with non-vulnerable ones. For example, one project alternative might result in non-vulnerable populations paying an additional 2% of household income on transportation, but vulnerable populations 5% more. In this case, vulnerable populations would pay a larger share of their household income *relative* to non-vulnerable populations.

Absolute impacts focus on the actual change experienced by individuals and groups; they're used to help maximize the potential benefit of a project on vulnerable communities. At an individual scale, this may involve looking at a set of typical trips taken during the course of the day by different individuals and then predicting the impact on them of pricing strategies and investment alternatives.

At this individual scale it is easier to understand the costs that some low-income commuters may face. These realistic scenarios can help us better understand the impacts of different types of mitigations (such as discounts, caps, and/or exemptions). These illustrative examples and case studies are a vital complement to the indicators that aggregate population data.

Impact analyses may include technical modeling. Technical models simulate future scenarios by predicting how people will choose among different options. For example, a transit ridership model might predict that a faster bus route will attract about 15% more riders; the model would also estimate where these riders come from and the impact of fewer cars on the road.

Technical models are often complex and they typically rely on incomplete or generalized information. Models can be extremely useful, though, for depicting likely reactions to changes in the transportation system and producing numbers that decision-makers (and the broader community of stakeholders) can more easily understand and work with. Just the same, equity advocates will need to work with planners to know the limits of the models, their strengths and weaknesses, and to ensure that models properly serve the needs of vulnerable communities.

Cordon pricing and area pricing proposals carry their own set of modeling challenges; the lack of U.S. examples makes it that much harder to *confidently* predict the response of people to such programs, since consumer demand must be inferred from other examples. Still, quality modeling can help us understand what changes might occur in travel patterns and choices.

One issue with pricing studies is that decision-makers and the public often focus on *costs* divorced from potential *benefits*; models can help raise a deeper awareness of those benefits. In New York City, the Move NY plan used an integrated spreadsheet model to assess traffic improvements, revenue generation, and other benefits expected from reforming road tolls and transit fare policies. It created a way to test different scenarios and measure their impacts, to understand the costs *and* benefits of saved time for transit riders and drivers, as well as to predict environmental benefits and improvements in active transportation.[17]

The following list of questions addresses the range of impacts equity advocates should be looking at. Some of these questions reflect issues already raised in this toolkit and its companion report, but are also useful to consider at this stage.

QUESTIONS TO ASK	
3.1	***Affordability*.** How will the pricing change affect the travel costs of the low-income user? Will low-income drivers be "priced out" of certain trips? Will the requirements to use newly tolled facilities be too burdensome? *Also, will low-income individuals have ready access to transponders and means of paying tolls that don't require credit card or bank accounts, or the fronting of significant amounts of cash?*
3.2	***Choices*.** What reasonable alternative transportation choices (roads, transit, etc.) will be available to those who cannot afford the toll?
3.3	***Travel Time*.** If pricing produces travel-time savings, are they experienced by all users? *Will the non-toll alternatives be equitable in terms of travel time or distance? Will low-income commuters change their travel times or modes as a result of road pricing?*

3.4	***Transit.*** What impact will the project have on transit (e.g., changes to bus routes, travel time, frequencies)?	
3.5	***Local Roads.*** Will the project divert a substantial amount of traffic through a vulnerable community? *If so, what impacts on air quality, noise, and safety (bicycle and pedestrian) might be expected? Will there be shifts in demand for parking that impact these communities?*	
3.6	***Social Impacts.*** Will broad changes resulting from road pricing reduce traffic and bring more community cohesion? *May it further isolate some communities or particular populations?*	
3.7	***Access to Opportunities.*** How will the project impact the access that people from vulnerable communities have to likely destinations? *Likely destinations include jobs, schools, hospitals, social services, places of worship, shopping, as well as to cultural and recreational resources.*	
3.8	***Businesses.*** How will the project impact business access for both customers and deliveries? *Are any small and local businesses at risk, and if so, are there measures that can protect them?*	
3.9	***Noise.*** Will there be noise impacts attributable to road pricing?	
3.10	***Rents.*** Are there foreseeable changes in housing or commercial rents and/or land values attributable to changes in access to opportunities?	
3.11	***Environmental.*** What impacts will pricing have on air quality, and where are these impacts likely to be felt? *In addition to impacts on air quality, will the toll facility improve or worsen water quality and drainage conditions for particular populations? Will it increase the number of vehicles carrying hazardous materials through or near vulnerable communities?*	
3.12	***Locations.*** What physical infrastructure (such as tolling barriers) will need to be built, and how much of it will be located in vulnerable communities? *Will eminent domain be required? Whose homes are likely to bear the burden?*	

ADDITIONAL RESOURCES

NCHRP's *Assessing the Environmental Justice Effects of Toll Implementation or Rate Changes: Guidebook and Toolbox* has several useful resources for this step. Tool #7, "Using Travel Demand Models for Environmental Justice Assessments," as well as Tool #8, "Applying a Select Link Analysis to Assess Trip Patterns," provide excellent background on the potential uses and limitations of these two modeling techniques.

EQUITY TOOLKIT

Step #4

Choose Strategies to Advance Transportation Equity

Purpose

The purpose of this step is to identify which set of policies and investments can best maximize equity across all groups, redress historic inequities, and minimize the harm to vulnerable populations.

Discussion

Chapter 3 of this toolkit's companion report identifies a range of strategies that can advance equity. Some of the most relevant strategies—whether for affordability, access or health—may have been identified previously and even implemented (in part) in local or regional plans or in recommendations made by community groups.

A growing number of public agencies may have already adopted a stated equity strategy; if they do, that is a great place to start. Examples include San Francisco Muni's equity strategy and the priority list for Seattle's Transportation Equity Program.[18]

While there are many different actions that can be taken to help improve the equity of the transportation system, their relative impact will vary based on a wide range of conditions and circumstances. It is for this reason that it is never enough to merely *specify* an equity program, but to develop a range of options, analyze them for their potential impacts, and make adjustments so as to minimize negative impacts (and costs) and maximize positive results. This process is necessarily iterative; the number of iterations depends on the scale of expected impacts, the resources available to deal with them, and how widespread those impacts are.

It is only after a set of iterations that the final pricing proposal and associated equity strategy may advance to the decision-making bodies for formal approval—a process that may require equity advocates to conduct further outreach to both vulnerable communities and to decision-makers.

What kinds of strategies or actions may be implemented as part of an equity program? The table below provides a quick outline of some sample strategies; others can be found in this toolkit's companion report, while still others might be identified by the communities themselves.

STRATEGY	*EXAMPLES*	*ISSUES*
Affordability and Driver Assistance	**Driver Discounts, Caps & Exemptions,** such as: • Free or discounted transponders • Toll discounts or credits for low-income households • Exemptions for people with disabilities • No tolls during off-peak hours	If there are too many of these, then other components of the program, like increasing bus and carpool speeds or climate benefits, may be heavily impacted.
	Cash Payments (for those without credit cards or bank accounts)	Must be convenient to access and minimize up-front deposits.
	Transit Discounts • Free or discount transit passes • Subsidize bike and car share costs	
Greater Mobility Options and Safer Active Transportation Networks	**Improved Transit Service** • New routes to more destinations • Faster, more reliable service • Improved stations/stops	Must ensure routes serve vulnerable communities, operate at beginning and end of shifts; minimize need to transfer; not impose undue time penalties; and get as close as possible to job sites.
	Carpool and Vanpool Programs • Carpool matching services such as Scoop • New vanpool routes • Additional park-and-ride lots	These may often be the most effective way to serve suburban and rural areas.
	Pedestrian/Bike Improvements • Improved pedestrian network • Improved bicycle network • Pedestrian-scale lighting	Must be useful to enough people to qualify as an equity promotion measure.
	New Mobility Programs, such as: • Bike share • Car share • Creative use of ride-hailing or other services to connect to transit • Shuttles/Microtransit • Carpool apps and programs	Even when affordable, access might be limited. Options should exist for people without smartphones.

Programs for Seniors and People with Disabilities	**Accessible Information** (senior help lines, materials)	Must be easy for seniors to access and plan trips.
	Targeted Transit/Shuttle Routes	Must serve destinations accessed frequently by seniors at the right times.
Healthier Communities	**Encourage Clean Air Vehicles** • Credits for drivers of clean vehicles • Purchase clean transit vehicles	Transit should be prioritized on routes that pass through marginalized communities.

QUESTIONS TO ASK:

4.1	What strategies are most promising to provide greater affordability, and potentially price certainty, as part of the pricing proposal?
4.2	What strategies will most help *commuters* from vulnerable communities?
4.3	What strategies will most benefit *non-commuters* in vulnerable communities?
4.4	What strategies have affected communities *already identified* as part of other planning processes that can be implemented/supported through funding from the road pricing project? *Such plans may be in-depth and already have broad community support, so their value can be considerable.*
4.5	Can planners run the transportation models on the final alternatives to get a finer grain prediction of impacts?

ADDITIONAL RESOURCES

For more information on cutting-edge equity strategies:

- San Francisco MUNI: www.sfmta.com/projects/muni-service-equity-strategy
- Seattle: www.seattle.gov/transportation/projects-and-programs/programs/transportation-equity-program

EQUITY TOOLKIT

Step #5

Provide Accountable Feedback and Evaluation

Purpose

Road pricing strategies, once implemented, will lead to shifts in travel behavior. Toll revenues will also begin to flow to programs and efforts aimed at delivering equitable outcomes. Ongoing monitoring and evaluation can help identify problems or issues that may emerge, as well as point to new opportunities to help advance equity.

Equity advocates need to ensure that:

- Monitoring and evaluation occur along a reasonable timeline (though it should also be understood that some impacts, like health and traffic safety, may by their nature take some time to become clear);
- There are agreed-upon mechanisms for providing feedback to decision-makers on both the successes and shortcomings of the program, as well as to highlight and act upon emerging opportunities; and
- The results of monitoring and evaluation are communicated clearly and consistently with affected communities.

Discussion

In more traditional transportation projects, community engagement is focused on the period from project scoping through project completion. Congestion pricing, however, should be considered more of a *dynamic process*. Downtown congestion pricing projects especially will have to be evaluated and modified at regular intervals. It is therefore important to plan for formal, continuous community engagement and collaboration *throughout* implementation, evaluation, and ongoing project monitoring and modifications.

The *Public Involvement Plan* should lay out the process for involving stakeholders and community members in all stages of the project.

It is also important to note that the final set of outcomes and indicators should still be relevant during this evaluation phase. The indicators, to the extent feasible, should be used for ongoing project evaluation and monitoring, much as London has done.[19] In this way the original goals can continue to exercise influence over the project.

Several of the downtown congestion pricing programs have started as pilot programs, in part because of public resistance and the uncertainty of their impacts. Pilots allow for evaluation and modifications to address concerns before the permanent adoption of the program. While pilots can be useful, they can also be complicated and expensive to administer. Any pilot program needs to have clearly described milestones and decision points, with clear opportunities for impacted communities to influence the project's ultimate status.

A road pricing proposal not only presents an opportunity to advance equity at a project level; it can usher in and even institutionalize a stronger equity focus in transportation planning. Equity advocates should look for opportunities to ensure that transportation planning agencies, and the elected bodies that oversee them, make equity representation and goals a permanent and central part of the process.

CASE STUDY

Stockholm[20]

Stockholm, a city of 1.2 million, implemented a 7-month pilot cordon pricing charge for the central city in 2006. Though initially unpopular, public sentiment shifted once the benefits of the program were experienced and people saw that the negative impacts were not as large as they feared. A referendum approved making the program permanent.

After the trial period, Stockholm commissioned a study analyzing the equity impacts of the cordon pricing scheme. Among the key findings, the city learned:

- High-income individuals were affected more than low-income;
- Men paid 65% more congestion prices than women;
- Relatively few drivers paid the majority of congestion charges – but most paid occasionally;
- Young and low-income individuals benefitted from lower transit fares; and
- Journeys in central areas were shorter, with a lower percentage by car.
- Program improvements have also included 18 new regional bus lines and 2,800 new regional park-and-ride spaces.

While planners had an explicit goal of reducing car traffic around the cordon by 10 – 15%, traffic has actually decreased by 22%, while greenhouse gas emissions have fallen by 14%. Businesses in the central city saw sales grow by 5%; while the rise cannot be definitively tied to the pricing program, it certainly demonstrates that there were minimal to no negative impacts on businesses. Deliveries also became easier due to decreased congestion.

CASE STUDY

Portland, Oregon

After adopting a "Strategic Plan to Advance Racial Equity, Diversity and Inclusion" in 2016, Oregon Metro created a 15-member advisory and oversight community body that reports directly to the Metro Council. The body advises the Council and staff on racial equity work, provides community oversight and accountability, and serves as a conduit of information to and from the community. In this way, impacted communities have a voice in future decision making and build the expertise, personal relationships, and power to engage over the long-term, rather than on a case-by-case basis.

CASE STUDY

New York City

Move NYC—the congestion pricing proposal spearheaded by Sam Schwartz—includes provisions for a way to "lockbox revenue" to ensure the money raised by tolling would be used on relevant transportation projects in Manhattan. By creating a new financial authority to which bridge tolls would flow, the estimated $720 million in new revenues would be directed to the MTA and its agencies. Additional legal safeguards, including commitments to bondholders, would further cement local control of the new tolls.

The revenue design addressed one of the largest equity concerns raised by opponents of road pricing strategies: distrust of government officials to spend revenues on critical, applicable transportation projects within the region. The proposed mechanism was a novel solution for protecting revenues. The pricing scheme also contained provisions to ensure that drivers who lacked effective transit alternatives would not be unduly penalized.

QUESTIONS TO ASK:	
5.1	What *priority* is given to project funding commitments, which *entity* is making those commitments, and who specifically is accountable for follow-through? *Are commitments, implementation, and adjustment reported publicly and transparently?*
5.2	Who is responsible for determining if the project meets its goals and commitments to vulnerable populations, and on which timeline?
5.3	If the project includes a pilot program, • What is the proposed timeline? • What milestones or targets are included? • What data needs to be generated and disseminated to the public? • Who is responsible for making the decision whether to make the program permanent, make further changes, or terminate the program?
5.4	Who is responsible for providing continuous oversight of equity issues following project implementation?
5.5	What equity issues remain to be dealt with? How heavily will decision-makers weigh the adopted equity outcomes and indicators, relative to other priorities?
5.6	Are there ongoing opportunities for vulnerable communities to participate in the entire transportation planning process?

Notes

[1] Communication with Dan Firth, X DATE, the Executive Director of Vancouver's Independent Mobility Pricing Commission. Dan recounted how even a relatively simple system like the downtown cordon in Gothenburg, Sweden, required eight such iterations. Dan had previously worked with London's and Stockholm's programs.

[2] It should be noted that the NCHRP document is mostly oriented to highway pricing strategies; while some of its insights and frameworks may be useful for cordon or area pricing proposals, there are issues and concerns with these that are not fully covered.

[3] National Cooperative Highway Research Program (NCHRP), *Assessing the Environmental Justice Effects of Toll Implementation or Rate Changes: Guidebook and Toolbox* (Washington, DC: National Academies Press, 2018).

[4] NCHRP, pp. 281-286.

[5] Richard D. Plotnick, et al., "A Geography-Specific Approach to Estimate the Distributional Impact of Highway Tools: An Application to the Puget Sound Region of Washington State," *Journal of Urban Affairs* (7 August 2011), 33(3), pp. 345–366.

[6] NCHRP, p. 95.

[7] NCHRP, pp. 303-314.

[8] Mobility Pricing Independent Commission, Metro Vancouver Mobility Pricing Study (Vancouver, BC, May 2018), www.translink.ca/~/media/Documents/plans_and_projects/regional_transportation_strategy/Research/Metro_Vancouver_Road_Pricing_Research_Study_Report.ashx.

[9] Seattle Race and Social Justice Initiative, "Racial Equity Toolkit to Assess Policies, Initiatives, Programs, and Budget Issues" (Seattle Office for Civil Rights, August 2012), www.seattle.gov/civilrights/programs/race-and-social-justice-initiative/racial-equity-toolkit.

[10] Hana Creger, Joel Espino, and Alvaro S. Sanchez, *Mobility Equity Framework: How to Make Transportation Work for People* (Oakland, California: Greenlining Institute, 2018), greenlining.org/publications/2018/mobility-equity-framework/.

[11] A particularly useful paper is Brian Taylor, "How Fair is Road Pricing? Evaluating Equity in Transportation Pricing and Finance," (National Transportation Policy Center, 29 September 2010).

[12] Adopted from NCHRP, p. 56.

[13] NCHRP, p. 310.

[14] Hana Creger, et. al. (2018).

[15] NCHRP, pp. 281-286.

[16] Hana Creger, et. al. (2018).

[17] Charles Komanoff, "The Fix: NYC Congestion Pricing Plan Looks Solid – If Cuomo Aims High," in *Streetsblog NYC* (23 January 2018), nyc.streetsblog.org/2018/01/23/the-fix-nyc-congestion-pricing-plan-looks-solid-if-cuomo-aims-high/.

[18] SFMTA, "Muni Service Equity Strategy," www.sfmta.com/projects/muni-service-equity-strategy. Accessed on 12 December 2018. And Seattle Race and Social Justice Initiative (2012).

[19] Transport for London, *Changes to the London Congestion Charge Scheme: Integrated Impact Assessment* (July 2018). On page 17 there is a summary chart comparing a proposed change to the original project goals. There is much more detail that follows, including an "equalities analysis" that begins on page 67.

[20] Jonas Eliasson, "The Stockholm congestion charges: an overview," CTS Working Paper (Stockholm: Center for Transport Studies, 2014), www.transportportal.se/swopec/cts2014-7.pdf; Transek, *Equity Effects of the Stockholm Trial* (Stockholm, 2006), www.stockholmsforsoket.se/upload/Sammanfattningar/English/Equity Effects of the Stockholm Trial.pdf; and San Francisco County Transportation Authority, *San Francisco Mobility, Access, and Pricing Study,* Final Report to the Authority Board (San Francisco: SFCMTA, December 2010), p. 6.

Exhibit G

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January 11, 2024

Carter Rubin
Natural Resources Defense Council
1314 Second Street
Santa Monica, CA 90401

Subject: Comments on the Yolo 80 Corridor Improvements Project

Dear Mr. Rubin,

I have reviewed the VMT impacts in the Yolo 80 Corridor Improvements Project Draft Environmental Impact Report / Environmental Assessment ("DEIR") dated November 2023. I make the following findings:

1) The DEIR underestimates induced vehicle miles traveled ("VMT"). Applying the current version of the National Center for Sustainable Transportation (NCST) Induced Travel Calculator, the project would induce up to 44.4% higher VMT than presented in the DEIR.

2) The DEIR states that SACSIM is incapable of properly accounting for induced travel and estimates VMT impacts outside SACSIM. However, the DEIR improperly relies on SACSIM calculated traffic volumes and speeds for accounting for other project impacts. In particular:

    a. The model outputs relied on for the traffic analyses and the traffic metrics are useless, and it cannot even be determined if any of the alternatives satisfy the project's purpose and need.

    b. The region is an air quality nonattainment area and conformity must be demonstrated both at the project level and the regional level. The model outputs relied on for the project level air pollution metrics are useless. The DEIR fails to address how induced travel affects regional air pollution.

c. The model outputs relied on for the energy metrics and the energy metrics are useless.

3) The DEIR's conclusions that the project would not induce land use growth are contradicted by the SACSIM modeling.

4) The DEIR overestimates the VMT reductions that would follow the proposed mitigation. Problems in the DEIR VMT mitigation estimates include:

   a. The voluntary trip reduction program would expand Yolo Commute to the entire region. Yolo Commute includes a 50 percent reduction on monthly transit fares. The DEIR includes a 50 percent fare reduction as a separate mitigation measure, i.e., double counting. The DEIR also assumes the maximum VMT reduction percentage that would occur through an employer implementing a trip reduction program with the assistance of Yolo Commute. It cannot be assumed just giving Yolo Commute more money is the same as every employee in the region implementing a trip reduction program with involvement of their human resources staff.

   b. Adding three trains in each direction on the Capitol Connector would only return service to pre-pandemic levels. This should not be considered mitigation for the proposed project.

   c. Microtransit is a new service provided by Yolo Commute that provides "last mile" transit access through subsidizing vehicles that operate like shared Ubers in very limited geographic areas. The DEIR falsely assumes that expanding the microtransit area would have the same multiplier effect on regional transit ridership as increasing fixed route service miles or service hours by 25%, which would be much more costly.

   d. The DEIR acknowledges that counting mitigation benefits for both subsidizing monthly transit passes and reducing transit fares is double counting the benefits, but then does this anyway. As the reduction in monthly transit fares is also counted in the voluntary trip reduction program benefits, the DEIR is triple counting reduced transit fares.

5) I estimate that the proposed mitigation would only offset 7.5% to 7.8% of induced VMT versus the 43% claimed in the DEIR.

6) California's 2022 Scoping Plan for Achieving Carbon Neutrality calls for VMT per capita reductions of 30% per capita by 2045 relative to a 2019 baseline. It states that reducing VMT per capita will require "more sustained action." A good start would be to stop digging the hole deeper, which the proposed project would do.

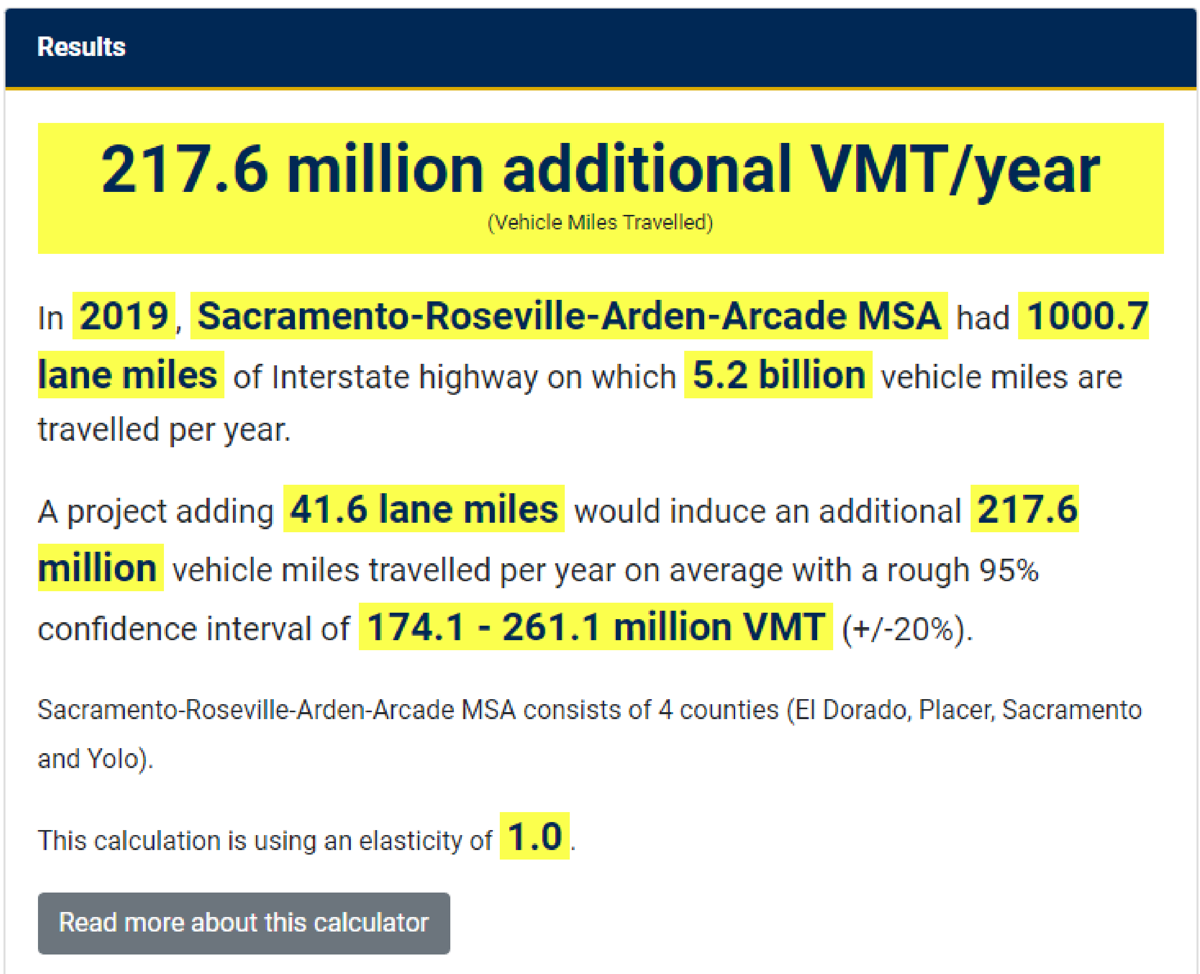
The DEIR Underestimates Induced Travel

The DEIR acknowledges that the SACSIM model is incapable of accounting for induced travel. The DEIR states:

> Since the SACSIM travel demand model does not pass the TAF (Caltrans 2020b) checklist for travel demand models to adequately estimate induced demand, the National Center for Sustainable Transportation (NCST) Induced Travel Calculator was applied as outlined by the TAF procedures. (DEIR, p. 2-117)

Alternatives 2a, 3a, 4a and 5a each add 1 additional lane in each direction. The DEIR reports 180,784,500 induced total annual VMT for these alternatives. (DEIR, Table 2.1-26, p. 2-123.

The project length is 20.8 miles (DEIR, p. Summary-2) Therefore, the project adds 41.6 lane miles of freeway capacity. I applied the Calculator on December 20, 2023, and the estimated induced travel was 174.1 – 261.1 million VMT per year, i.e., up to 44,4% higher than the value given in the DEIR (see below).



Results

217.6 million additional VMT/year

(Vehicle Miles Travelled)

In **2019**, **Sacramento-Roseville-Arden-Arcade MSA** had **1000.7 lane miles** of Interstate highway on which **5.2 billion** vehicle miles are travelled per year.

A project adding **41.6 lane miles** would induce an additional **217.6 million** vehicle miles travelled per year on average with a rough 95% confidence interval of **174.1 - 261.1 million VMT** (+/-20%).

Sacramento-Roseville-Arden-Arcade MSA consists of 4 counties (El Dorado, Placer, Sacramento and Yolo).

This calculation is using an elasticity of **1.0**.

Read more about this calculator

It is possible that the Calculator has been updated since the DEIR analysis was performed, but it would be conservative to assume the higher end of the induced travel estimated range, i.e., 261.1 million VMT per year.

The DEIR estimates 4.2% higher induced VMT for the alternatives with median ramps - 2b, 3b, 4b and 5b. This indicates that these alternatives add about 1.74 additional lane miles of capacity. Factoring up the Calculator range by this same percentage results in an estimate of 181.4 – 272.1 million VMT per year. it would be conservative to assume the higher end of the induced travel estimated range for these alternatives, i.e., 271.1 million VMT per year.

The SACSIM Model Fails to Account Properly for Induced Travel

The DEIR states that SACSIM is incapable of properly accounting for induced travel, and estimates VMT impacts outside SACSIM. However, as discussed in detail below, the DEIR relies completely on SACSIM for accounting for other project impacts including traffic, energy consumption, and air pollution. As these other impacts are all based on travel volumes, it is improper to calculate these impacts from SACSIM as it has been accepted in the DEIR that SACSIM's traffic forecasts are wrong.

The document "Caltrans 2020b" cited in the DEIR in determining that SACSIM is incapable of properly estimating induced travel demand is Transportation Analysis Framework First Edition: Evaluating Transportation Impacts of State Highway System Projects (September 2020). Table 4 in this document is checklist "for evaluating adequacy of travel demand models for estimated induced travel" with five sets of review questions. The DEIR does not include the answers for the SACSIM model but acknowledges that the model fails the first question on the checklist:

> "Is the model's specification of future land use sensitive to travel time and cost, i.e., varying across modeling scenarios to simulate the land use response to network changes?"

The Traffic Demand Modeling Report: Interstate 80/U.S. Highway 50 Managed Lanes (March 2023) states:

> For long-term effects, the SACSIM19 model does not include a process for capturing potential changes in trip generation or land use growth allocation between no build and build alternatives. According to SACOG, the SACSIM19 model represents future conditions (including long-term induced vehicle travel effects) expected to occur under the build alternatives. What is not captured is how the no build alternative would affect long-term effects on trip generation and land use growth allocations. (p. 40)

The Traffic Demand Modeling Report (p. 40) states that the land use and trip generation inputs applied for all alternatives are "expected to occur under the build alternatives," and that "how the no build alternative would affect long-term effects on trip generation and land use growth allocation" "is not captured." This convoluted language captures the mindset of the entire DEIR, i.e. that induced land use and traffic growth are certain, but the authors don't know how to back this out for a no build alternative. This clearly is backwards. The no build condition should be the baseline, and induced land use and traffic should be estimated.

This mindset leads to faulty reasoning. Given that the induced land use and traffic growth are assumed as inevitable, only build alternatives can satisfy this induced demand. This causes nonsensical no build traffic forecasts as documented in the Traffic Demand Modeling Report Table 25 (p. 60) reproduced below.[1]

Table 25: Daily VMT Change and Induced VMT

Alternative	SACSIM19 Daily VMT Change		NCST Long-Term Induced Daily VMT
	2029	2049	
1 (No Build)	-	-	-
2 (Add HOV)	+2,088,000	-3,003,000	+495,300
3 (Add HOT2+)	+2,066,400	-2,883,300	+495,300
4 (Add HOT3+)	+1,985,000	-3,029,000	+495,300
5 (Add Toll)	+2,035,600	-3,095,200	+495,300
6 (Add Transit)	+1,574,800	-2,598,300	-
7 (Convert HOV)	+1,787,200	-3,050,400	+12,300
8 (Add HOV with Median Ramps)	+2,120,300	-2,909,900	+516,000
9 (Add HOV without Enterprise Crossing)	+2,178,100	-2,919,000	+495,300
10 (Add GP)	+1,866,900	-2,599,100	+495,300
11 (Add HOT2+ with Median Ramps)	+2,073,000	-2,880,700	+516,000
12 (Add HOT3+ with Median Ramps)	+1,991,600	-3,026,300	+516,000
13 (Add Toll with Median Ramps)	+2,042,200	-3,092,500	+516,000
14 (Add Transit with Median Ramps)	+1,574,800	-2,598,300	-
15 (Convert HOV with Median Ramps)	+1,819,300	-2,957,400	+33,000

Notes: The SACSIM19 model includes two additional counties (Sutter and Yuba). Annual VMT converted to daily VMT using a factor of 300 to account for less travel on weekends and holidays. Long-term induced daily VMT estimated with an elasticity of 1.0 using NCST Induced Travel Calculator based on 2019 VMT in the four-county MSA (El Dorado, Placer, Sacramento, and Yolo).

In the table reproduced above, SACSIM19 shows much lower VMT in 2049 for all build alternatives relative to the no build alternative. This is simply wrong and is contradicted by real world evidence from dozens of induced travel studies.

[1] The numbers in the "NCST Long-Term Induced Daily VMT" column in the Table above were calculated by dividing the annual estimated reported in DEIR Table 2.1-26 (p. 2-123) by 365 days/year. A smaller divisor should have been used to compare to the average weekday volume in SACSIM to properly account for lower traffic volumes on weekends. Therefore, the Calculator values should be higher than those shown, even without accounting for the higher current Calculator induced travel range discussed above.

The Travel Demand Modeling Report explanation for these erroneous results is:

> In the SACSIM model, the travel time savings under 2029 build conditions are sufficient to induce new vehicle trips and increase regional VMT. Under 2049 conditions, much higher levels of congestion exist under no build conditions such that traffic re-routes long distances during peak periods. The build alternatives improve travel times and allow this traffic to remain on the most direct freeway routes causing a reduction in regional VMT. The 2049 demand forecasts were produced through linear extrapolation of the 2040 forecasts. While this approach minimizes the potential to underestimate future volumes, it may contribute to less reasonable induced VMT forecasts under 2049 conditions especially considering the model's limited sensitivity to congestion due to static assignment. Therefore, the 2029 results offer a more reasonable assessment of short-term induced travel effects. (Travel Demand Modeling Report, p. 60)

This weak attempt at a justification simply highlights the severity of the underlying errors, i.e. that induced land use and trip generation is the baseline, and the failure to accommodate this induced land use and trip generation in the no build alternative would result in "much higher levels of congestion exist under no build conditions such that traffic re-routes long distances during peak periods." This is backwards, as it is the build alternatives that would induce land use and traffic growth. In the no build alternative land use and trip generation growth would be discouraged, and the modeled "much higher levels of congestion" would not occur.

The land use and trip generation inputs used in the no build alternative modeling are invalid, and all outputs from the no build modeling are invalid. As discussed below, this invalidates not only the SACSIM induced VMT estimates, but all other metrics derived from SACSIM and relied on in the DEIR including traffic operations, air quality and energy.

The Growth Conclusions in the DEIR are Contradicted by the SACSIM Modeling

The SACSIM modeling results reproduced above demonstrate that the land use assumptions are inconsistent with the 2049 no build alternative but are consistent with the build alternatives. This is evidence that the build alternatives will induce land use changes that are assumed with the build alternatives.

> According to SACOG, the SACSIM19 model represents future conditions (including long-term induced vehicle travel effects) expected to occur under the build alternatives. What is not captured is how the no build alternative would affect long-term effects on trip generation and land use growth allocations. (Traffic Demand Modeling Report, p. 40)

Therefore, proper growth analysis requires different no build and build land use forecasts which the DEIR fails to do. Instead, the DEIR makes baseless assertions that there would be no induced land use:

> Build Alternatives 2a and 2b would not directly increase development of residential land uses, encourage growth outside of existing growth boundaries, or alter existing access to residential and employment areas. Therefore, no adverse effects associated with growth would be anticipated.
>
> [Build Alternatives 3a and 3b] … the effects would be the same as effects described under Build Alternatives 2a and 2b.
>
> [Build Alternatives 4a and 4b] ... the effects would be the same as effects described under Build Alternatives 2a and 2b. (DEIR, p. 2-53 -2-54)

These assertions are contradicted by the SACSIM modeling that shows that the land use inputs are inconsistent with the no build alternative but are consistent with the build alternative. This demonstrates a strong likelihood of induced land use that is not disclosed in the DEIR.

The Traffic Metrics Relied on in the DEIR Taken from the Invalid SACSIM Model are Useless

The DEIR states:

> The purpose of the proposed project is to:
>
> - Ease congestion and improve overall person throughput
> - Improve freeway operation on the mainline, ramps, and at system interchanges
> - Support reliable transport of goods and services throughout the region
> - Improve modality and travel time reliability
> - Provide expedited traveler information and monitoring systems.

The DEIR relies on SACSIM to evaluate how well the alternatives satisfy the project purpose. DEIR Table 2.1-25 (p. 2-121) based on SACSIM outputs summarizes many of the performance metrics related to the project purpose.

Table 2.1-25. Alternatives Comparison – Horizon Year 2049

Performance Measure	Alt 1	Alt 2a	Alt 3a	Alt 4a	Alt 5a	Alt 6a	Alt 7a	Alt 2b
Regional VMT	5	2	3	2	1	4	2	3
Corridor PMT	5	2	1	3	4	5	5	2
Persons served at bottlenecks	3.5	1	2	2.5	2.5	3.5	5	1
General purpose lane peak hour travel time	3.5	1.5	1.5	2	2	3	5	2
General purpose lane peak hour planning time index	4	2	2	2.5	1.5	3	5	2.5
Managed lane peak hour travel time	4.5	2	1.5	1.5	1.5	3	5	1.5
Vehicle hours of delay	4	2	2.5	2	1.5	2.5	5	1.5
Average speed	4	1.5	2.5	2	2	2.5	5	1
Total vehicles served	3.5	1.5	2	3	3	3	5	1
Total persons served	3	1	2	4	3	2.5	5	1
Deficient segments	5	2.5	2.5	2	1.5	3	4	1.5
Average score	4.1	1.7	2.0	2.4	2.1	3.2	4.6	1.6

Source: Caltrans 2023d
Notes: Comparison is based on a scale of 1 to 5, where 1 represents very good performance and 5 represents very poor performance.
Key: VMT = Vehicle miles traveled; PMT = Personal miles traveled

In the table, the no build Alternative 1 rates worst on "Regional VMT", i.e., highest, because the metric is based on the invalid 2049 no build modeling documented above that falsely indicates higher no build VMT. This is clearly wrong. Similarly, none of the other metrics listed for the no build alternative are valid. Travel time and delay are overestimated because the no build modeling was done with build land use and trip generation. Speed is underestimated because the no build modeling was done with build land use and trip generation. The number of “deficit segments” is overestimated because the no build modeling was done with build land use and trip generation. All the no build metrics are wrong.

And because the no build metrics are all wrong, the comparisons of the build metrics with the no build metrics are also wrong. There is no way to know from the invalid 2049 modeling whether any of the build alternatives satisfy the project purpose and need better than the no build alternative, or whether any build alternative would better satisfy the project purpose than any other build alternative. The traffic metrics relied on in the DEIR taken from the invalid SACSIM model are useless.

The Air Pollution Metrics Relied on in the DEIR Taken from the Invalid SACSIM Model are Useless

The DEIR’s Air Quality Report states that the region is Nonattainment for air pollutants including:

- Ozone – State Status Nonattainment and Federal Status Nonattainment – Severe 15
- PM_{10} - State Status Nonattainment
- $PM_{2.5}$ - Federal Status Sacramento and Yolo Counties Nonattainment – Moderate[2]

The DEIR includes extensive air pollution analyses of traffic operations for the study corridor and concludes that for every alternative – both no build and build – there would be “No effect” for project-level conformity (CO), Project-level conformity (PM2.5) or roadway vehicle emissions/criteria pollutant emissions.

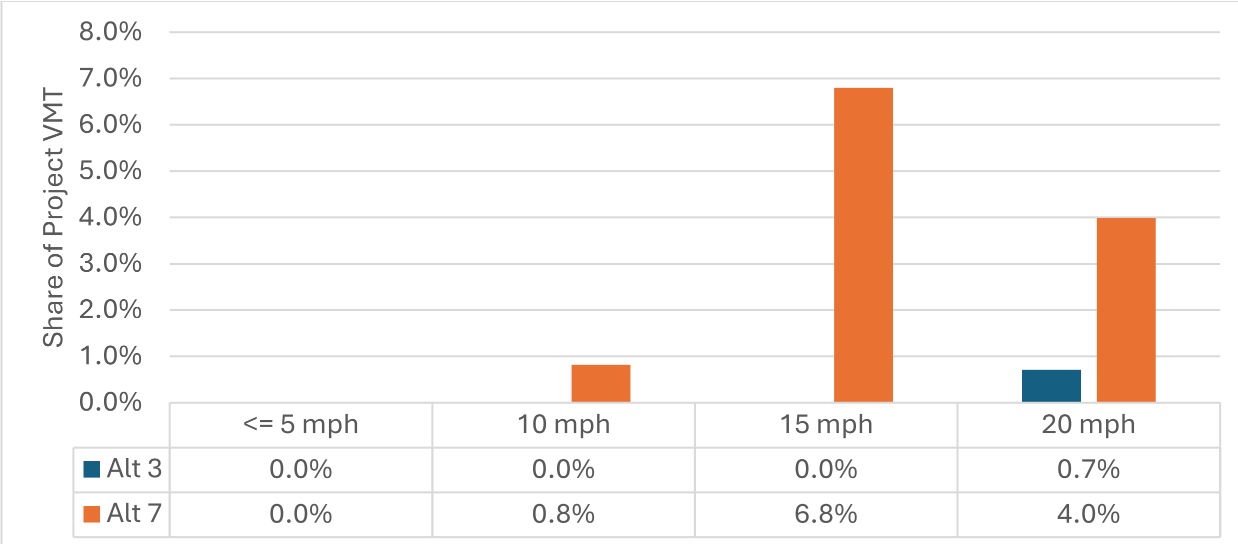
The foundation for the DEIR air pollution analyses are the modeled traffic volumes and traffic speeds from the invalid 2049 SACSIM alternatives modeling. This is erroneous both for calculating study corridor emissions and regional emissions.

In the study corridor emissions analyses, SACSIM forecasts excessive delay and high emissions per mile in the non-widening alternatives. Appendix G of the Air Quality Report includes Summary Tables of CT-EMFAC Results for 2049 for Alternatives 2, 3, 4, 5, 6 and 7 – but not for Alternative 1, the No Build alternative. As the Alternative 1 model results are unavailable, Alternative 7, Take-A-Lane, will be used to represent a non-widening alternative and compared to Alternative 3, adding HOT lanes.

As shown in the figure below, the SACSIM model outputs input to CT-EMPAC have 16.4 times as much of the daily VMT operating below 20 mph for Alternative 7 vs Alternative 3.

[2] Air Quality Report: YOLO 80 Corridor Improvements Project, August 2023. p. 7.

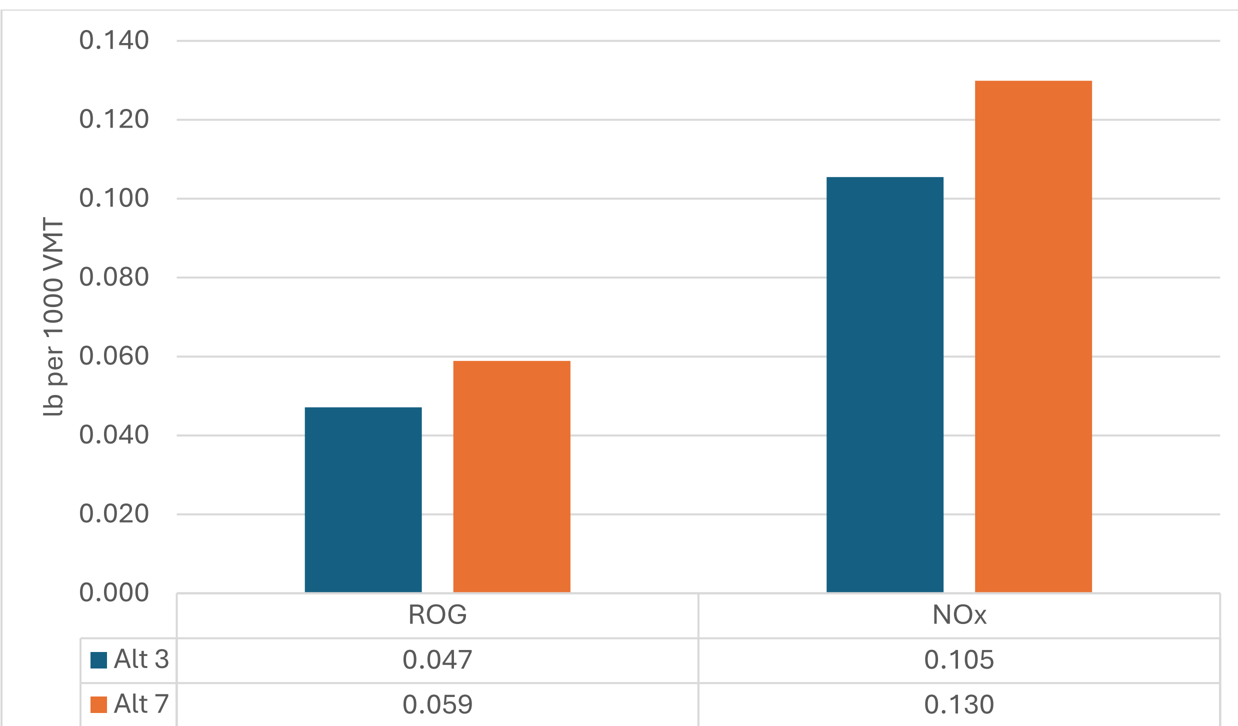
CT-EMPAC VMT Speed Bin Outputs for 2049 Reported in Appendix G of the Air Quality Report



As referenced above: “According to SACOG, the SACSIM19 model represents future conditions (including long-term induced vehicle travel effects) expected to occur under the build alternatives.” Therefore, the extreme congestion forecast for Alternatives 1 and 7 is unrealistic for the non-widening alternatives, and a false basis for estimating emissions.

The figure below shows that this false congestion results in significantly higher ozone precursors (ROG and NOx) emissions per mile for Alternative 7 relative to Alternative 3.

CT-EMPAC VMT Emissions/VMT Outputs for 2049 Reported in Appendix G of the Air Quality Report



Given these false levels of modeled congestion in the non-widening alternatives, the study corridor air pollution analyses cannot properly account for induced travel from the build alternatives. Therefore, the air pollutant metrics relied on in the DEIR are useless.

There are even greater air quality impacts at the regional level. The DEIR states:

> "Transportation Conformity" applies to highway and transit projects and takes place on two levels: the regional (or planning and programming) level and the project level. The proposed project must conform at both levels to be approved. (DEIR, p. 2-180)

The DEIR makes no effort to demonstrate conformity at the regional level, but instead relies on conformity analysis done in conjunction with the Regional Transportation Plan ("RTP"). (DEIR, p. 2-181). The RTP conformity analysis again leads back to the SACSIM model that fails to properly account for induced travel. If induced travel were properly considered, it is likely the build alternatives would result in more regional air pollution than the no build alternative. Regional air pollution is not properly analyzed in the DEIR.

The Energy Metrics Relied on in the DEIR Taken from the Invalid SACSIM Model are Useless

The DEIR falsely claims, based on the invalid SACSIM modeling, that:

> When compared to No Build Alternative 1, Build Alternatives 2a and 2b are expected to result in a 14.5 percent and 0.8 percent, respectively, decrease in energy use in the year 2049 (Table 2.2-34). The project's proposed improvements under Build Alternatives 2a and 2b would improve roadway operations and reduce traffic delay within the project limits. Excess fuel consumption associated with vehicle delay and congestion within the project limits would decrease compared to No Build Alternative 1. (DEIR, p. 2-268)

The DEIR purports that the other build alternatives also result in lower energy consumption than the no build alternative.

The SACSIM modeling falsely shows these results because it improperly includes induced land use and trip generation in the no build alternative. This exaggerates congestion and fuel consumption in the no build alternative and makes model comparisons with the build alternatives useless.

DEIR Overestimates VMT Mitigation Reductions

The DEIR overestimates the VMT reductions that would follow the proposed mitigation. Problems in the DEIR VMT mitigation estimates include:

1) The voluntary trip reduction program would expand Yolo Commute to the entire region. Yolo Commute includes a 50 percent reduction on monthly transit fares. The DEIR includes a 50 percent fare reduction as a separate mitigation measure, i.e., double counting. The DEIR

also assumes the maximum VMT reduction percentage that would occur through an employer implementing a trip reduction program with the assistance of Yolo Commute. It cannot be assumed just giving Yolo Commute more money is the same as every employee in the region implementing a trip reduction program with involvement of their human resources staff.

2) Adding three trains in each direction on the Capitol Connector would only return service to pre-pandemic levels. This should not be considered mitigation for the proposed project.

3) Microtransit is a new service provided by Yolo Commute that provides "last mile" transit access through subsidizing vehicles that operate like shared Ubers in very limited geographic areas. The DEIR falsely assumes that expanding the microtransit area would have the same multiplier effect on regional transit ridership as increasing fixed route service miles or service hours by 25%, which would be much more costly.

4) The DEIR acknowledges that counting mitigation benefits for both subsidizing monthly transit passes and reducing transit fares is double counting the benefits, but then does this anyway. As the reduction in monthly transit fares is also counted in the voluntary trip reduction program benefits, the DEIR is triple counting reduced transit fares.

These problems are discussed in greater detail in the following sections.

Voluntary Trip Reduction Program VMT Is Overestimated

The largest component in the DEIR VMT mitigation is “voluntary trip reduction program in Yolo County” with a reduction of 24.7 million VMT per year, which is 43% of the mitigation. The VMT Mitigation Memo describes the program this way:

> The Voluntary Trip Reduction Program mitigation measure would expand the current program provided by Yolo Commute, the Yolo County transportation management association, to apply for all residents and workers. The program could include features such as community-based travel planning, ridesharing, transit pass subsidies, and pay-per-mile auto insurance. An estimated 20 percent of workers are currently eligible. This measure would expand the program to cover the other 80 percent. CAPCOA strategy T-5 estimates a 4 percent reduction in home-based work trips when employees in a study area participate in the voluntary trip reduction program. If transit pass subsidies are included as part of this strategy, then the separate reduction in Table 2 would not apply. (VMT Mitigation Memo p. 4)

The reference for the 4% reduction, The California Air Pollution Control Officers Association (CAPCOA) Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity (“Handbook”) states:

> Voluntary CTR programs must include the following elements to apply the VMT reductions reported in literature.
>
> * Employer-provided services, infrastructure, and incentives for alternative modes such as ridesharing (Measure T-8), discounted transit (Measure T-9), bicycling (Measure T-10), vanpool (Measure T-11), and guaranteed ride home.
>
> * Information, coordination, and marketing for said services, infrastructure, and incentives (Measure T-7). (p. 83)

Yolo Commute provides all these services today including 50% off Yolobus monthly passes.[3]

The Handbook text reads “employer-provided” services, and it is not clear that it will be possible to expand these programs to all workers. While Yolo Commute would receive additional funding, there are no resources provided for funding human resources staff in what are currently non-member businesses to actively promote these programs to their workers, and many work in small business without human resources staff.

Using the example of the guaranteed ride home, all workers would need to know of the eligibility requirements and the mechanics of getting reimbursed as shown on the following page.

[3] https://www.yolocommute.net/incentives-programs/

Yolo TMA Guaranteed Ride Home Process
https://www.yolocommute.net/incentives-programs/)

You may use the Yolo TMA's Guaranteed Ride Home up to six (6) times a year for the following circumstances:

- Your ridesharing partner has an emergency and you have no way to get home
- Unscheduled, approved overtime
- You are ill and must go home
- You must get to a family emergency
- Your commute bicycle broke down and cannot be repaired at your work site
- Unexpected severe weather is preventing you from bicycling or walking home after work today

The following uses are not eligible for reimbursement:

- Personal errands
- Medical or dental appointments
- Building evacuations
- Business travel
- Job related injuries
- A natural disaster (floods)
- Transit problems (the transit provider is responsible for providing another bus)
- Missed bus, carpool or vanpool ride home
- Other reasons deemed invalid by program administrator

How To Use...

When an urgent need requires you to get home, we know you don't have time to deal with vouchers or pre-authorizations. That's why Yolo Commute makes it easy: just use the options below and we'll reimburse you.

Taxi, Lyft, Uber and Via:

Use who you want. Yolo Commute will reimburse for up to $50. Simply fill out the below form after your trip.

Rental Car:

Commuters traveling 20 or more miles from work will use Enterprise Rent-a-Car. You are responsible for returning the car to the rental agency within 24 hrs, with the same fuel level as when rented. A credit/debit card will be necessary to initiate the rental; however, only Yolo Commute will be charged for the vehicle cost, less gas refill and optional insurance.

Reimbursement:

Fill out the below form for GRH reimbursement...

Yolo Commute Member Organization*(Required)*

Only Yolo Commute members are eligible... [followed by rest of form]

To get reimbursed, the form needs to be completed and submitted. Today, there are only 14 employer members listed and the submitter enters one of them. It is likely that sometimes Yolo Commute checks with the employer members about claims, particularly in the case of repeat claims. How will this work with hundreds of small employers, including sole proprietors?

The VMT Mitigation Memo states:

> An estimated 20 percent of workers are currently eligible. This measure would expand the program to cover the other 80 percent. CAPCOA strategy T-5 estimates a 4 percent reduction in home-based work trips when employees in a study area participate in the voluntary trip reduction program. If transit pass subsidies are included as part of this strategy, then the separate reduction in Table 2 would not apply. (p. 5)

Yolo Commute includes a 50% transit pass price reduction; therefore, the transit fare subsidy listed as a separate mitigation measure cannot be included.

The Handbook specifies that the 4% maximum should be reduced for "Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. (p. 84) The DEIR includes no downward adjustment for these workers.

It is unrealistic to assume a 4% reduction across the board by giving Yolo Commute additional funds. This program will be very complicated to implement at a county level, and the effects likely would be much less than the 4% reduction assumed. A more realistic estimate, that also considers those who cannot participate, is half, i.e., a 2% average reduction.

Expand Capitol Corridor Frequency VMT Reduction Is Overestimated

The second largest component in the VMT mitigation is expanding the Capitol Corridor frequency. The DEIR states that this would mitigate 12.6 million VMT per year (22% of the total mitigation):

> The addition of three roundtrip train services on the Capitol Corridor route from Oakland to Sacramento would also reduce VMT, as mentioned in the attached VMT Mitigation Plan. The calculations and basis for the VMT reduction is based on a Traffic Congestion Relief Program (TCRP) equation, that utilizes a direct effect and indirect effect of train services. In this case, the three additional roundtrips save 6.3 million passenger miles, which is then multiplied by 2 to obtain the VMT reduction. Hence, the VMT reduction number of 12.6 million is shown in the VMT Mitigation Plan. (DEIR p. 2-31)

The YOLO 80 Managed Lanes Project Draft VMT Mitigation Plan dated October 20, 2023 states

> Currently running 12 roundtrip trains, this measure would allow for a total of 15 roundtrip trains (p. 2)

This 25% increase sounds impressive, but with a closer look, this appears to be only returning to pre-pandemic service levels. A local news report in 2021 stated:

> Capitol Corridor service was cut from 30 trains per day pre-pandemic to just 10 per day, seven days per week last year.
>
> Weekday service increased to 16 daily trains last June, but ridership is still nearly 90 percent below pre-pandemic levels, according to data from Capitol Corridor's February 2021 performance report.[4]

The report says there were 30 trains per day (15 trains in each direction) pre-pandemic.

The Capitol Corridor website states:

> **Service Levels**
>
> Over the course of the year, the Capitol Corridor increased service, except for a brief summer period when Amtrak experienced workforce shortages. A January 24, 2022, schedule change provided more midday service in the eastbound direction, as well as increased late afternoon and evening weekday service. The temporary reduction in service, which began August 15, 2022, ended on October 3, 2022, when we returned to full service on weekends and to 12 of 15 roundtrips on weekdays.[5]

This excerpt indicates that 15 roundtrips a day is considered the normal service level. Returning to normal service levels after the pandemic does not count as mitigation.

Even if the added frequency were true mitigation, the estimated VMT reduction doesn't make sense. It is based on a multiplier of 2.0 that is taken from a "Traffic Congestion Relief Program (TCRP) equation, that utilizes a direct effect and indirect effect of train services." I was unable to find documentation for this multiplier. There are several reasons why the true multiplier is less than 1.0 including:

- Parties traveling together would otherwise be in a multiple-occupant vehicle rather than a single-occupant vehicle.
- VMT associated with rail station access – Capitol Corridor reports 36% drop or pickup[6], i.e., extra VMT from roundtrips to and from the stations as well one-way trips from 16% park-and-ride, and
- Induced trips – induced travel is not only from roads; improved transit service also induces travel.

Getting to a multiplier of 2.0 requires heroic assumptions about indirect effects such as significant changes in land use and auto ownership that are illogical for a change in frequency. A multiplier of 0.7 would be more appropriate, i.e., a 65% reduction from what is assumed in the DEIR, and again, that is only if the increased frequency is considered as true mitigation rather than just a return to pre-pandemic service levels.

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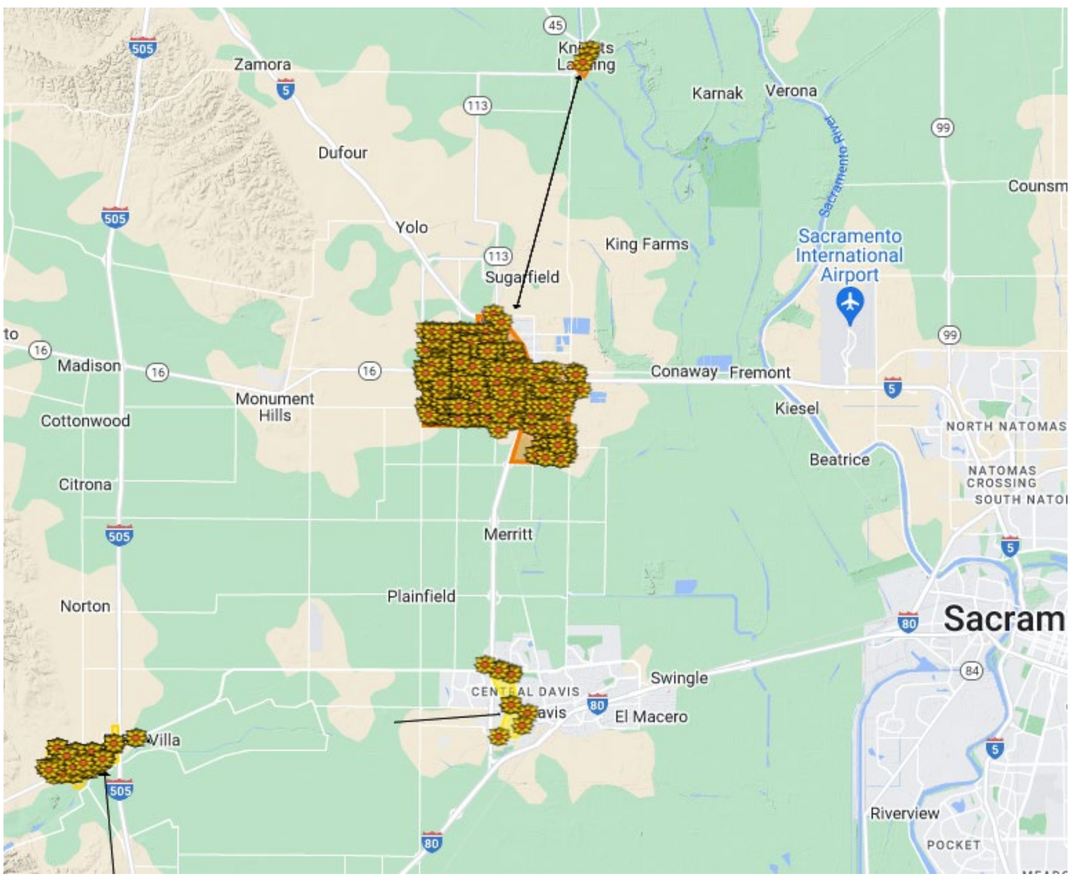
[4] Bay City News. Capitol Corridor Sees Uptick in Ridership Amid Pandemic, March 23, 2021. https://patch.com/california/martinez/capitol-corridor-sees-uptick-ridership-amid-pandemic
[5] https://www.ccperformance.org/#helthsafety
[6] https://www.ccperformance.org/#helthsafety

Micro Transit in Yolo County VMT Reduction is Overestimated

The third highest VMT mitigation component is "Micro Transit in Yolo County" – "Expand transit service by 25% to add flexible route buses with more frequent service and/or longer service hours, add more buses to an existing route; no physical improvements; payment to Yolo County." (DEIR, p. 2-125) This description appears to be trying to bridge a contradiction between the proposed measure and the Handbook measure relied on to calculate the benefits. The words "micro transit" and "flexible route" describe the proposed service. The words "more frequent service and/or longer service hours" are taken from the Handbook and do not describe the proposed service.

The word "microtransit" has a particular meaning for Yolobus that is distinct from either "fixed route" or "paratransit."[7] The Yolobus microtransit service, labeled "BeeLine" "is a shared on-demand transportation service which allows users to request a ride where and when they need it rather than scheduled fixed route service which stops at bus stops following a set schedule."[8] It is operating as a limited area service like a shared Uber or Lyft for a fare of $4 subsidized by state and local funds. It currently has only a small service area as shown on this map.

Current BeeLine Interactive Map (October 2023)[9]



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[7] https://yolobus.com/wp-content/uploads/2022/06/YCTD-Final-Budget-for-FY-2022-23.pdf
[8] https://yolobus.com/wp-content/uploads/2021/10/MicrotransitFAQ.pdf
[9] https://www.google.com/maps/d/u/0/embed?mid=1XL64pzso_2pgrkOYGHlk-yz5TNyEyLo&ehbc=2E312F&noprof=1&ll=38.64159722236725%2C-121.75868239853513&z=11

This is a new service with an introductory fare of $1 in at least some areas, and there do not appear to be reliable performance metrics yet. However, it is likely that the subsidies per ride will be large. The most recent Fiscal Year budget (2022-2023) shows expenses of $878,000 and passenger fares of only $7,000.[10]

In the areas where the microtransit service is available, it can link to Yolobus fixed route service and provide the "last mile" service that is missing in many rural and suburban areas. The DEIR appears to be suggesting that adding $1.5 million a year to this program can expand the Yolobus geographic service area by 25%. This 25% is different from increasing "transit service miles or service hours" by 25%. Therefore, it is wrong to use the equation for Handbook measure T-25 Extend Transit Network Coverage or Hours to estimate VMT mitigation.

There is insufficient data for the microtransit service yet to estimate the VMT benefits, but an upper limit to the benefits would be proportional to the percentage increase in regional transit subsidy. The proposed $1.5 million per year is much less than 25% of regional transit subsidies today. The VMT Mitigation Memo states: "The additional transit service is expected to be provided by Unitrans or Yolobus." (p. 4) In its most recent annual report to the Federal Transit Administration (2022), the Yolo County Transportation District (which operates Yolobus) reported operating expenses of $13,144,190 with fare revenues covering only 10.2% of the expenses.[11] In Fiscal Year 2021-2022, Unitrans expenses totaled $7,358,000.[12] The largest component of the budget is student fees; non-subsidy cash income including fares, advertising and miscellaneous totaled only $225,000. Subsidized expenses for the two services were $19 million for these past years, and certainly at least $20 million today. Therefore, the upper limit to the potential service increase would be $1.5 million / $20 million = 7.5% - not 25%, i.e., 30% of what is assumed in the DEIR. The upper limit for VMT reduction would be 30% of what is assumed in the DEIR.

Furthermore, this is the upper limit of potential benefits. The actual benefits are likely to be much smaller because the likely subsidies per passenger and per passenger mile are likely to be significantly greater than for existing fixed route service.

Subsidize Monthly Transit Passes in Yolo County and Reduce Transit Fares

The fourth and fifth highest VMT mitigation components both involve reducing net transit fares. The VMT Mitigation Memo analyses these two approaches separately:

- Subsidize Monthly Transit Passes in Yolo County with TDM+/Handbook
- Reduce Transit Fares with SACSIM

The VMT Mitigation Memo acknowledges the overlap in these approaches and states:

> Some portion of the VMT reduction may not apply if the monthly transit pass subsidy strategy in Table 2 above is also implemented. The strategies offer different methods for reducing transit costs but may end up targeting similar people that could dampen the reported effectiveness. (Footnote 2, p. 17)

[10] https://yolobus.com/wp-content/uploads/2022/06/YCTD-Final-Budget-for-FY-2022-23.pdf
[11] www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2022/90090.pdf
[12] https://unitrans.ucdavis.edu/media/uploads/2022/12/21/gmfy22annualrpt_final.pdf

The DEIR double counts these benefits anyway but goes beyond that. As discussed above, the DEIR also counts these benefits in the Trip Reduction measure, so they are triple counted in the DEIR.

In my revised estimates, I keep the monthly transit pass subsidies as part of the Trip Reduction measure and zero it out here.

The DEIR also exaggerates the VMT reduction from reducing transit fares because it double counts the benefits for Yolobus monthly pass holders. In my revised estimate, I reduce the DEIR estimate by 50%.

Revised VMT Mitigation Estimates

The table below adjusts the DEIR VMT mitigation estimates to more realistic values.

VMT Mitigation Estimates (million VMT per year)

measure	DEIR	realistic	notes
Voluntary trip reduction program in Yolo County	24.7	12.35	50% due to challenges
Expand Capitol Corridor frequency between Oakland and Sacramento	12.6	0.00	just returning to pre-pandemic service
Micro transit in Yolo County	6.2	1.86	upper limit on benefits
Subsidize monthly transit passes in Yolo County	5.6	0.00	double counted
Reduce transit fares	3.7	1.85	partly doubled counted
Expand Causeway Connection Route 138	3.1	3.10	not reviewed in detail
Expand Unitrans	1.2	1.20	not reviewed in detail
total	57.1	20.36	

The Proposed VMT Mitigation Is Inadequate

As discussed above, the DEIR uses annual induced travel estimates of 180,784,500 VMT for Alternatives 2, 3, 4 and 5 and 188,340 VMT for Alternatives 2a, 3a, 4a and 5a. These numbers are also in Table 1 of a November 16, 2023, Fehr and Peers Memorandum re I-80/US 50 Managed Lanes – VMT Mitigation Estimates ("VMT Mitigation Memo").

As documented above, these induced travel estimates are significantly lower than the values given in the current Calculator. The most conservative estimates are 261.1 million VMT per year and 271.1 million VMT per year for the two sets of alternatives.

The VMT Mitigation Memo takes the initial induced VMT number – which is too low – and reduces it by 29% because of an estimate that 19-29% of the induced travel is commercial driving. The VMT Mitigation Memo takes the higher value of 29% and reduces the induced travel by this amount. The Memo states that this "change was tentatively accepted by Caltrans headquarters (HQ) staff."

Approval by HQ staff is not a valid rationale for this assumption. The only justification I can think of for this reduction is that the mitigation measures do not apply to commercial driving, and that this assumed 29% of the induced VMT cannot be mitigated. If this is the intent of the 29% reduction, is important that the DEIR states this clearly with a statement like: “The 29% of inducted travel that is from commercial driving cannot be mitigated.”

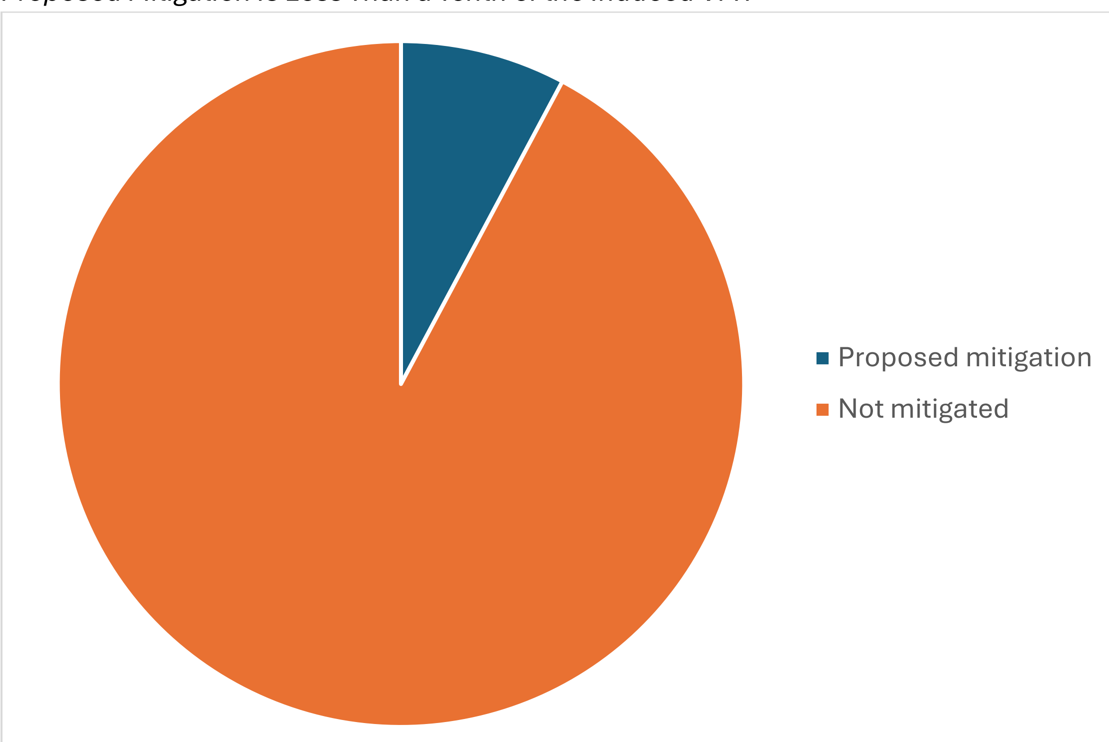
Instead, the DEIR appears to be pretending that the “commercial driving” VMT can be simply ignored as it claims that the mitigation totaled, 57.1 million, represents “43% of induced VMT” (Table 2.1-27, p. 2-126). In fact, it represents only:

- 31.6% of DEIR estimated induced VMT for Alternatives 2, 3, 4 and 5
- 30.3% of DEIS estimated induced VMT for Alternatives 2a, 3a, 4a and 5a
- 21.9% of more conservative induced VMT for Alternatives 2, 3, 4 and 5
- 21.1% of more conservative induced VMT for Alternatives 2a, 3a, 4a and 5a

Substituting the more realistic VMT mitigation estimate of 20.36 million VMT per year documented above, the mitigation represents only:

- 7.8% of more conservative induced VMT for Alternatives 2, 3, 4 and 5
- 7.5% of more conservative induced VMT for Alternatives 2a, 3a, 4a and 5a

Proposed Mitigation Is Less Than a Tenth of the Induced VMT



The Proposed VMT Mitigation Includes Projects that are Necessary to Meet the State's Climate Goals – Without Digging a Deeper Hole

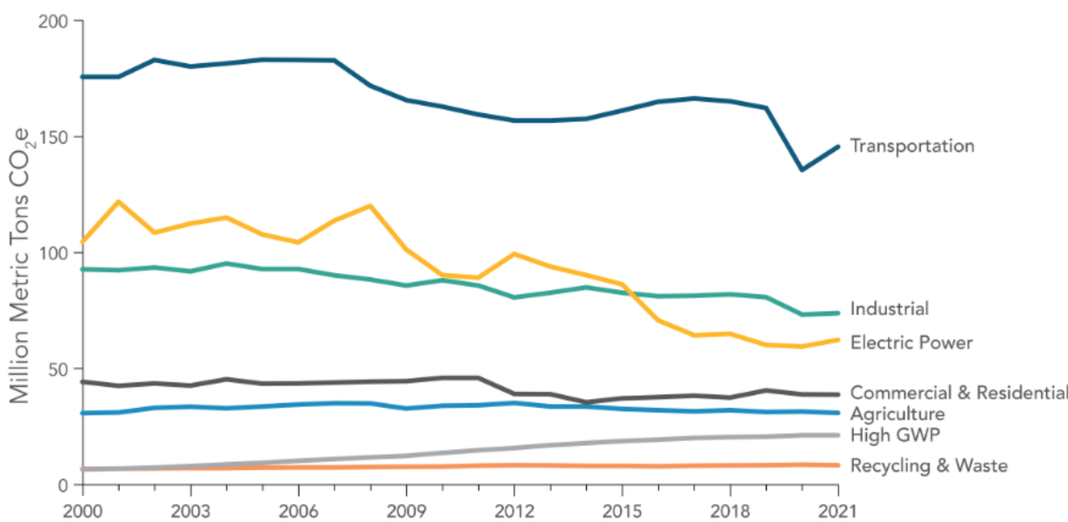
California's 2022 Scoping Plan for Achieving Carbon Neutrality states:

> The 2022 Scoping Plan models vehicle miles travelled (VMT) reductions of 25% per capita below 2019 levels by 2030 and 30% per capita below 2019 levels by 2045. These targets are not regulatory requirements, but would inform future planning processes. Functionally, achieving these targets would require more sustained action than the prior targets to further shift the transportation system away from dependency on personal vehicles and broaden choice.[13]

As stated in this excerpt, reducing VMT per capita will require "more sustained action."

In the most recent California GHG, transportation GHG emissions are not only higher than other sectors but are increasing.[14]

2000–2021 GHG Emissions by Category as Defined in the Scoping Plan



Part of this more sustained action regarding VMT is to stop digging a deeper hole.

Sincerely,

Norman L. Marshall

Norman L. Marshall

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[13] ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp-appendix-b-final-environmental-analysis.pdf

[14] https://ww2.arb.ca.gov/ghg-inventory-graphs

Resume

NORMAN L. MARSHALL, PRESIDENT

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EDUCATION:

Master of Science in Engineering Sciences, Dartmouth College, Hanover, NH, 1982
Bachelor of Science in Mathematics, Worcester Polytechnic Institute, Worcester, MA, 1977

PROFESSIONAL EXPERIENCE: (32 Years, 18 at Smart Mobility, Inc.)

Norm Marshall helped found Smart Mobility, Inc. in 2001. Prior to this, he was at RSG for 14 years where he developed a national practice in travel demand modeling. He specializes in analyzing the relationships between the built environment and travel behavior and doing planning that coordinates multi-modal transportation with land use and community needs.

Regional Land Use/Transportation Scenario Planning

Portland Area Comprehensive Transportation System (PACTS) – the Portland Maine Metropolitan Planning Organization. Updating regional travel demand model with new data (including AirSage), adding a truck model, and multiclass assignment including differentiation between cash toll and transponder payments.

Loudoun County Virginia Dynamic Traffic Assignment – Enhanced subarea travel demand model to include Dynamic Traffic Assignment (Cube). Model being used to better understand impacts of roadway expansion on induced travel.

Vermont Agency of Transportation-Enhanced statewide travel demand model to evaluate travel impacts of closures and delays resulting from severe storm events. Model uses innovate Monte Carlo simulations process to account for combinations of failures.

California Air Resources Board – Led team including the University of California in $250k project that reviewed the ability of the new generation of regional activity-based models and land use models to accurately account for greenhouse gas emissions from alternative scenarios including more compact walkable land use and roadway pricing. This work included hands-on testing of the most complex travel demand models in use in the U.S. today.

Climate Plan (California statewide) – Assisted large coalition of groups in reviewing and participating in the target setting process required by Senate Bill 375 and administered by the California Air Resources Board to reduce future greenhouse gas emissions through land use measures and other regional initiatives.

Chittenden County (2060 Land use and Transportation Vision Burlington Vermont region) – led extensive public visioning project as part of MPO’s long-range transportation plan update.

Flagstaff Metropolitan Planning Organization – Implemented walk, transit and bike models within regional travel demand model. The bike model includes skimming bike networks including on-road and off-road bicycle facilities with a bike level of service established for each segment.

Chicago Metropolis Plan and Chicago Metropolis Freight Plan (6-county region)— developed alternative transportation scenarios, made enhancements in the regional travel demand model, and used the enhanced model to evaluate alternative scenarios including development of alternative regional transit concepts. Developed multi-class assignment model and used it to analyze freight alternatives including congestion pricing and other peak shifting strategies.

Municipal Planning

City of Grand Rapids – Michigan Street Corridor – developed peak period subarea model including non-motorized trips based on urban form. Model is being used to develop traffic volumes for several alternatives that are being additional analyzed using the City's Synchro model

City of Omaha - Modified regional travel demand model to properly account for non-motorized trips, transit trips and shorter auto trips that would result from more compact mixed-use development. Scenarios with different roadway, transit, and land use alternatives were modeled.

City of Dublin (Columbus region) – Modified regional travel demand model to properly account for non-motorized trips and shorter auto trips that would result from more compact mixed-use development. The model was applied in analyses for a new downtown to be constructed in the Bridge Street corridor on both sides of an historic village center.

City of Portland, Maine – Implemented model improvements that better account for non-motorized trips and interactions between land use and transportation and applied the enhanced model to two subarea studies.

City of Honolulu – Kaka'ako Transit Oriented Development (TOD) – applied regional travel demand model in estimating impacts of proposed TOD including estimating internal trip capture.

City of Burlington (Vermont) Transportation Plan – Led team that developing Transportation Plan focused on supporting increased population and employment without increases in traffic by focusing investments and policies on transit, walking, biking and Transportation Demand Management.

Transit Planning

Regional Transportation Authority (Chicago) and Chicago Metropolis 2020 – evaluated alternative 2020 and 2030 system-wide transit scenarios including deterioration and enhance/expand under alternative land use and energy pricing assumptions in support of initiatives for increased public funding.

Capital Metropolitan Transportation Authority (Austin, TX) Transit Vision – analyzed the regional effects of implementing the transit vision in concert with an aggressive transit-oriented development plan developed by Calthorpe Associates. Transit vision includes commuter rail and BRT.

Bus Rapid Transit for Northern Virginia HOT Lanes (Breakthrough Technologies, Inc and Environmental Defense.) – analyzed alternative Bus Rapid Transit (BRT) strategies for proposed privately-developing High Occupancy Toll lanes on I-95 and I-495 (Capital Beltway) including different service alternatives (point-to-point services, trunk lines intersecting connecting routes at in-line stations, and hybrid).

Roadway Corridor Planning

I-30 Little Rock Arkansas – Developed enhanced version of regional travel demand model that integrates TransCAD with open source Dynamic Traffic Assignment (DTA) software, and used to model I-30 alternatives. Freeway bottlenecks are modeled much more accurately than in the base TransCAD model.

South Evacuation Lifeline (SELL) – In work for the South Carolina Coastal Conservation League, used Dynamic Travel Assignment (DTA) to estimate evaluation times with different transportation alternatives in coastal South Caroline including a new proposed freeway.

Hudson River Crossing Study (Capital District Transportation Committee and NYSDOT) – Analyzing long term capacity needs for Hudson River bridges which a special focus on the I-90 Patroon Island Bridge where a microsimulation VISSIM model was developed and applied.

PUBLICATIONS AND PRESENTATIONS (partial list)

DTA Love: Co-leader of workshop on Dynamic Traffic Assignment at the June 2019 Transportation Research Board Planning Applications Conference.

Forecasting the Impossible: The Status Quo of Estimating Traffic Flows with Static Traffic Assignment and the Future of Dynamic Traffic Assignment. *Research in Transportation Business and Management* 2018.

Assessing Freeway Expansion Projects with Regional Dynamic Traffic Assignment. Presented at the August 2018 Transportation Research Board Tools of the Trade Conference on Transportation Planning for Small and Medium Sized Communities.

Vermont Statewide Resilience Modeling. With Joseph Segale, James Sullivan and Roy Schiff. Presented at the May 2017 Transportation Research Board Planning Applications Conference.

Assessing Freeway Expansion Projects with Regional Dynamic Traffic Assignment. Presented at the May 2017 Transportation Research Board Planning Applications Conference.

Pre-Destination Choice Walk Mode Choice Modeling. Presented at the May 2017 Transportation Research Board Planning Applications Conference.

A Statistical Model of Regional Traffic Congestion in the United States, presented at the 2016 Annual Meeting of the Transportation Research Board.

Exhibit H

RESEARCH REPORT

Institute of Transportation Studies | UNIVERSITY OF CALIFORNIA

The Induced Travel Calculator and Its Applications

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February 2021

ITS UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

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16. Abstract

The National Center for Sustainable Transportation's Induced Travel Calculator (Calculator) has generated substantial interest in the professional community as a method for estimating the additional vehicle miles traveled (VMT) induced by expanding the capacity of major roadways. The Institute of Transportation Studies at the University of California, Davis (ITS-Davis) initiated a technical assistance project to support Caltrans and others in applying the Calculator. This report: (1) provides an overview of the Calculator and the induced vehicle travel effect, (2) summarizes the results from an earlier study comparing the Calculator's estimates with other induced travel analyses, (3) describes the technical assistance efforts and outcomes, and (4) discusses plans for future improvements to the Calculator. During the project, ITS-Davis advised Caltrans as it developed its Transportation Analysis Framework to guide transportation impact analysis for projects on the State Highway System. Caltrans published the final document in September 2020, in which it recommends that the Calculator be used where possible to estimate induced VMT. ITS-Davis also advised on efforts to apply the Calculator's elasticity-based method to estimate induced VMT from out-of-state highway capacity expansion projects, including projects in Portland, Oregon, Washington, D.C., Kenya, and China. In a follow-up project, ITS-Davis will work with Caltrans to improve the Calculator documentation to answer questions raised by Caltrans and others, explore possible technical improvements to the Calculator, and explore opportunities for assessing the validity of the Calculator's induced VMT estimates.

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About the UC Institute of Transportation Studies

The University of California Institute of Transportation Studies (UC ITS) is a network of faculty, research and administrative staff, and students dedicated to advancing the state of the art in transportation engineering, planning, and policy for the people of California. Established by the Legislature in 1947, ITS has branches at UC Berkeley, UC Davis, UC Irvine, and UCLA.

Acknowledgments

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Disclaimer

The Induced Travel Calculator and Its Applications

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Glossary

Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
FWHA	Federal Highway Administration
HOV	high-occupancy vehicle
HPMS	Highway Performance Monitoring System
MSA	metropolitan statistical area
NCST	National Center for Sustainable Transportation
TSN	Transportation System Network
VMT	vehicle miles traveled

Executive Summary

Executive Summary

In early 2019, the National Center for Sustainable Transportation developed and launched an online tool that allows users to estimate the additional vehicle travel induced by expanding the capacity of major roadways in California's urbanized counties (i.e., counties within Census-defined metropolitan statistical areas). The Induced Travel Calculator (Calculator) has generated substantial interest among policymakers and practitioners as a method for estimating induced vehicle miles traveled (VMT). Approximately 1,800 people used the Calculator at least once in 2020. At the Institute of Transportation Studies at University of California, Davis (ITS-Davis), we initiated a technical assistance project to support Caltrans and others in applying the Calculator.

This report describes our technical assistance efforts and outcomes, as well as our plans for future improvements to the Calculator. We also discuss the induced vehicle travel effect, our impetus for developing a tool to estimate induced VMT, and how the Calculator works. In addition, we summarize the results from an earlier study we conducted to better understand how the Calculator's induced VMT estimates compare to other induced travel analyses. In that study we applied the Calculator to estimate the VMT induced by five highway expansion projects in California and compared our estimates with the induced travel analysis completed for the projects' actual environmental impact assessments.

During the project we advised Caltrans as it developed its Transportation Analysis Framework to guide transportation impact analysis for projects on the State Highway System. Caltrans published the final document in September 2020, in which it recommends that the Calculator be used where possible to estimate—or at least benchmark—induced VMT. We also advised on efforts to apply the Calculator's elasticity-based method to estimate induced VMT from out-of-state highway capacity expansion projects, including projects in Portland, Oregon, Washington, D.C., Kenya, and China.

With growing usage, it is essential that the Calculator be maintained and, where feasible, improved to better meet transportation impact analysis needs in California and elsewhere. To that end, we will work with Caltrans on a follow-up project to: (1) improve the Calculator documentation to answer questions raised by Caltrans and others; (2) explore possible technical improvements to the Calculator; and (3) explore opportunities for assessing the validity of the Calculator's induced VMT estimates.

Contents

Introduction

Roadway capacity expansion is often proposed as a solution to traffic congestion and even as a way to reduce greenhouse gas (GHG) emissions. The cited logic is often that increasing roadway capacity increases average vehicle speeds, which improves vehicle fuel efficiency and reduces per-mile emissions of GHGs and local air pollutants. But that logic is flawed because it fails to account for the induced vehicle travel effect. Constructing new highway lanes generally increases the average speed of highway traffic and thereby reduces the effective cost of driving on the highway. That, in turn, induces more travel on the highway and more vehicle miles traveled (VMT), which often increase traffic congestion back to pre-expansion levels.

Despite its importance, the induced travel effect is often not fully accounted for in travel demand models or in the environmental review process for capacity expansion projects. This often results in agencies overestimating the benefits of highway capacity expansions (like reduced traffic congestion) and underestimating the environmental costs (like emissions of GHGs and local air pollutants) (Naess, Nicolaisen and Strand, 2012; Milam et al., 2017).

With these problems in mind, we developed an online tool to help agencies estimate the VMT induced annually by adding lanes to major roadways in California's urbanized counties. The website[1] for the Induced Travel Calculator (Calculator) went live in early 2019, and we followed its release with several education and outreach activities, including a recorded webinar[2] in May 2019. Our outreach efforts spurred continuing discussions with the California Department of Transportation (Caltrans) and others about incorporating the Calculator into environmental impact analyses for highway capacity expansion projects. Those discussions highlighted three things in particular:

1. a need to better understand how the Calculator's estimates of induced VMT compare to other induced travel analyses;
2. a need for the National Center for Sustainable Transportation (NCST) to provided continued technical assistance to agencies and other practitioners in applying the Calculator; and
3. an ongoing need to maintain the Calculator and update and improve its functionality where feasible.

We started to address the first need as part of an earlier project, where we applied the Calculator to estimate the VMT induced by five highway expansion projects in the state that had undergone environmental review within the last 15 years. This short-term follow-up project focused on the second and third needs. We provided continued advice and technical assistance to Caltrans as it formulated its Transportation Analysis Framework – its guidance for the evaluation of environmental impacts for highway projects under the California

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[1] The Calculator is currently available here: https://blinktag.com/induced-travel-calculator. Note that we might move the Calculator to a new website in the coming year. Regardless of where the Calculator is hosted, this page will always contain a link to the correct page: https://ncst.ucdavis.edu/research-product/induced-travel-calculator.

[2] Available at https://its.ucdavis.edu/webinar/a-new-web-tool-to-calculate-induced-travel.

Environmental Quality Act (CEQA). We also consulted with other agencies and practitioners about applying the Calculator, including adapting it for use outside of California. In addition, we developed a plan and obtained funding for improving the Calculator in 2021.

This report proceeds as follows. The next (second) chapter provides background on induced travel. The third chapter describes the Calculator. The fourth chapter summarizes the results from our comparative analysis of the induced VMT estimation for five capacity expansion projects in California. The fifth chapter summarizes our technical assistance efforts and outcomes. The sixth chapter discusses our plan for improving the Calculator. And the seventh chapter concludes.

Background on Induced Vehicle Travel

Induced travel is a well-documented effect in which expanding capacity on a highway (or other major roadway) increases the average travel speed on the highway or provides access to previously inaccessible areas, both of which reduce the perceived "cost" of driving and thereby induce more driving (Handy, 2015). In the shorter term, the reduced time cost of vehicle travel can cause people to substitute driving for other travel modes, elongate their driving routes, or take additional trips. These behavioral responses can affect both personal and commercial driving (Duranton and Turner, 2011; Milam *et al.*, 2017). In the longer term, it can lead people to live farther away from where they work (or vice versa) and even spur commercial or residential growth in the region (Duranton and Turner, 2011; Milam *et al.*, 2017). Figure 1 illustrates the induced travel effect.

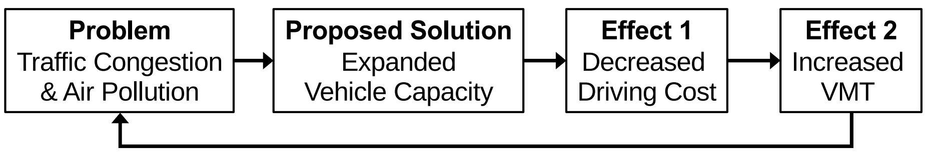

Figure 1. Induced Vehicle Travel Effect of Highway Capacity Expansions

The magnitude of the induced travel effect is typically measured as the elasticity of VMT with respect to lane miles, as shown in Equation 1. The elasticity is the percentage in VMT that results from a 1% increase in lane miles. An elasticity of 1.0 means that VMT will increase by the same percentage as the increase in lane miles.

$$\text{Elasticity} = \frac{\text{\% Change in VMT}}{\text{\% Change in Lane Miles}} \qquad \text{(Eq. 1)}$$

There is ample support in the literature for the induced travel effect. Handy and Boarnet (2014, p. 4) reviewed the induced travel studies published between 1997 and 2011 and concluded that the "best estimate of the long-run effect of highway capacity on VMT is an elasticity close to 1.0." That means that within 5 to 10 years after construction of the capacity expansion, VMT will have increased by a commensurate percentage, likely negating any initial reduction in traffic congestion.

Most recent studies have estimated elasticities in the same ballpark for capacity expansions on major roadways—like interstates, freeways, highways, expressways, and principal arterials—in urbanized areas (Duranton and Turner, 2011; Melo, Graham and Canavan, 2012; Graham *et al.*, 2014; Hsu and Zhang, 2014; Hymel, 2019). The consistency is particularly robust because the studies have used a wide range of methods to control for other VMT-inducing factors and the bi-directional relationship (simultaneity) between VMT and capacity expansion. Table 1 summarizes the five econometric studies of induced travel in urbanized areas that we identified from our review of the peer-reviewed journal literature over the last 10 years (2011-2020).

Table 1. Recent Studies Estimating Induced Travel Elasticities

Authors	Study Location	Study Years	Roadway Types	Methodology (Estimator)	Elasticity
Duranton & Turner (2011)	United States (metropolitan statistical areas)	1983–2003	Interstate highways	2-stage least squares regression with instrumental variables	1.03 (10 year)
			Other highways, principal arterials, collectors, and minor arterials	Pooled ordinary least squares	0.67–0.89 (10 year)
Melo et al. (2012)	United States (urbanized areas)	1982–2010	Arterials	Generalized method of moments	0.98 (~10 year)
Graham et al. (2014)	United States (urbanized areas)	1985–2010	Freeways and arterials	Propensity score	0.77 (~10 year)
Hsu & Zhang (2014)	Japan (urban employment areas)	1990–2005	National expressways	2-stage least squares regression with instrumental variables	1.24–1.34 (3-5 year)
Hymel (2019)	United States (urban areas)	1981–2015	Freeways and other limited-access roads	2-stage least squares regression with instrumental variables	0.89–1.06 (5 year)

Notes: Most of the studies compared multiple estimators and model specifications. The table attempts to summarize the preferred estimators and elasticities reported by the studies' authors.

The Induced Travel Calculator

A growing body of empirical evidence demonstrates the induced travel effect, and mitigating induced VMT is vital to reducing GHG emissions. Nonetheless, induced travel is often not fully accounted for in travel demand models or in the environmental review process for capacity expansion projects (Naess, Nicolaisen and Strand, 2012; Milam *et al.*, 2017). The primary issue is that most models do not include all of the feedback loops necessary to capture the behavioral changes caused by capacity expansion (Milam *et al.*, 2017; Litman, 2019). For example, not many models feed changes in estimated travel times back into the trip distribution or trip generation stages of the model, which ignores the possibility that improved travel times from a capacity expansion will: (a) increase the number of trips that households and freight operators choose to make, or (b) cause them to choose more distant trip destinations. Neither do most models feed changes in estimated travel times back into assumptions about the growth and distribution of population and employment.

With these limitations in mind, we developed an online tool to help agencies estimate the VMT induced annually by adding lanes to major roadways in California's urbanized counties. We followed Milam et al.'s (2017, p. 6) recommendation to produce "elasticity-based estimates of VMT levels derived from the project's lane mile changes" and the elasticity values reported in the literature. The Induced Travel Calculator estimates project-induced VMT using the project length entered by the user, lane-mile and VMT data from Caltrans, and estimates of elasticities from peer-reviewed studies. To estimate the induced VMT for capacity expansion projects, the Calculator solves the following equation (Equation 2) based on the user-specified project geography and lane mile length:

$$\% \, \Delta \text{ Lane Miles} * \text{Existing VMT} * \text{Elasticity} = \text{Project-Induced VMT} \qquad \text{(Eq. 2)}$$

The Calculator produces long-run estimates of induced VMT—the additional annual VMT that could be expected 5 to 10 years after facility installation. All estimates account for the possibility that some of the increased VMT on the expanded facility is traffic diverted from other types of roads in the network, though the studies generally show that "capacity expansion leads to a net increase in VMT, not simply a shifting of VMT from one road to another" (Handy & Boarnet, 2014, p. 5).

The Calculator currently applies only to public (not private) facilities with Federal Highway Administration (FHWA) functional classifications of 1, 2, or 3 in one of California's urbanized counties (the 37 counties within a metropolitan statistical area [MSA]). That corresponds to interstate highways (class 1), other freeways and expressways (class 2), and other principal arterials (class 3). The Calculator is also limited to use for capacity expansions (lane additions, roadway lengthening, and new facility construction). It cannot be used to estimate the VMT effects of capacity reductions, and it should not be used to estimate the induced VMT from lane type conversions without supplemental analysis. In addition, the Calculator is conservatively limited to use for additions of general-purpose and high-occupancy vehicle (HOV) lanes. It should not be used to estimate induced VMT from additions of toll lanes without supplemental analysis. Other caveats also apply to using the Calculator, which are enumerated on the Calculator website.[3] We describe below the data sources and specifications for the inputs to the Calculator equation.

Lane Mile Data

The Calculator uses 2016 lane mileage data from Caltrans' Transportation System Network (TSN) database (similarly reported in the Highway Performance Monitoring System [HPMS]). The percent change in lane miles is calculated by dividing the number of project-added lane miles (input by the user) by the total lane miles of the same facility type in the same geography. For interstate highways (FHWA functional class 1), lane mileage is calculated at the MSA level. For other Caltrans-managed freeways, expressways and major arterials (classes 2 and 3), lane mileage is calculated at the county level. The choice of geographies is discussed further below, in conjunction with elasticities. The data are available on the Calculator website.

VMT Data

The Calculator uses 2016 VMT data retrieved using Caltrans' TSN and HPMS database. The VMT is tallied for each county and each FHWA functional classification. Existing VMT on interstate highways (FHWA functional class 1) is calculated at the MSA level, and existing VMT on other Caltrans-managed freeways, expressways, and major arterials (classes 2 and 3) is calculated at the county level. The data are available on the Calculator website.

Elasticities

The Calculator uses an elasticity of 1.0 for lane additions to interstate highways, and an elasticity of 0.75 for lane additions to class 2 or 3 facilities.

For interstate highways (class 1 facilities), the 1.0 elasticity derives from Duranton and Turner (2011) and is consistent with the more recent studies that likewise use robust statistical methods to estimate induced travel elasticities while addressing the simultaneity bias (the fact that increasing VMT can spur roadway expansion in addition to being caused by it) (see Table 1). At the time we developed the Calculator, Duranton and Turner (2011) was the most recent study we could find that used data across broad areas of the United States to estimate induced travel elasticities for class 1 facilities. And it remains perhaps the most thorough and stringently vetted induced travel study to date. Duranton and Turner's study used data from 1983, 1993, and 2003 for all MSAs in the US that had nonzero interstate lane mileage in all three years. Among other modeling, the study used a two-stage least squares regression with three instrumental variables to estimate the elasticity

[3] The Calculator is currently available here: https://blinktag.com/induced-travel-calculator. Note that we might move the Calculator to a new website in the coming year. Regardless of where the Calculator is hosted, this page will always contain a link to the correct page: https://ncst.ucdavis.edu/research-product/induced-travel-calculator.

of vehicle kilometers traveled on interstate highways in the 228 studied MSAs with respect to interstate lane kilometers in those MSAs. The authors concluded that their estimation method better controls for the possible bi-directional relationship between VMT and lane miles than do the methods used in previous studies. Using that "preferred estimation method," their "preferred estimate" was a long-run (10-year) elasticity of 1.03. However, while the authors concluded that "diversion of traffic from other road networks does not appear to play a large role," they cautioned that they could not "rule out the absence of a substitution effect" (p. 2646). They estimated that the "diversion of traffic from other classes of roads accounts for between 0 and 10 percent of the total [induced] interstate VKT [vehicle kilometers traveled]" (p. 2644).

Like Duranton and Turner (2011), the Calculator uses MSAs as the unit of analysis for interstate highway capacity expansions. The Calculator also uses a similar VMT elasticity (1.0), albeit rounded down (in part to account for the small potential substitution effect). That accords with Handy and Boarnet's (2014) conclusion that the best estimate for the long-run VMT elasticity for highway lane additions is close to 1.0. It is also consistent with the more recent econometric studies that have estimated long-run induced VMT elasticities (Table 1).

For other publicly managed highways, expressways and major arterials (class 2 and 3 facilities), the 0.75 elasticity derives from Duranton and Turner (2011) and Cervero and Hansen (2002), as well as the subsequent studies summarized in Table 1. While Duranton and Turner (2011) could not use their preferred method to estimate elasticities for state highways and other "major roads"[4] besides interstates, their elasticity estimates using ordinary least squares regression all fall between 0.67 and 0.89. Cervero and Hansen (2002) similarly estimated an intermediate-run (5-year) VMT elasticity of 0.79 for lane mile additions to state-owned roadways in California's urbanized counties (then numbering 34, and now 37), using three-stage least squares regression. Those elasticities are similar to other longer-term elasticities calculated for combined major road types (not just interstate highways) in California and across the US (see Table 1 for recent studies; see Handy and Boarnet (2014) for earlier studies).

Like Cervero and Hansen (2002), the Calculator uses urbanized counties (those within MSAs) as the unit of analysis for capacity expansions on non-interstate highways, expressways, and major arterials managed by a governmental agency (mostly Caltrans). The Calculator also uses a similar VMT elasticity (0.75) for those facilities as Cervero and Hansen (2002) estimated for state-owned and maintained roadways (0.79), and within the range Duranton and Turner (2011) found for non-interstate "major roads" in the urbanized areas of MSAs (0.67 to 0.89). The Calculator's 0.75 elasticity is rounded down from the estimates of Cervero and Hansen (2002) and Duranton and Turner (2011), in part to account for the small potential substitution effect discussed in Duranton and Turner (2011). The 0.75 elasticity is also consistent with the longer-term elasticities calculated in other recent studies for combined major road types in the US (Melo, Graham and Canavan, 2012; Graham *et al.*, 2014; Hymel, 2019).

[4] Besides non-interstate highways, these "major roads" included principal arterials, minor arterials, and collectors.

Comparing the Calculator Estimates to the Induced Travel Analyses for Five Highway Projects in California

Our conversations with Caltrans and others highlighted a need to better understand how the Calculator's induced VMT estimates compare to other induced travel analyses. We started to address that need as part of an earlier project, where we applied the Calculator to estimate the VMT induced by five highway expansion projects in the state that had undergone environmental review within the last 15 years. The five projects are: (1) the U.S. Highway 101 HOV Widening (Marin-Sonoma Narrows), (2) State Route 1 Corridor Analysis of HOV Lanes (Santa Cruz), (3) the State Route 210 Mixed-Flow Lane Addition (San Bernardino), (4) the State Route 99 South Stockton Six-Lane Project, and (5) the Interstate 405 HOV Widening. After estimating each project's induced VMT using the Calculator, we compared each estimate with the corresponding induced travel analysis completed for the project's actual environmental impact assessments (Volker, Lee and Handy, 2020).

We found that the environmental analysis documents for the five projects varied wildly in their discussion of induced vehicle travel impacts. Two documents did not discuss the induced travel phenomenon at all. And the only two documents to analyze it in detail did so in responses to comments, not in the original analysis. Even when the documents did analyze induced travel in detail, the discussion of the effect was internally inconsistent and inconsistent with the induced travel literature.

In terms of quantitative analysis, three of the five documents reported estimates of induced VMT. And all three estimates were lower than what we estimated using the Calculator. In two of the three cases, the estimates were an order of magnitude lower. Figure 2 compares the estimates.

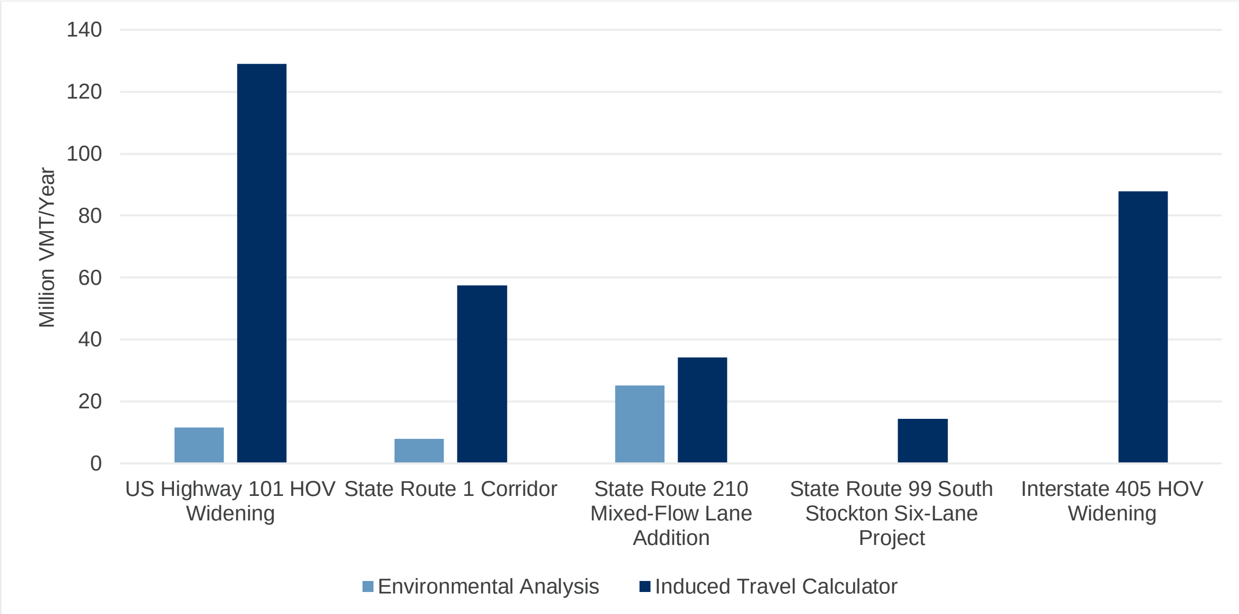

Figure 2. Induced VMT Estimates for the Five Highway Expansion Projects

Overall, our results provide additional evidence that environmental analyses often fail to consistently and accurately discuss—let alone estimate—the induced travel effects of highway capacity expansion projects. Our full analysis is published in the Transportation Research Record: Journal of the Transportation Research Board (Volker, Lee and Handy, 2020).

Technical Assistance Efforts and Planned Improvements to the Calculator

Our conversations with Caltrans and others highlighted several needs in addition to better understanding how the Calculator compares to other induced travel analyses. These additional needs were: (1) for NCST to provided continued technical assistance to agencies and other practitioners in applying the Calculator; and (2) ongoing maintenance of the Calculator, and updates and improvements to its functionality where feasible. This short-term project focused on those two goals. We summarize our efforts and upcoming plans below.

Technical Assistance

Throughout 2020, we were in frequent communication with staff at Caltrans and other practitioners about how to use the Calculator more formally in environmental analyses of highway expansion projects, both in California and elsewhere. Most prominently, we provided technical assistance to Caltrans as it developed its Transportation Analysis Framework, which helps guide CEQA transportation impact analysis for projects on the State Highway System. That technical assistance entailed numerous emails and calls regarding how the Calculator works, the research and data that underpins it, and potential ways to improve the Calculator and the information on the Calculator website. We also conducted further literature reviews as part of this process and iteratively updated the Calculator website along the way. In addition, Dr. Handy was a panelist on the expert panel convened by Caltrans to guide its choice of induced travel estimation methods for the Transportation Analysis Framework. Dr. Volker also consulted with the panel in an informal capacity. Caltrans published the Transportation Analysis Framework in September, in which it recommended that the Calculator be used where possible to estimate—or at least benchmark—induced VMT: “In cases where the NCST Calculator can be directly used, it should either be used exclusively or used to benchmark results from a [travel demand model]” (California Department of Transportation, 2020, p. 14).

In addition to working with Caltrans, we also communicated about the Calculator with other agencies, NGOs, consultants, academics, and other interested people, primarily in response to queries about how to apply the Calculator (or induced travel concepts generally) to analyze highway capacity expansion projects, including projects elsewhere in the United States (outside of California) and even internationally. For example, we consulted with the Institute for Transportation and Development Policy about estimating the induced VMT from two proposed highway project in other countries. We advised consultants regarding estimating induced travel from highway projects in the Washington, D.C. and Portland, Oregon regions. We met with the Regional Modeling Working Group in the San Francisco Bay Area to discuss the Calculator. And we frequently receive and respond to informational queries about the Calculator from members of the public.

Overall, our technical assistance efforts have both responded and contributed to the substantial interest in the Calculator. Across the last calendar year (2020), approximately 1,800 people used the Calculator at least once, according to Google Analytics.

Updating and Improving the Calculator

Particularly now that Caltrans has recommended using the Calculator in transportation impact analyses for projects on the State Highway System, it is essential that the Calculator be maintained and, where feasible, improved to better meet transportation impact analysis needs in California and elsewhere. To that end, we executed a contract agreement with Caltrans (State Agreement 65A0686) to explore, implement, and recommend possible improvements to the Calculator. More specifically, we plan to do three things.

First, we will improve the Calculator documentation to answer questions raised by Caltrans and others. That will include adding an FAQ page to the website, with answers to frequently asked questions like these:

- Are auxiliary lane miles included in the data used to estimate the elasticities?
- Is truck VMT included in the estimates of the elasticities?
- How do the econometric methods used in the empirical studies from which the elasticities are taken control for factors such as population growth, economic downturn, and gas price change?
- Is it appropriate to apply lower elasticities in areas with less traffic congestion?

Second, we will explore possible technical improvements to the Calculator. These include both near-term improvements based on available research and data, as well as long-term improvements that would require additional research and/or data collection. Potential improvements we will explore include the following:

- Updating the lane mile and VMT data from 2016 to more recent data;
- Applying the Calculator to toll lanes;
- Providing induced VMT estimates specific to general purpose lanes, HOV lanes, and high-occupancy toll lanes;
- Allowing users to adjust the induced VMT calculations based on project context; and
- Providing guidance using an elasticity-based method to estimate induced VMT from projects outside of California.

Third, we will explore opportunities for assessing the validity of the Calculator’s induced VMT estimates. This might involve, for example, applying the Calculator to actual projects in a variety of contexts and comparing its estimates to those from travel demand models. However, a true validation of the Calculator might not be possible, given the long periods of time over which projects are constructed and induced travel effects occur, as well as the challenge of isolating the effect of capacity expansion from the effects of other factors in real-world settings.

Conclusion

The induced travel effect is often not fully accounted for in travel demand models or in the environmental review process for capacity expansion projects. We developed an online tool—the NCST Induced Travel Calculator—to help agencies estimate the VMT induced annually by adding lanes to major roadways in California's urbanized counties. We also provided technical assistance on the Calculator and induced VMT estimation to Caltrans, other agencies, NGOs, consultants, academics, and other interested people. Caltrans now officially recommends using the Calculator in transportation impact analyses for projects on the State Highway System. Efforts have also been made to apply the Calculator's elasticity-based method to estimate induced VMT from out-of-state highway capacity expansion projects. With growing usage, it is essential that the Calculator be maintained and, where feasible, improved to better meet transportation impact analysis needs in California and elsewhere. To that end, we have a new contract with Caltrans to (1) improve the Calculator documentation to answer questions raised by Caltrans and others; (2) explore possible technical improvements to the Calculator; and (3) explore opportunities for assessing the validity of the Calculator's induced VMT estimates.

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Exhibit I

Transportation Analysis Framework

First Edition

Evaluating Transportation Impacts of State Highway System Projects

California Department of Transportation
Sacramento, California
September 2020

ACKNOWLEDGEMENTS

The *Transportation Analysis Framework* (TAF) and *Transportation Analysis Under CEQA* (TAC) were prepared by the California Department of Transportation working with State Administration partners and Stakeholders from the public, private and non-profit sectors. Contributors within the Department included staff and management from the Headquarters Divisions of Environmental Analysis, Transportation Planning, Traffic Operations, and Legal, as well as from the Director's Office Sustainability Team. The Headquarters team benefitted from input provided by the Caltrans Executive Team as well as by staff and management from Caltrans districts.

The documents are the products of a collaboration among State government partners. Throughout the development of the documents, the Caltrans team worked closely with technical and policy experts from the Governor's Office of Policy and Research and the California Air Resources Board.

A list of the individuals who contributed to the preparation of the TAF and TAC is included at the end of this document. We are grateful for the time and effort that they generously gave to develop and document the Department's new approach to analyzing and evaluating transportation impacts of projects on the State Highway System.

LETTER FROM THE DIRECTOR

To Caltrans staff, partners, and stakeholders,

I am pleased to issue the enclosed guidance document: *Transportation Analysis Framework* (TAF) as part of the California Department of Transportation's (Caltrans) continuing commitment to implement the California Environmental Quality Act (CEQA) in alignment with State goals and policies. The TAF, and its companion document, *Transportation Impacts Analysis under CEQA for Projects on the State Highway System* (TAC) provides Caltrans policy along with guidance for implementing Senate Bill (SB) 743 (Steinberg, 2013) codified at Public Resources Code section 21099.

The new processes being implemented through Caltrans' environmental program are a key part of Caltrans' increasingly important work to confront the challenge of climate change and build more livable communities. Caltrans is actively implementing strategies to reduce emission of greenhouse gases, including initiatives to use clean fuels and vehicles, and to reduce waste. Perhaps most importantly, we are rethinking the way we invest so people can drive less.

Reducing total driving, or Vehicle Miles Traveled, is the focus of the TAF, TAC and the associated changes to transportation impact analysis under CEQA for projects on the State Highway System. In plain terms, the more we drive our cars, the more damage we cause to the environment and our health—and the less time we spend with our families and communities. A Vehicle Miles Traveled-based approach supports transportation projects that create more travel choices, such as new rail lines, improved bus service, trails, paths, and safer streets for walking and bicycling. As these modes of transportation grow, we can reduce the dependence and burden on our already congested highway system.

Thank you to our partners and stakeholders, as well as to Caltrans staff, whose contributions have helped to shape this document. I look forward to your continued partnership as we make the changes needed to meet California's goals for climate, air quality, and public health. It's an exciting time to continue our commitment to provide more transportation options to Californians and reduce our dependence on driving.

Sincerely,

Toks Omishakin
Director

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FOREWORD

The *Transportation Analysis Framework* (TAF) and *Transportation Analysis under CEQA* (TAC) guide CEQA transportation impact analysis for projects on the State Highway System (SHS). The California Department of Transportation (Caltrans) has prepared these documents to guide implementation of Senate Bill (SB) 743 (Steinberg, 2013). The TAF and TAC establish Caltrans guidance on how to analyze induced travel associated with transportation projects and how to determine impact significance under CEQA, respectively. These documents guide transportation impact analysis for projects on the SHS only. The non-capacity-increasing maintenance projects like re-paving and filling potholes are unaffected, as are many safety improvements, including traffic calming measures to slow traffic, and transportation projects that create facilities for pedestrians and cyclists and transit projects.

In response to a high level of interest in the guidance from Caltrans' transportation partners, climate and environmental advocates and others, Caltrans has hosted a total of 130 meetings with stakeholders and provided a 60-day informal feedback period on the draft documents. Statewide outreach events included two external webinars attended by over 850 participants, and three external technical roundtables attended by more than 150 participants. These Caltrans events were supplemented by OPR's webinar and Office Hours outreach which reached over 3,500 participants. Additionally, Caltrans met regularly through the guidance development process with key stakeholders including the Self-help Counties Coalition, the ClimatePlan coalition, and the Rural Counties Task Force.

Caltrans received feedback on the drafts from 37 agencies including counties, cities, and MPOs as well as from consultants, advocates, coalitions and other State agencies. Throughout the process, a small number of controversial issues stood out. To address the difference of opinions around key technical issues, Caltrans convened an expert panel of academics and practitioners through UC Berkeley Tech Transfer. The panel chair presented the group's conclusions to stakeholders at a virtual Technical Roundtable prior to finalizing the group's recommendations. Caltrans and State partners have accepted the panel's recommendations, which are reflected in the guidance documents.

The Caltrans TAF and TAC guidance documents reflect a cultural shift for how Caltrans interprets, analyzes and mitigates transportation impacts. This shift will impact the entire project delivery process and shape the future of California's transportation system. The September 2020 TAF and TAC are the first versions of these materials, and we anticipate future improvement as our understanding and expertise deepens through implementation. Your continuing input and partnership with Caltrans will help further improve the guidance. Your commitment and participation in this ongoing work is appreciated.

1 INTRODUCTION

1.1 OVERVIEW OF GUIDANCE DOCUMENTS

This document, *Transportation Analysis Framework: Evaluating Transportation Impacts of State Highway System Projects (TAF)* is one component of a set of materials prepared by Caltrans to guide the implementation of SB 743 (Steinberg, 2013). The TAF is a companion to the *Transportation Analysis under CEQA (TAC)*, which describes changes to the environmental review process for many projects on the State Highway System (SHS). These changes better align the analysis of transportation impacts with State objectives for greenhouse gas emissions reduction, preservation of the environment, and public health. Practitioners should consult both documents in conducting a transportation analysis.

Additionally, the Governor's Office of Planning and Research (OPR) has prepared a Technical Advisory on *Evaluating Transportation Impacts in CEQA* (OPR 2018) to assist agencies conducting a transportation impact analysis for both land use and transportation projects based on Vehicle Miles Traveled (VMT). Caltrans relied on OPR's recommendations in developing this guidance. Practitioners should consult the OPR Technical Advisory when evaluating transportation impacts of projects on the SHS.

1.2 PURPOSE OF THE TRANSPORTATION ANALYSIS FRAMEWORK

The purpose of this *Transportation Analysis Framework* is to assist Caltrans district staff and others responsible for assessing likely transportation impacts as part of environmental review of proposed projects on the SHS by providing guidance on the preferred approach for analyzing the VMT attributable to proposed projects (induced travel) in various project settings. The TAF and TAC together provide the guidance needed to implement amendments to the 2018 CEQA Guidelines and Caltrans policy for analyzing transportation impacts. The policy states:

Consistent with the language of Section 15064.3 of the CEQA Guidelines, Caltrans concurs that VMT is the most appropriate measure of transportation impacts under CEQA. The determination of significance of a VMT impact will require a supporting induced travel analysis for capacity-increasing transportation projects on the SHS when Caltrans is lead agency or when another entity acts as the lead agency.

Many types of projects will be unaffected by the use of VMT as the metric for determining transportation impacts because they are assumed not to lead to a substantial increase in vehicle travel. See Section 5.1 of the TAC for further detail regarding screening. Note that for transportation projects not on the SHS, per the CEQA Guidelines, local agencies have the discretion to select a different metric for determining transportation impacts.

This Framework focuses on the analysis of transportation impacts only. It is not intended to supersede guidance for analysis under CEQA of other resources (such as air quality or noise) or under the National Environmental Policy Act (NEPA). Those analyses have their own distinct requirements.

The TAF is to be used in conjunction with the guidance provided in the TAC. The flow chart provided in Figure 1 illustrates the steps for transportation impact analysis using the TAC and TAF. As shown, if a project is determined to be of a type that is likely to induce travel, the analyst follows the framework described in the TAF. The TAF framework should be applied to the proposed project and all project alternatives. The results of applying the TAF's analytical framework is intended to provide the substantive information from which significance determinations under CEQA can be made, as further described in the TAC.

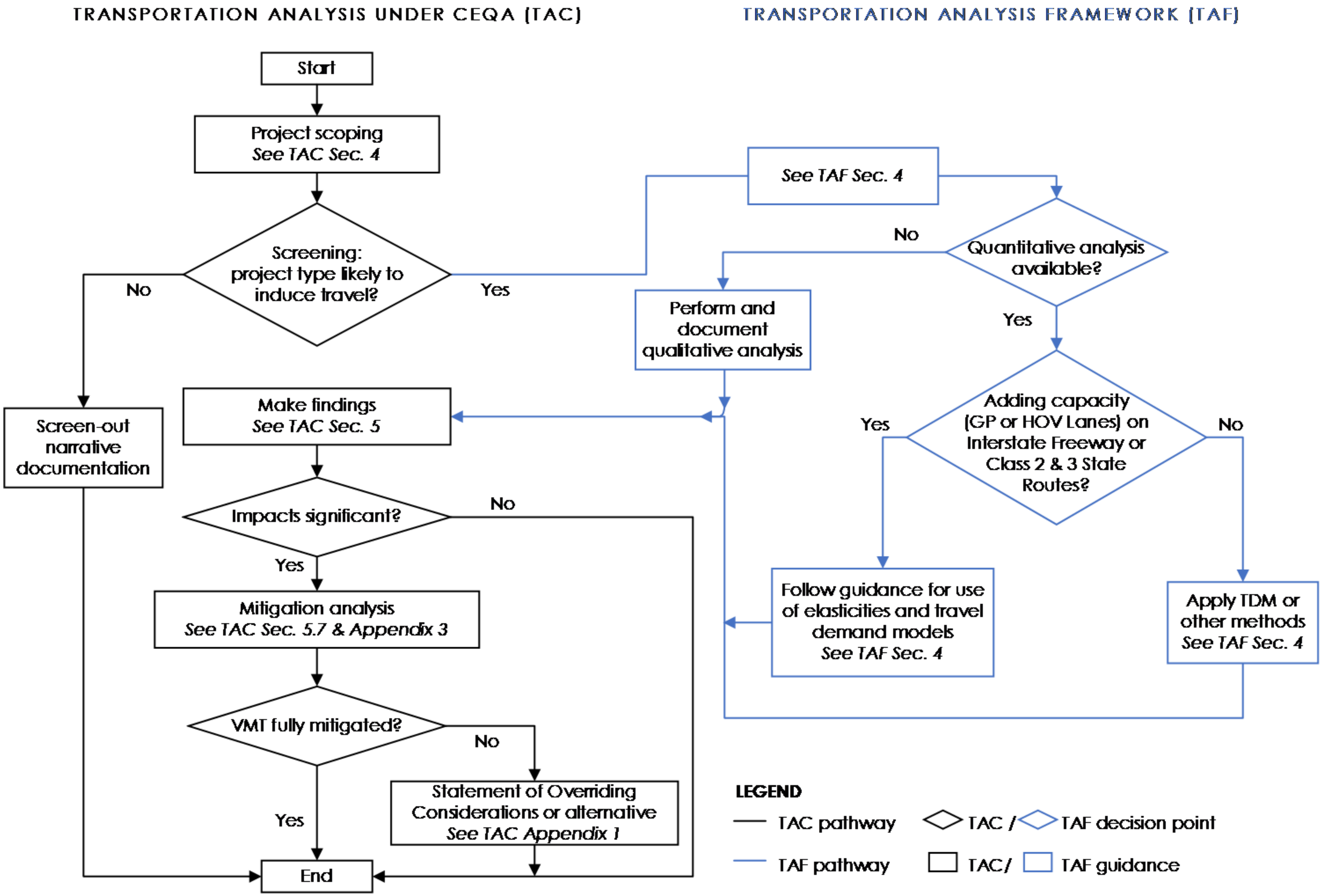


Figure 1. Steps in CEQA Transportation Impact Analysis for SHS Projects

2 FUNDAMENTALS

2.1 Focus of Transportation Impact Analysis

CEQA analysis of transportation impacts of proposed projects on the SHS focuses on the amount of driving attributable to the proposed project, measured as change in VMT. CEQA requires identifying, assessing and disclosing potentially adverse environmental impacts resulting from a project, i.e. impacts that would not occur but for the project. Generally stated, the transportation impact of a roadway project is the overall increase in VMT that is attributable to the project, distinct from any background changes in VMT due to other factors such as population or economic growth. The transportation impact is the difference in VMT with the project and without the project. The difference in VMT may be negative for some projects that reduce VMT; zero for projects which do not affect VMT or positive for those projects which are associated with an increase in VMT. The analysis reflects the phenomenon of induced travel, which is discussed below.

Generally, the project types associated with an increase in the total amount of driving are projects that add passenger vehicle and light duty truck capacity to the SHS. Many project types, including maintenance and rehabilitation projects as well as most safety projects, will be identified as unlikely to induce travel, requiring only screening and a narrative documenting that analysis and conclusion. Such projects are identified through the screening process depicted in Figure 1 and discussed in Section 5 of the TAC. Other types of projects are specifically excluded from transportation impact analysis process. These types of projects typically include pedestrian, bicycle and transit infrastructure projects.

2.2 Induced Travel Definition and Illustration

2.2.1 INDUCED TRAVEL DEFINITION

When transportation system changes effectively reduce the cost of travel to individuals and businesses, there is typically a change in user behavior. Induced travel is the term used to describe this phenomenon, which is illustrated conceptually in Figure 2. The reduction of travel time from T_1 to T_2 ($T_1>T_2$) due to network improvement leads to increased VMT from VMT_1 to VMT_2 ($VMT_1<VMT_2$).The reduced "cost" may be due to reduced travel time as shown in Figure 2, increased reliability, lower price, or some combination of factors.

The induced travel phenomenon manifests itself in multiple ways:

- Longer trips. The ability to travel a long distance in a shorter time increases the attractiveness of destinations that are farther away, increasing trip length and vehicle travel.

- Changes in mode choice. When transportation investments reduce automobile travel time, travelers tend to shift toward automobile use from other modes, increasing vehicle travel.
- Route changes. Faster travel times attract more drivers to the altered route, which can increase or decrease VMT, depending on whether trips are shortened or lengthened.
- Newly generated trips. Shorter travel times can induce additional trips, which increases vehicle travel. For example, an individual who previously telecommuted or shopped online might choose to accomplish those tasks with car trips as they become quicker and less stressful.
- Location and land use changes. In choosing where to live or where to locate or expand a business, households and investors take travel costs into account. In choosing where to allow development, local governments take available capacity into account, as do investors in new development. Over the long term, changes associated with these decisions lead to further changes in the other aspects of travel (routes, modes, destinations, number of trips made) as people adjust to the choices available at the new location.

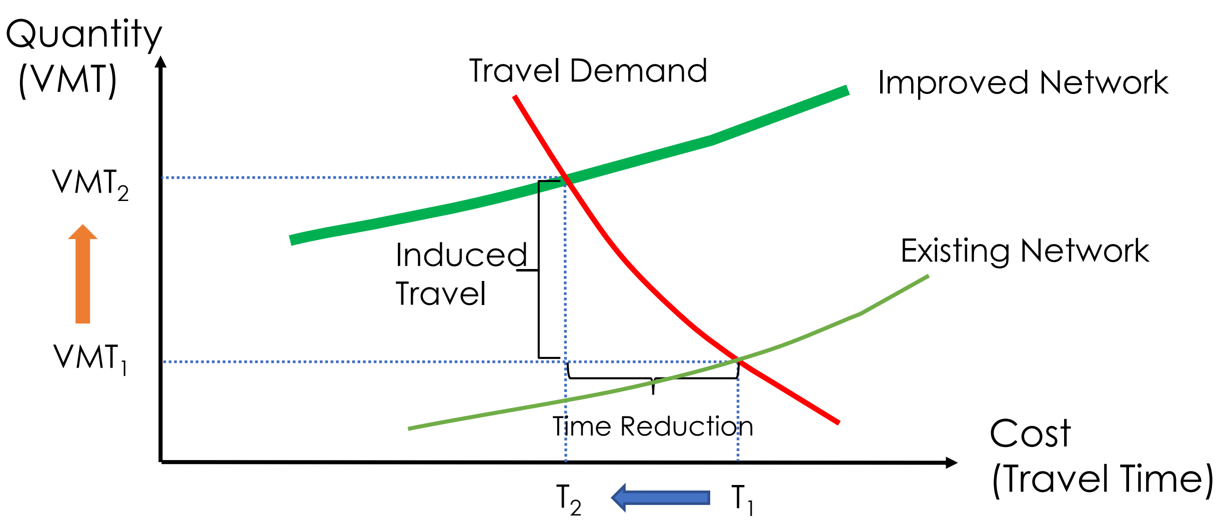
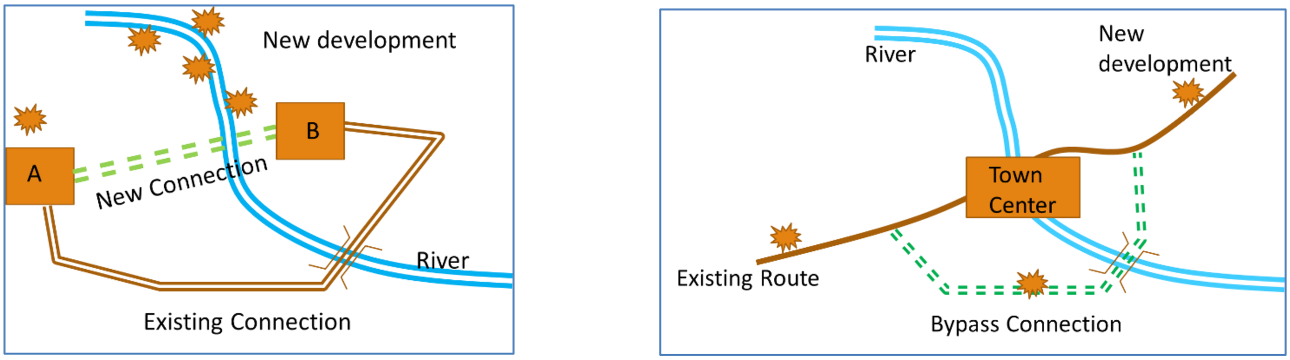


Figure 2. An Illustration of Induced Travel due to Reduced Travel Time

A variety of road project types can create the conditions where induced travel can occur (Noland and Lem, 2002). Importantly, induced travel is not limited to increased travel on the facility that has been changed. Trip-making in a wider area will be affected because of the various types of change described above. As illustrated conceptually in Figure 3a, a new connection across a natural barrier, a river in this case, may not only see increased travel between the points that directly benefit from the new connection (Town A and Town B); but may also alter travel patterns in a wider area. In the longer term, the nearby areas may see new development that would not have occurred in the absence of the increased transportation network capacity. In Figure 3b, the bypass will not only divert traffic away from the town center but may in the longer term generate development along the new connection and alter the travel pattern of the entire area. For example, town center stores may give way to big box stores along the new connection, stimulating additional driving.



(a) (b)

Figure 3. Connectivity and Induced Travel - Conceptual Sketches

As noted above, the changes in travel are not limited to the specific project and its environs, nor do they necessarily appear immediately; some of these changes are seen in the short term and in the project corridor, while others occur over a wider area (potentially, the commute shed and beyond) and play out over a time frame of many years. Some academic studies of the induced travel effect quantify both "short run" and "long run" induced travel effect magnitudes. Generally, "short run" magnitudes measure induced travel that occurs in the first year or two, while "long run" magnitudes measure induced travel that occurs in 5-10 years. The long-run induced travel effect that combines direct impacts with the indirect impacts stimulated by land use change is the full effect of a project. Even roads that simply provide greater access under conditions of no congestion may facilitate development in locations that lead to increased travel.

Additional vehicle travel provides additional mobility benefits to users and may also support expanded access to housing and employment opportunities. However, additional travel also tends to increase negative externality costs. Induced travel will reduce the effectiveness of capacity expansion as a strategy for alleviating traffic congestion and may reduce the benefits of such projects in lowering emissions. Mobility and accessibility increases can still be valuable, but their benefits may be offset partially or entirely by the impacts of added travel.

2.2.2 INDUCED TRAVEL - ILLUSTRATION

With a hypothetical project, Figure 4 illustrates the induced travel effect unfolding over time. The baseline trend, shown in the figure by the line labeled "VMT Without Project", shows the VMT on the network growing over time, perhaps the result of population and/or economic growth. On the other hand, the increase in vehicle travel associated with the increase in network capacity is shown by the line labeled

"VMT With Project". The VMT attributable to the project, or induced travel, is the difference between VMT on the network with the project compared to VMT on the network without the project counted in the horizon year.

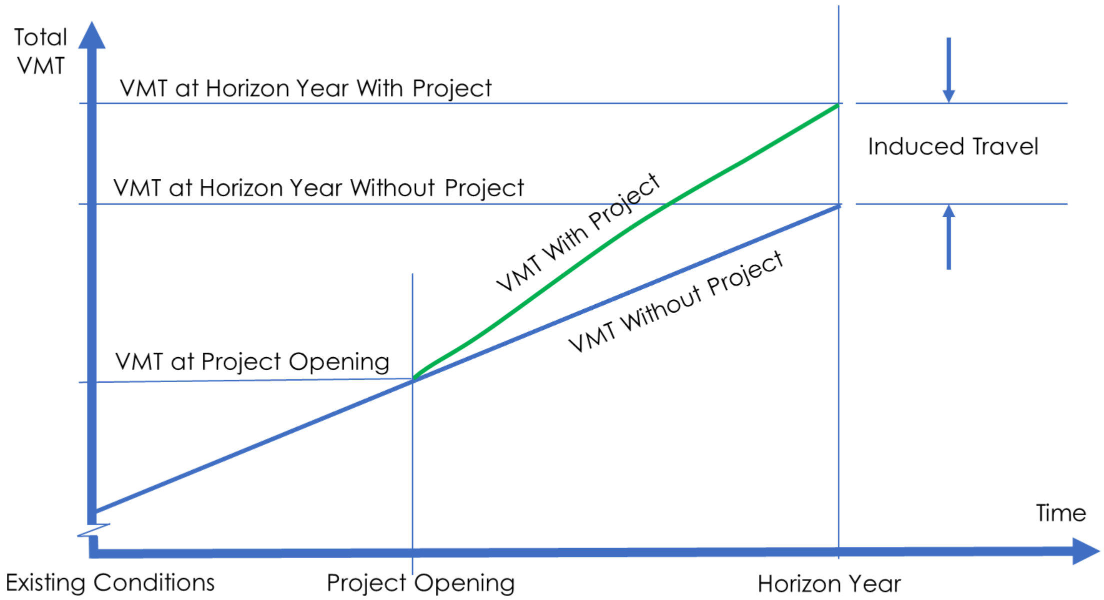


Figure 4. Identification of Induced Travel (VMT Attributable to a Transportation Project)

While the theory behind induced travel is straightforward, empirically estimating this effect has proven to be complicated, as a brief overview of the literature illustrates. The extent to which travel changes occur depends on the elasticity of travel demand, but how to estimate that elasticity and its effects over a network and over time has been debated. The next section of the TAF describes the most common tools for estimating induced travel. Section 4 then provides guidance on selecting the appropriate tools for analysis of specific projects. See, e.g., literature reviews in Cervero, 2002; Noland and Lem, 2002; Duranton and Turner, 2011; Handy and Boarnet 2014a; Handy and Boarnet 2014b; and Milam et al. 2017.

3 TOOLS FOR ESTIMATING INDUCED TRAVEL

3.1 OVERVIEW

Projecting the amount of induced travel attributable to a project is complex. Travel growth associated with overall population and economic growth need to be separated from the likely effects of system investments, and changes can occur over many years and a large area. It is not a simple matter of monitoring traffic on the particular facility and its immediate environs, because some of the travel changes are likely to affect other elements of the overall transportation system. As described above in Section 2, induced travel can result in trips diverted to different routes, trips switched to different modes; longer trips reflecting the choices of farther destinations, and additional trips. In addition, transportation improvements can affect the relative attractiveness of different locations for both housing and commercial development, leading to land development projects that in the longer term can reshape the pattern of activity and trip making in the region. Because of these complexities, studies of induced travel have turned to a variety of models to help identify the key factors affecting VMT.

Methods used to study induced travel include models specifically investigating the effects of transportation investments on induced travel, travel demand models designed for multiple analysis and forecasting tasks and sometimes used to estimate the share of travel that is induced, and case studies of travel growth and its causes in particular corridors and regions. The guidance provided in Section 4 directs CEQA practitioners to select and apply a single method or a combination of methods based on project characteristics and context and the applicability of the available tools. A general discussion of the two primary tools available for estimating induced travel in connection with infrastructure investments is provided below. Elasticity-based methods including the National Center for Sustainable Transportation (NCST) induced travel calculator are discussed in Section 3.2 and use of travel demand models is discussed in Section 3.3.

3.2 ELASTICITY-BASED METHODS

A key approach in representing the induced travel effect is reporting it as an elasticity based on empirical studies of changes in travel associated with past increases in roadway capacity. Mathematically, the elasticity of VMT is the percent increase in VMT associated with a given percent increase in roadway lane miles. Over time, both short-term and longer-term estimates of the elasticity of VMT with respect to highway improvements (most commonly measured in lane miles) have been produced for different types of facilities and for different geographic scales, with increasingly sophisticated methods controlling for the overall effects of growth and other factors also affecting VMT.

The NCST at the University of California at Davis has developed an online tool, the NCST induced travel calculator, that uses elasticities to estimate induced travel associated with the addition of new general purpose (GP) or high occupancy vehicle (HOV) lanes on the SHS. Guidance for the use of the NCST induced travel calculator, (referred to here as "the NCST Calculator" or "the Calculator"), is provided in Section 4. This Section describes strengths and limitations of the Calculator to provide users with a deeper understanding of this tool.

The NCST Calculator incorporates elasticities of VMT with respect to capacity increases, drawing on the best available peer-reviewed papers on the topic; other recent high-quality studies have reported similar elasticities to those used in the Calculator (NCST 2019a; NCST 2019b; and Panel Report 2020). The cited studies control for other factors that could confound the estimates. The use of these elasticities in the estimation of induced travel is reasonable. However, analysts need to be aware that they are long-term average elasticities for the particular highway types and contexts studied. Some project-to-project variation is to be expected. Recognizing this, the guidance in Section 4 advises using the Calculator's results to benchmark results from other methods, and it also provides analysts with an opportunity to document why particular projects can be reasonably expected to result in changes that vary more substantially from the Calculator's results.

The panel of academics and practitioners that advised the team developing this guidance concluded that:

- The peer-reviewed studies the Calculator has chosen to rely upon are widely considered to be the best available, and other recent studies have found similar elasticities, adding credence to those used by the Calculator;
- The standard errors for the models estimating the elasticities are reported in the papers and are at acceptable levels;
- The elasticities extracted from the studies account for the full set of possible impacts and distinguish infrastructure-induced VMT impacts from other factors that could be driving observed changes (e.g., general growth in population and economic activity);
- Since the elasticities in the calculator are based on traffic count and lane mileage data and are derived from econometric analyses that use advanced methods to control for possible confounding variables, they are a strong indicator of likely regional average, long-run responses (Panel Report 2020).

The Calculator elasticities are long-term elasticities. Some studies such as Cervero and Hansen (2002) also produce short-term elasticities, either by looking at a short time frame or by omitting factors that tend to appear over the longer term, such as land use changes. ("Short term" in this context means under five years and can be as little as a year or two; "long term" can be 10 years into the future.) While the studies in the literature use differing time frames, there is no clear conclusion to be drawn from the literature regarding how fast the changes occur. Highly congested areas are likely to have considerable unsatisfied demand for travel; and therefore, the response to new capacity may be rapid. Areas at the urban fringe have also been found to generate high levels of induced traffic, more likely to manifest over time, as new facilities alter development opportunities, business and housing locations, and users' overall travel patterns.

3.2.1 SENSITIVITY TO DIFFERENT PROJECT TYPES

Any project that adds capacity to the SHS has the potential for generating additional travel. However, the studies used to construct the NCST Calculator are limited to only GP and HOV lane facilities; and thus, the Calculator is applicable for assessing induced travel of GP and HOV lane addition only and not for special purpose lanes such as high-occupancy toll (HOT)/ managed lanes or truck lanes. The Calculator treats GP and HOV lanes identically.

Because there is a lack of a strong evidence base for estimating the induced travel effects of HOT lanes and other types of priced lanes, the NCST Calculator cannot be used for priced lanes such as HOT lanes. This limitation is reflected in the guidance provided in Section 4. Adding a lane restricted to a special purpose, such as a toll lane, freight or transit lane, may induce travel by particular users. It may also make capacity available in the GP lanes, in turn inducing traffic into the GP lanes. It can be complex to determine how much capacity is added by a managed lane, as its capacity is related to design, operating rules, and driver choices. Features including the number, location and design of entry and exit points can make a difference in facility performance and use. Operating hours, occupancy requirements, toll levels for HOT lanes, enforcement/violation rates may also influence impact on VMT.

HOT lanes, whereby single occupancy vehicles (SOVs) can legally use the HOV lane for a toll, are particularly complex. They are relatively new and therefore have not been studied extensively, though HOT lanes have been used in California and several other states and generated case studies (e.g., in Texas and Minnesota) as well as scenario-based analyses.

Like an HOV lane, a new HOT lane may attract vehicles from GP lanes due to their travel time benefit. However, the toll option is likely to lead to more complex travel behaviors than would an HOV lane. SOVs may move from GP lanes to the HOT lane, attracting new trips and longer trips formerly deterred by congestion, and inducing mode shift such as HOVs to SOVs.

3.2.2 SENSITIVITY TO PROJECT CONTEXT

Many practitioners raise concerns about the NCST Calculator's apparent lack of sensitivity to project context. For example, questions have been asked about whether the studies that underlie the Calculator match the background conditions where projects are being proposed - particularly non-metropolitan planning organization (MPO) counties, smaller MPOs, and rural areas of larger MPOs. Considerations include land use patterns and densities, modal choices and route options. In fact, similar concerns apply to the Travel Demand Models (TDMs), too. The aggregate data and estimated coefficients used in the TDMs reflect heavily the more urbanized, populous, modally diverse portions of the modeled region.

Whether the metropolitan statistical area (MSA) or urban county data apply to the more rural areas of a given county will depend on how integrated the area in question is to the broader urban economy. The MSA designation assumes that they are indeed integrated through commute patterns, which are a significant indicator of interconnectedness. Therefore, the Calculator is applicable throughout MSA areas. However, the Calculator is not applicable to rural counties. It will be used for projecting induced travel for GP and HOV lane projects in MSA counties as shown in Table 2. Section 4.4 provides an opportunity for analysts to describe cases where specific conditions make the induced travel effects of a project likely to be substantially different from the estimate derived from the Calculator.

As noted earlier, available studies do not offer a definitive answer about whether outlying areas are more or less likely to experience induced travel resulting from capacity increases. Several such studies suggest that the elasticity of demand may be higher in the outlying areas partly because of the relative percent increase in capacity, and partly because of the potential for location and land use shifts and increased travel to and from other parts of the metropolitan region (Panel Report 2020). Case examples also show that rural areas and areas with limited congestion can still experience induced travel resulting from new capacity because the new capacity improves travel times/ reduces costs and creates new patterns of accessibility and new location and land use opportunities. Available studies such as Duranton and Turner (2011) also indicate that accounting for transit services at the levels of service and geographic scales of availability experienced in most US contexts do not significantly alter the induced travel estimates.

3.2.3 SENSITIVITY TO DIFFERENT REGIONS

The NCST Calculator uses a constant elasticity across a county or an MSA. However, it accounts for variation in the travel-inducing strength between counties and regions by using the base year level of VMT as an input. Counties and regions that start with more traffic (higher existing VMT per lane mile) experience more induced travel for a given lane-mile addition. For example, a county or region that has twice the existing traffic per lane mile would see twice the amount of induced travel per lane mile added.

3.3 TRAVEL DEMAND MODELS

3.3.1 OVERVIEW

Travel models are often called Travel Demand Models (TDMs), though they also include models of transport supply. TDMs are widely used in California and throughout the United States as transportation system analysis and forecasting tools. Among their many applications, the travel models are used to measure network performance and identify deficiencies, to forecast future levels of service under anticipated levels of growth and change, and to generate the traffic data and projections needed for air pollution emissions estimates.

TDMs vary considerably in their specifications. Some MPOs and a few counties and cities in California have developed advanced activity-based models; many others use trip-based models. Some are run as part of an integrated land use-transportation modelling process while others handle current and future land use as a separate analysis step and use the results as inputs to the travel models. Models also vary in the extent to which they cover such issues as trip scheduling, time-of-day of travel, transit service characteristics (e.g., bus vs. rail), nonmotorized modes, and freight movements. Highway networks usually cover major collector and higher-level roads, but some models also include local roads.

TDMs vary also in their ability to estimate induced travel associated with highway investments. Some models can estimate induced travel reasonably well and some others cannot. For example, some model systems do not have the capability to account for changes in origin-destination patterns, increases in trip rates, and changes in location and land use resulting from transportation investments. In addition, models are not always applied in a way that fully uses their capabilities.

Many improvements have been made to travel models over the last two decades, but there remains considerable variation in the level of detail and the sophistication of the models in use in California and elsewhere. Depending on the specifics of model specification, estimation, and application, travel models may provide a reasonable estimate of induced travel, or they may under- or over-estimate induced travel. As Volker et al. (2020) reported, induced travel estimates set forth in some published environmental documents are well below those estimated by empirical studies, and underestimation is a concern. The likely reasons for such differences include:

- Land use changes and associated travel are a significant component of induced travel, but some transportation planning models treat land use as exogenous and some further assume it is fixed (i.e., land use is not altered as a result of transportation system changes.)
- Some travel models, either in specification or in application, do not include a mechanism to feedback network travel times and travel costs to land use mode choice, destination choice, and trip frequency modeling elements (Marshall 2018)
- Price and income are sometimes treated in limited ways; and therefore, important impacts on travel choice are not well represented in the models
- Reliability is often not represented by the travel model even though it can be important to the traveler: a small reduction in travel time can be accompanied by a large reduction in travel standard deviation, providing a meaningful improvement in reliability.
- Network levels of detail may be insufficient to reflect traffic conditions, available route and mode choices.
- Boundary cutoffs may mean that a portion of travel outside the model's boundaries is not well represented in model analyses, though it may be impacted by system changes.
- Models are not always run to traffic assignment equilibrium where network congestion is minimized.

- Models are often calibrated to observed data such that the alternative-specific constants take a large (outsized) importance in the choice models, rendering them less sensitive to time and cost.
- Finally, models may not have been thoroughly validated over a period of time in which travel times and costs have changed (such that it should be possible to see if the models would have predicted such changes.) (Panel Report, 2020)

A review of the capabilities of available travel demand models and their applications is therefore in order before relying solely on their outputs as a basis for evaluating induced travel impacts of projects on the SHS. The checklist in Section 4.5 provides specific guidance for evaluating whether a travel demand model is appropriate for use in estimating induced travel.

3.3.2 SOURCES FOR MODELING IMPROVEMENT GUIDANCE

Recent reports from the National Cooperative Highway Research Program (Erhardt et al. 2019) provide additional guidance on evaluating errors in models and could be valuable sources of advice. Guidance on modeling has been produced by State of California agencies, including the California Transportation Commission, the Governor's Office of Planning and Research, and the California Air Resources Board.

The Federal Highway Administration (FHWA) has also produced extensive advice on modeling, especially through its Travel Model Improvement Program (TMIP). The FHWA-HEP-10-042 report prepared by Cambridge Systematics, Inc. (2010) discussed the best practices on how to calibrate/adjust and validate/test TDMs, checking them for reasonableness. Note that checking the model can reveal underlying problems that need to be corrected; e.g., if VMT per household is unreasonably high or low, it would be advisable to make sure data errors were not introduced. Data from the US Census and travel surveys such as the National Household Travel Survey (NHTS) (https://nhts.ornl.gov/) provides useful comparisons. (NHTS data covers trip modes, lengths, and purposes, and all areas of the country, urban and rural.)

The TMIP advises that to be useful, tests of reaction to change must be done through applications of the model in full production mode. However, this is not always done in practice. Also, many models are validated on a reserved set of base year data; it would be useful to further validate predictive capabilities against a future year when such data are available.

4 GUIDANCE TO PRACTITIONERS

4.1 Applicability Of Guidance

The TAF should be consulted when a transportation project on the SHS could lead to a measurable and substantial increase in vehicle travel. The OPR Technical Advisory states that these projects would "…generally include… Addition of through lanes on existing or new highways, including general purpose lanes, HOV lanes, peak period lanes, auxiliary lanes, or lanes through grade-separated interchanges" (OPR 2018). Refer to Section 5.1 of the TAC for the project screening process and the list of project types that would not likely lead to a substantial or measurable increase in vehicle travel, and therefore generally should not require an induced travel analysis.

4.2 Selecting The Analysis Approach

4.2.1 OVERVIEW

Section 5.1 of the TAC guides the analyst through the process of screening a project on the SHS to determine whether a VMT significance determination is necessary. This process applies to both the project and project alternatives being considered. Such a determination requires analysis of induced travel impacts using one of the analysis approaches described in this section of the TAF.

Following a decision that induced travel analysis is needed, the analyst must select the analysis approach based on project location, facility type, and available tools as described in the following sections. The selection process applies equally to project alternatives under consideration. In a typical document, multiple alternatives will be described and analyzed. Analysis of induced travel may be necessary for each alternative, requiring selection and application of appropriate methods for each.

This guidance provides analysts with the basis for identifying the best available analysis approach for the project and alternatives. Table 1 guides the selection of preferred analysis approaches based on project location, project and facility type, and applicability of tools.

1. **Applicability of tools.** Section 4.3 provides a general discussion of the tools for estimating induced travel. In cases where the NCST Calculator can be directly used, it should either be used exclusively or used to benchmark results from a TDM. Where the NCST Calculator is not applicable and a TDM is suitable for use, a TDM should be used. The TDM should be assessed as adequate for assessing induced travel based on the checklist presented as Table 4 or should

undergo modifications in order to remedy identified deficiencies. Section 4.4 and 4.5 provide additional detail.

2. **Project location.** Whether the project is in an MSA or a rural county will influence the approach selected, since the NCST Calculator is not applicable in non-MSA counties. For projects in rural counties, the best available method should be selected by analysts and reasons for selecting the method should be documented. This would preferably be a TDM or other quantitative method. A qualitative assessment will be acceptable if it takes into account the potential for capacity additions to induce travel as a result of changes in travel behavior in response to reduced travel cost, improved reliability, or long-term land use change likely to be associated with the project.

3. **Project and Facility Type.** Only projects adding general purpose or HOV lanes can use the NCST Calculator directly. The Calculator's applicability varies by facility type as shown in Table 1.

4.2.2 GUIDANCE FOR SELECTING ANALYSIS APPROACH

Table 1 provides a selection matrix to be used in identifying the preferred VMT assessment method(s) based on location and project type. The application of the NCST Calculator and the TDM is described in Section 4.3 and 4.4, respectively. Table 1 applies only to the forecasting of induced travel associated with projects on the SHS for CEQA analysis. Depending on the method selected, other methods and tools may be necessary to forecast total VMT in the horizon year for other CEQA impact analysis and for NEPA analysis when applicable. Consult with Caltrans Division of Environmental Analysis (DEA) for details.

4.3 APPLICATION OF THE NCST CALCULATOR

The NCST Calculator can be applied to mainline general-purpose lane additions and mainline HOV lane additions on Class 1 facilities (Interstate freeways) and Class 2 and 3 facilities (Other Freeways, Expressways, and Other Principal Arterial state routes) as defined by the FHWA. See Appendix A for facility class definitions. Of the 58 counties in California, the Calculator can be applied directly in 37 counties that belong to MSAs but not in the remaining 21 non-MSA rural counties. See Table 2 for a list of the 37 MSA counties, and Table 3 for a list of the 21 non-MSA rural counties.

For a Class 1 facility, the NCST Calculator must be applied at the MSA level; while for Class 2 and 3 types of facilities, the Calculator must be applied at the county level. This is because the NCST Calculator was based on studies that examined only those geographies. As shown in Table 2, the Calculator applies to all Class 1, 2, and 3 facilities in 23 MSA counties. In 14 MSA counties the Calculator applies to Class 2 and

3 facilities only because either there are no Class 1 facilities in the county, or the Class 1 facility mileage is less than one mile in the county.

Table 1. Selection Matrix for Preferred Induced Travel Assessment Method for Projects on the SHS[1]

Project Type / Project Location	GP or HOV Lane Addition to Interstate Freeway	GP or HOV Lane Addition to Class 2 & 3 State Routes	Other VMT Inducing Projects and Alternatives
County in MSA with Class I Facility	Apply the NCST Calculator by MSA and/or TDM[2] benchmarked with NCST Calculator.	Apply the NCST Calculator by county and/or TDM[2] benchmarked with NCST Calculator.	Apply TDM[2] or other quantitative methods
Other MSA County	Apply TDM[2] or other quantitative methods		
Rural County	Apply TDM[2] or other quantitative methods		

[1]If preferred methods are not available, qualitative assessment is acceptable as shown in Figure 5.
[2]TDMs must be checked for applicability as described in Sections 4.4 and 4.5.

Freeway ramps and minor arterials or collector-distributor roads associated with a freeway fall outside the scope of application for the NCST Calculator. The VMT inducing effects for ramp, minor arterial, and collector-distributor road capacity projects should be evaluated as "Other VMT Inducing Projects" in Table 1.

The NCST Calculator allows users to directly assess the likely average increase in VMT resulting from induced travel associated with the planned addition of GP or HOV lane miles. The Calculator output represents the increase on area-wide facilities, not solely on the facility that the project would alter. It uses 2016 lane-mile and VMT data from Caltrans databases (and therefore applies only to California, as currently presented) together with long-term elasticities taken from the literature, specifically the Duranton and Turner (2011) nationwide estimate for Interstate facilities (which the Calculator rounds to 1.0) and the Cervero and Hansen (2002) California county-level estimate for class 2 and 3 facilities (0.75 as implemented in the Calculator). The user specifies the category of facility and lane miles being added and the county or Metropolitan Statistical Area (MSA) of application; the Calculator is only applied to counties for which there are data and for which the studies are applicable (Tables 2 and 3 indicate the Calculator's applicability to California counties).

While use of the online Calculator is the recommended approach to applying the elasticity-based method, the method may also be applied manually by the analyst.

A standard formula for estimating project induced VMT is embedded in the Calculator:

Project-Induced VMT = %Δ Lane Miles x Existing VMT x Elasticity

where,
%Δ Lane Miles = The increase of lane miles expressed as a percentage of the total lane miles in the study area. This must be a positive number.

Table 2. The 37 MSA Counties where the NCST Calculator Applies

23 MSA Counties: The NCST Calculator Applies to Class 1, 2, and 3 Facilities		
Alameda	Merced	San Joaquin
Contra Costa	Orange	San Mateo
Fresno	Placer	Santa Clara
Imperial	Riverside	Shasta
Kern	Sacramento	Solano
Kings	San Bernardino	Stanislaus
Los Angeles	San Diego	Yolo
Marin	San Francisco	
14 MSA Counties: The NCST Calculator Applies to Class 2 and 3 Facilities only		
Butte	San Benito	Sutter
El Dorado	San Luis Obispo	Tulare
Madera	Santa Barbara	Ventura
Monterey	Santa Cruz	Yuba
Napa	Sonoma	

Table 3. The 21 Rural Counties where the NCST Calculator does not Apply

Alpine	Inyo	Nevada
Amador	Lake	Plumas
Calaveras	Lassen	Sierra
Colusa	Mariposa	Siskiyou
Del Norte	Mendocino	Tehama
Glenn	Modoc	Trinity
Humboldt	Mono	Tuolumne

Additional details on application of the Calculator are available online at https://ncst.ucdavis.edu/research-product/induced-travel-calculator and also discussed in Appendix A.

As described above, the NCST Calculator uses empirical data to establish elasticities that reflect the likely change in travel volumes associated with a change in roadway capacity. The Calculator's output reflects an average areawide change, not simply the change in volumes on the facility itself. The NCST Calculator reports long-run induced travel results for the horizon year. Estimates for intermittent years can be determined with linear interpolation. The NCST Calculator does not distinguish between GP and HOV lanes, so the tool cannot be used to assess any potential difference in induced travel between those two project types.

The NCST tool may in some cases be used to provide a valuable point of reference in a quantitative assessment of the impacts of project types other than GP and HOV lanes. For example, while the NCST calculator does not apply directly to HOT lanes, in the absence of a travel demand model capable of projecting induced travel based on the checklist assessment, the NCST Calculator may supply a useful data point for consideration in the analysis of a HOT lane project.

4.4 Application of Travel Demand Models

As shown in Table 1, TDMs will be used to assess induced travel in the following two situations:

1. Applied in combination with the NCST Calculator as discussed below;
2. Applied alone when the NCST Calculator is not applicable.

Where a travel model is used, often the regional travel model will be the most appropriate scale to capture the entire area over which induced VMT is observed. However, as discussed above, some TDMs lack key elements for assessing induced travel. For example, some model systems do not have the capability to account for changes in origin-destination patterns, increases in trip generation rates, and changes in location and land use resulting from transportation investments. In addition, models are not always applied in a way that fully exercises these capabilities. Analysts should document the models, the calibration steps taken, reasonableness tests performed, and validation tests against later year conditions. Documentation should indicate both verification that the model has the capacity to reflect travel behavior accurately, and that it is run correctly, in order to assess induced travel.

When a travel model is used to assess induced travel, the following steps must be followed:

1. Assess the travel model and off-model processes using the checklist provided in Section 4.5.

2. If the NCST Calculator can be applied to the project, and the travel model passes the checks, apply both methods.
    a) Use the TDM results, if within 20 percent of the value provided by the NCST Calculator.
    b) If travel demand model results differ from that of the Calculator by more than 20 percent, use the Calculator's results exclusively, or use the TDM results and provide specific quantitative evidence explaining this variation. The evidence may include reference to quality academic studies, or analysis of specific project features or context justifying that the project's induced travel could be substantially higher or lower than the average value indicated by the NCST Calculator.

3. If the NCST Calculator cannot be applied to the project, and the travel model passes the checks, then apply travel models only.

4. If the NCST Calculator cannot be applied to the project, and the travel model does not pass all the checks, then:
    a) Disclose and document the areas of deficiency and make improvements to the model to address those issues. If that is not possible in the timeframe of the project analysis, use other options below.
    b) Apply off-model approaches using the best available information or tools to compensate for TDM's deficiencies, making approximations as needed where more precise data or information are not available.
    c) Where a quantitative assessment cannot be reasonably undertaken, a qualitative assessment may be undertaken (see Section 4.6).

When both the NCST Calculator and TDMs are used as guided by Table 1, a detailed method selection flow chart is provided in Figure 5 to further facilitate the process of selecting an analysis approach.

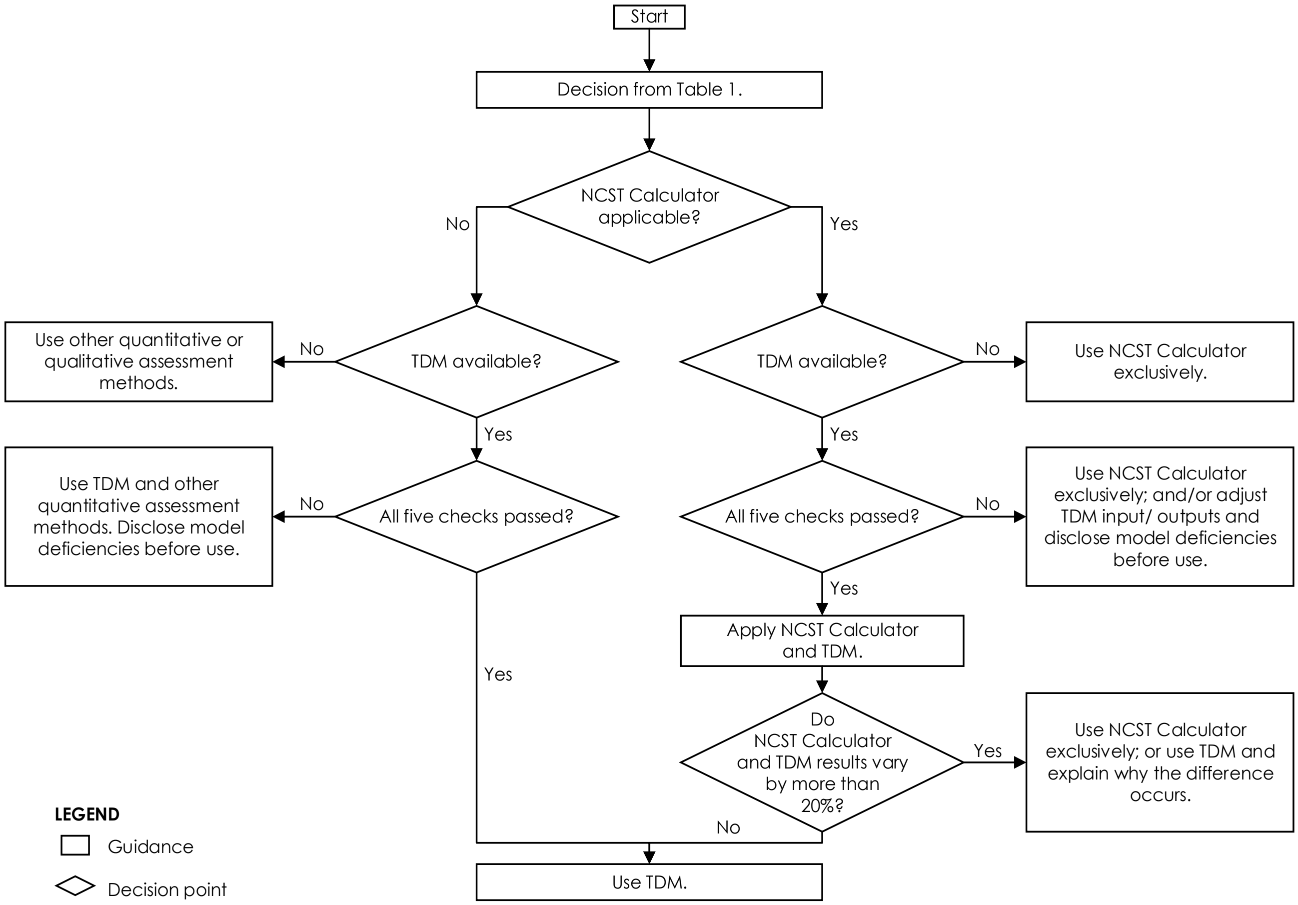


Figure 5. A detailed assessment method selection flow chart.

4.5 THE CHECKLIST FOR EVALUATING MODEL ADEQUACY

The checklist in Table 4 specifies model capabilities required for induced travel assessment. The checklist focuses on both modeling mechanisms and modeling practices. The purpose is to ensure induced travel modeling mechanisms are built in, and established modeling practices are followed in implementing a TDM for induced travel modeling. There are five checks in total. In general, a model should pass all five checks before the analyst concludes that the TDM is appropriate for making projections of induced travel. As noted elsewhere, assessments made using models that do not satisfy all checks should include disclosure of deficiencies, documenting ways in which the deficiencies may affect results.

Table 4. A Checklist for Evaluating Adequacy of Travel Demand Models for Estimating Induced Travel

<table>
<tr><td colspan="2">Check 1. Land use response to network changes[1]. Check the box if the answer to the question is “yes”. “Check 1” passes if either box 1a or 1b is checked.</td></tr>
<tr><td>1a
☐</td><td>Is the model’s specification of future land use sensitive to travel time and cost, i.e., varying across modeling scenarios to simulate the land use response to network changes?</td></tr>
<tr><td>1b
☐</td><td>If future year land use is exogenous to the modeling process, are land use assumptions determined via a Delphi method (Linstone and Turoff eds., 1975; Rand Corp, 1969; Cavalli-Sforza and Ortolano, 1984; and Melander 2018) or through examination of outcomes under a range of modeling scenarios, including both build and no build alternatives?</td></tr>
<tr><td colspan="2">[1] Any TDM used to assess induced travel must be paired, or iterated, with an approach for predicting changes in land use caused by the project. OPR’s Technical Advisory (Appendix 2, Induced Travel Mechanisms, Research, and Additional Assessment Approaches, p. 34) lists options for incorporating land use effects in a travel model-based assessment.</td></tr>
<tr><td colspan="2">Check 2. Sensitivity of trip-making behavior to network travel times and travel costs[2]. Check the box if the answer to the question is “yes”. “Check 2” passes when box 2a, 2b, and 2c are all checked.</td></tr>
<tr><td>2a
☐</td><td>Do changes in network travel times and travel costs by mode (e.g. vehicle operating costs, tolls, parking costs, transit fares, etc.) influence mode choice, destination choice (including workplace location), route choice, and trip frequency?</td></tr>
<tr><td>2b
☐</td><td>Are the network travel times and costs fed back into the mode choice, destination choice, route choice, and trip frequency models so that travel times and costs are roughly consistent with the “converged” travel times and costs from traffic assignment?</td></tr>
<tr><td>2c
☐</td><td>Does the modeling reflect the heterogeneity and complexity of travelers’ responses to time and cost changes relevant to the examined project?</td></tr>
</table>

Table 4. A Checklist for Evaluating Adequacy of Travel Demand Models for Estimating Induced Travel (cont'd)

<table>
<tr><td colspan="2">[2]. If the trip generation sub-model is not sensitive to travel time, then the analyst will need to provide for a manual intervention in the trip generation stage of the model to adjust the trip generation rates in the model for off-line computed induced travel effects of the project, its alternatives, and potential mitigation measures.
The analyst can employ activity based travel model parameters that are available from a similar region to manually estimate off-model the effects of the project, its alternatives, and potential mitigation measures on trip generation with and without the project for the desired forecast years (with the land use linkage described above activated) and noting the predicted percentage change in trip generation by purpose predicted by the activity based TDM parameters. These percentages, which will vary by project alternative, may then be applied to the output of the trip generation stage of the trip-based model.</td></tr>
<tr><td colspan="2">Check 3. Sufficiency of detail and coverage of modelled roadway and transit networks[3]. Check the box if the answer to the question is "yes". "Check 3" passes if both box 3a and 3b are checked.</td></tr>
<tr><td>3a
☐</td><td>Are the roadway and transit networks provided in sufficient detail and coverage to reflect the full set of route and mode choices available to the traveler?</td></tr>
<tr><td>3b
☐</td><td>If the project would lead to induced travel extending beyond the model's boundary, has the model been modified to incorporate the larger geography, or has an off-model assessment captured the additional travel generated?</td></tr>
<tr><td colspan="2">[3]. In cases where the project would lead to induced travel that extends beyond the model's boundary, the model should either be modified to incorporate that geography (e.g. by adding "halo zones") or an off model assessment should be made to capture the additional travel (e.g. where that travel is destined for a population center outside the model area, multiply gateway volumes by distance from the gateway to that population center).
For sufficiency of geographical coverage, the analyst should use select link analysis to check whether links that run up to the model's edge show increased volumes as a result of the project. If they do, VMT increases likely continue outside the model's boundary. Where that is the case, one of three approaches can be used to capture that VMT. First, "halo zones" can be added to capture the additional VMT within the model. Second, a reasonable assumption can be made about length of the missing portion of the trip (e.g. use the distance to next major jobs or population center, if trips are likely allocated there), and that distance can be multiplied by the volume. Third, a model with greater coverage, such as the California Statewide Travel Demand Model (CSTDM), can be used.</td></tr>
</table>

Table 4. A Checklist for Evaluating Adequacy of Travel Demand Models for Estimating Induced Travel (cont'd)

For temporal coverage, the analyst should examine the peaking of traffic flows in the area served by the project to determine the needed temporal coverage of the model (weekday peak hours, peak periods, daily, weekends and holidays, recreational seasons, full year), and then check to ensure the model assesses those time periods.	
Check 4. Network assignment processes[4]. Check the box if the answer to the question is "yes". "Check 4" passes if box 4a is checked.	
4a ☐	Is the modeling guidance published by FHWA (Cambridge Systematics, 2008, 2010) followed, in order to provide a sufficient level of convergence in network assignment such that the differences in outcomes between modeling scenarios can be reliably attributed to the differences in scenario definitions rather than the network assignment process itself?
[4]. For static roadway assignment, a relative gap between model runs of 0.001 is a good safe harbor.	
Check 5. Model Calibration and Validation[5]. Check the box if the answer to the question is "yes". "Check 5" passes if box 5a is checked.	
5a ☐	Has the model been validated across points in time and changes in travel time and cost in order to confirm that it is appropriately sensitive to changes in these factors?
[5]. In order to preserve sensitivities, alternative specific constants shall not deviate substantially in overall magnitude relative to the other variables unless the resulting sensitivity is validated based on observed data.	

4.6 QUALITATIVE ASSESSMENT APPROACH

The CEQA Guidelines 15144 specify, "Drafting an EIR or preparing a Negative Declaration necessarily involves some degree of forecasting. While foreseeing the unforeseeable is not possible, an agency must use its best efforts to find out and disclose all that it reasonably can." Specifically addressing transportation impact analysis, CEQA 15064.3 states, "…if existing models or methods are not available to estimate the VMT for the particular project being considered, a lead agency may analyze the project's vehicle miles traveled qualitatively. For many projects, a qualitative analysis of construction traffic may be appropriate." When neither the NCST Calculator nor an appropriate TDM is available, modeling improvement cannot practically be accomplished, and no other quantitative assessment approach can be identified, a qualitative assessment approach may be appropriate.

When a project type is identified from the screen-out list contained in Section 5.1 of the TAC, a simple narrative will generally suffice in terms of induced travel assessment.

4.7 DOCUMENTATION

Documenting the factual and analytic basis for the decisions made throughout the project development process is critical to explaining how those decisions were made. The mandate to document facts and analysis used in reaching a conclusion applies to both the decisions made in analyzing a proposed project for whether a VMT analysis is required and if so, the technical level details as to how it was performed. These requirements apply to CEQA alternatives as well as to the proposed project.

Documentation of each fact relied upon, each inference derived from established facts and the logical approach taken to reach a conclusion are necessary so others, including a court if the matter is litigated, can follow the analytical path taken by the practitioner. The requirement to adequately document the analytical path applies whether the practitioner is a Caltrans staff member, a partner agency staff member or a consultant retained to prepare the analysis.

4.7.1 CALTRANS UNIFORM FILING SYSTEM

Caltrans has established a formal "Uniform Filing System" which must be the framework for documenting the facts, inferences and conclusions reached when reviewing a project's potential impacts. Taken together, the Uniform Filing System's components form the "Administrative Record" for the project. Training for how to apply the Uniform Filing System, and the creation and maintenance of the Administrative Record, is available through the Division of Environmental Analysis. See, e.g., http://etp.dot.ca.gov/env/files/admin-record/presentation_html5.html for additional background. Note that for those projects where NEPA compliance is required, similar procedures for records retention are required. See, e.g., https://dot.ca.gov/programs/environmental-analysis/standard-environmental-reference-ser/volume-1-guidance-for-compliance/ch-38-nepa-assignment#files.

Caltrans, like many other entities, has enterprise-level policies relating to the automatic deletion of emails after a certain amount of time elapses. While those policies generally apply, in order to assure retention of the records which document the analytical path taken in performing an analysis, relevant emails and any attachments should be retained in the project file, either in electronic format or by printing and saving to the project's paper file.

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APPENDIX A. THE NCST INDUCED TRAVEL CALCULATOR

SCOPE OF NCST INDUCED TRAVEL CALCULATOR

The technical documentation for the NCST Induced Travel Calculator states that (see https://ncst.ucdavis.edu/research-product/induced-travel-calculator *accessed August 11, 2020*):

- The calculator is limited to use for capacity expansions. It cannot be used to estimate VMT effects of capacity reductions or lane type conversions.
- The calculator is limited to use for additions of general-purpose and high occupancy vehicle (HOV) lanes.
    - It should not be used for additions of toll lanes or high occupancy-toll (HOT) lanes.
    - Hundreds of both general-purpose and HOV lane mile additions were included in the two studies used to derive the elasticities for the Calculator (Duranton & Turner, 2011); (Cervero & Hansen, 2002). By contrast few toll and high-occupancy toll (HOT) lanes were added before the end of the data collection periods for the two studies. The studies' estimated elasticities therefore might not reflect toll and HOT lanes. This Calculator should not be used to estimate the induced travel impacts of toll and HOT lanes.
- The calculator produces long-run estimates of induced VMT, the additional annual VMT that could be expected 5 to 10 years after facility installation.
- All estimates account for the possibility that some of the increased VMT on the expanded facility is traffic diverted from other types of roads in the network. In general, the studies show that "…capacity expansion leads to a net increase in VMT, not simply a shifting of VMT from one road to another" (Handy & Boarnet, Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions Policy Brief, 2014)
- The Calculator currently uses 2016 lane mileage and VMT data from the Highway Performance Monitoring System (HPMS), including both passenger and heavy-duty vehicle data. The data will be updated periodically as new data become available.
- Knowledge of local conditions can help contextualize the calculator's estimates.

FHWA FUNCTIONAL CLASSIFICATION SYSTEM

The FHWA functional classification system used in the UC Davis NCST Induced Travel Calculator is defined in an FHWA memorandum (https://www.fhwa.dot.gov/policy/ohpi/hpms/fchguidance.cfm):

Functional Class 1 = Interstate
Functional Class 2 = Other Freeways and Expressways

Functional Class 3 = Other Principal Arterial

A variety of roadway facilities in California are represented within these functional classifications and in the corresponding Caltrans HPMS data, including but not limited to: State Highway System (SHS), local roadways, Department of Defense roads, State Parks roads, and U.S. Forest Service roads.

Note that according to the technical documentation for the NCST Induced Travel Calculator, functional classes 1, 2, and 3 are within the scope of the NCST Calculator if they are state highways.

CONCEPTS

Handy and Boarnet (2014a, 2014b) define "induced travel" as an "increase in vehicle miles traveled (VMT) attributable to increases in capacity." Handy and Boarnet (2014a, 2014b) then state:

> *"Increased highway capacity can lead to increased VMT in the short run in several ways: if people shift from other modes to driving, if drivers make longer trips (by choosing longer routes and/or more distant destinations), or if drivers make more frequent trips. Longer-term effects may also occur if households and businesses move to more distant locations or if development patterns become more dispersed in response to the capacity increase. Capacity expansion can lead to increases in commercial traffic as well as passenger travel."*

Handy and Boarnet (2014a, 2014b) also state:

> *"The induced-travel impact of capacity expansion is generally measured with respect to the change in VMT that results from an increase in lane miles, determined by the length of a road segment and its number of lanes (e.g. a two mile segment of a four-lane highway equates to eight lane miles). Effect sizes are usually presented as the ratio (elasticity) of the percent change in VMT associated with a one percent change in lane miles."*

According to a survey of the literature by Handy and Boarnet (2014a, 2014b), "Elasticity estimates of the short-run effect of increased highway capacity range from 0.3 to 0.6. Estimates of the long-run effect of increased highway capacity are considerably higher, mostly falling in the range from 0.6 to just over 1.0.

RESEARCH BASIS

Handy and Boarnet (2014a, 2014b) provide some of the technical background for six of the studies they included in their policy brief. Key characteristics shared by many of the research studies upon which the elasticity estimates are based are:

- They measure changes in regional, county, or statewide VMT and lane-miles of road in most cases only on freeways. Some focused on state-owned highways. One used sample from the US DOT Highway Statistics database for all road types in that database.

- Data on changes in capacity and traffic volumes for non-freeways, minor roads and arterials was not available to the researchers in most cases, so they could not account for diversion effects, where traffic shifts to and from minor roads and arterials in the region to the freeways. The background documentation for the NCST Calculator states that Duranton estimated this unmeasured diversion effect to be between zero and 10% (which would have no effect or would reduce the reported elasticity).
- The long-term time frames considered varied from 14 years to 22 years.
- Researchers fitted log-linear regression models with lane-miles as one of various explanatory factors for observed changes in regional or county VMT.
- They all included changes in population as one of the explanatory factors but varied in what additional variables impacting VMT were included. Some included income, some employment density, some fuel cost. The additional explanatory factors usually lowered the elasticity with respect to lane-miles.
- They used different approaches to control for demand driven capacity construction, called “simultaneity bias.”
- Three of the studies used only California data. Three used data from around the United States.

APPENDIX B. PANELIST BIOGRAPHICAL SKETCHES

As mentioned in the Foreword of this document, in Spring 2020 Caltrans convened an expert panel of academics and practitioners through the University of California Berkeley Tech Transfer in order to provide recommendations on key issues associated with analysis of induced travel impacts. The panel was charged with making recommendations on how to estimate travel "attributable to the project", best tools to use, reasons for differences in estimates from various tools, and ways to resolve or reconcile differences if they occur. The panel also provided advice on "next steps", including the need for further guidance and additional research. A short biography of each of the eight panelists is presented here.

Elizabeth Deakin (Panel Chair) is Professor Emerita of City and Regional Planning and Urban Design at UC Berkeley and an affiliated faculty member of the Energy and Resources Group. She previously was Director of the UC Transportation Center (1999-2008) and co-director of the Global Metropolitan Studies Center (2004-2009). She also served as vice-chair and then chair of the UC Berkeley Academic Senate (2013-2015).

Deakin's research and teaching focus on transportation and land use policy, the environmental impacts of transportation, and equity in transportation, and she has published over 300 journal articles, conference papers, book chapters, and research reports. Since her retirement she has continued to carry out research projects and mentor students and has co-edited a book on international experiences with high speed rail and edited a book on transportation, land use, and environmental planning.

She has been appointed to several government posts including city and county commissions and state advisory boards in California. She has testified on transportation legislation before the US Senate Public Works Committee, the House Technology and Infrastructure Committee and the House Science Committee, as well as before California Senate and Assembly committees and city councils.

She was the co-creator of several transportation-land use plans that won prizes from APA and AIA and has received awards for best paper (TRB energy committee) and best reviewer for a journal (ASCE).

Fred Dock is the former Director of Transportation for the City of Pasadena, California. During his tenure and under his direction, Pasadena pioneered the use of VMT and multi-modal transportation performance metrics and developed a Complete Streets Framework that focused on achieving the City's goals for safety and sustainability. Now retired from the City, he advises on transportation policy and practice with emphasis in urban transportation issues and performance measures.

Prior to joining the City of Pasadena, Mr. Dock consulted for engineering and planning firms in northern and southern California, Chicago, and Minneapolis for 30 years. He directed and prepared a variety of engineering and planning projects ranging from impact analysis to corridor studies to regional plans. He was one of the principal investigators for the University of Minnesota's research on Transportation and Regional Growth. His work in operations included advanced traffic control systems and simulation modeling of complex traffic networks.

He led a nationwide initiative on urban street design that developed a context-based framework for street design and resulted in the publication of *Designing Walkable Urban Thoroughfares* (ITE, 2010). That work is the basis for the modified system of functional classification in the 7th Edition of the AASHTO Green Book. His work with transit-oriented development is nationally recognized by the Transportation Research Board for both policy and practice and by the Urban Land Institute, for which he authored *Developing Around Transit* (ULI, 2005) with other nationally recognized individuals.

Mr. Dock has received various awards, including the 2015 Dale Prize for Excellence in Urban and Regional Planning when the theme was *Streets for Everyone: Advancing Active Transportation*. Mr. Dock earned both bachelor's and master's degrees in civil engineering from the University of California at Berkeley. He is currently a registered Civil Engineer and Traffic Engineer in California, a PTOE and an AICP. He was previously registered as a Professional Engineer in the states of Illinois, Michigan, and Montana.

Gordon Garry is currently mostly retired after a professional career of 40 years. He keeps an active role professionally through various projects with government agencies and NGOs.

From 1990 to 2017 he was a senior staff member at the Sacramento Area Council of Governments. Mr. Garry developed and managed an increasing array of data, forecasting, and scenario programs to support the agency's transportation, air quality, land use planning, and climate change efforts. Mr. Garry was responsible for modeling projections and analyses in these areas that meet local, state, and Federal planning requirements. Also, while at SACOG he worked with a number of regional agencies across California and the country to develop and implement these technical tools in support better decision making for public agencies.

Prior to joining SACOG he worked at the City of Santa Rosa CA, SRF Consulting in Minneapolis, and the South Dakota Department of Transportation. Mr. Garry received his B.S. in Economics at South Dakota State University and his Master's in City and Regional Planning at the Harvard Kennedy School of Government.

Susan Handy is a Professor in the Department of Environmental Science and Policy and the Director of the National Center for Sustainable Transportation at the University of California, Davis. She is internationally known for her research on the relationships between transportation and land use, particularly the impact of neighborhood design on travel behavior. Her current work focuses on bicycling as a mode of transportation and on strategies for reducing automobile dependence.

Dr. Handy holds a B.S.E. in Civil Engineering from Princeton University, an M.S. in Civil Engineering from Stanford University, and a Ph.D. in City and Regional Planning from the University of California at Berkeley.

Michael McNally is Professor of Civil and Environmental Engineering and of Urban Planning and Public Policy, and a Faculty Associate of the Institute of Transportation Studies at the University of California, Irvine. He received his Ph.D. in Engineering in 1986 from UC Irvine and was with the School of Urban and Regional Planning and the Department of Civil Engineering at USC prior to joining the faculty at UCI in 1987. Research interests focus on the study of complex travel behavior, investigations of interrelationships between transportation and land use, and the development of new technologies and modeling methodologies which reflect and support these research areas.

Among various research awards, he received a Presidential Young Investigator Award from the National Science Foundation. He has served as Principal Investigator on a variety of funded projects, including research and development relating to: operational models of activity-based travel forecasting, web-based self-administered travel surveys, GPS-based, wireless in-vehicle data collection systems, information technology for shared-use station car programs, multi-jurisdictional corridor decision support systems with integrated traffic microsimulation models, the role of information on traveler behavior, and the evaluation of advanced traffic management and control technologies.

Elizabeth Sall is a Principal at UrbanLabs LLC a mission-driven urban science and research firm. Ms. Sall specializes in the intersection of policy with data and technology especially as it relates to travel behavior and multi-modal transportation network management. She is currently serving as the Mobility Data Team lead for the California Integrated Travel Project at CalSTA/Caltrans and is the technical lead on several travel model development projects.

Ms. Sall has served in numerous capacities as a consultant and through appointed volunteer positions with the Transportation Research Board (TRB) and Zephyr Foundation for Improved Travel Analysis. She has served as a task lead for the recently published NCHRP Report 934 *Travel Forecasting Accuracy Assessment Research* and is serving on the panel for NCHRP 08-121 *Accessibility Measures in Practice: Guidance for Agencies*. In the past, she has served as the chair for SHRP2 C46 *Resource on Advanced Integrated Models and Implementation Strategy*, on the panel for NCHRP Report 775 *Applying GPS Data to Understand Travel Behavior*, and as a researcher for NCHRP Report 716 *Travel Demand Forecasting: Parameters and Techniques.* Ms. Sall is currently serving the TRB as a member of Committee on Travel Demand Forecasting and the Transportation Research Record Advisory Board and has served in the past on the following committees: Planning Applications, Travel Forecasting Resource, Metropolitan Policy and Practices, and the Task Force on Bring Activity-Based Models to Practice. She has served on seven of the past eight organizing committees for the TRB Innovations in Travel Modeling Conference series and six of the past TRB Planning Applications Conferences including as conference chair and technical track leads. Outside TRB, she is the co-founder and workforce development lead for the Zephyr Foundation for Improved Travel Analysis, a former leader of the Washington DC Chapter of ITE, and frequent collaborator and presenter with NACTO, MobilityData IO, and a variety of Universities. Ms. Sall serves frequently on Peer Review Panels facilitated by the Travel Model Improvement Program and a variety of other expert panels for both research and policy.

As the former Deputy Director for Technology, Data and Analysis of the San Francisco County Transportation Authority Ms. Sall was responsible for developing, maintaining, and applying an Activity-Based Travel Demand Model that served as the basis for local long-range planning documents, FTA New- and Small-Starts submissions, the environment review process, and various land use and transportation studies. Ms. Sall began her career as a consultant working on a variety of projects ranging from project-level forecasting and travel impact analysis to urban and rural long-range transportation plans and neighborhood planning studies. She has Civil Engineering degrees from North Carolina State University (B.S.) and the University of Texas at Austin (M.S.).

Alex Skabardonis is an internationally recognized expert in traffic flow theory and models, traffic management and control systems, design, operation and analysis of transportation facilities, intelligent transportation systems (ITS), energy and environmental impacts of transportation. He is a Professor at the University of California, Berkeley, and program Leader at California PATH, a statewide ITS research center. He has worked extensively in the development and application of models and techniques for traffic control, performance analysis of highway facilities and applications of advanced technologies to transportation. He has served as Principal Researcher for 85 extramurally funded contracts and grants totaling over $30M and has published over 350 papers and technical reports. He is co-developer of the California Freeway Performance Measurement System (PeMS) and the Berkeley Highway Laboratory that produced the NGSIM vehicle trajectories database used by transportation researchers worldwide.

Dr. Skabardonis teaches graduate courses on transportation modeling and analysis, traffic operations and intelligent transportation. He has advised and supported more than 120 graduate students toward their MS and PhD degrees at UC Berkeley. He also developed and taught workshops on traffic management, control systems and traffic simulation models attended by more than 500 transportation professionals. He holds an undergraduate degree in Civil Engineering from the Technical University of Athens and master's and PhD degrees in CE from Southampton University in the United Kingdom.

Joan Walker conducts research on behavioral modeling, with an expertise in discrete choice analysis and travel behavior. She works to improve the models that are used for transportation planning, policy, and operations. Professor Walker joined UC Berkeley in 2008 as faculty in the Department of Civil and Environmental Engineering and a member of the interdisciplinary Global Metropolitan Studies (GMS) initiative. She received her Bachelor's degree in Civil Engineering from UC Berkeley and her Master's and PhD degrees in Civil and Environmental Engineering from Massachusetts Institute of Technology. Prior to joining UC Berkeley, she was Director of Demand Modeling at Caliper Corporation and an Assistant Professor of Geography and Environment at Boston University. She is a recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE) – the highest honor bestowed by the U.S. government on scientists and engineers beginning their independent careers. She served for six years as the Chair of the Committee on Transportation Demand Forecasting (ADB40) for the Transportation Research Board of the National Academies. She is an instigator and founding stakeholder of The Zephyr Foundation, which aims to advance rigorous transportation and land use decision-making for the public good and was awarded its Leadership Award in 2020. She has served as Acting Director of UC Berkeley's Institute of Transportation Studies (ITS).

APPENDIX C. GLOSSARY OF ACRONYMS AND TERMS

Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
CSTDM	California Statewide Travel Demand Model
DOT	Department of Transportation
EIR	Environmental Impact Report (State)
EIS	Environmental Impact Statement (federal)
FHWA	Federal Highway Administration
GHG	Greenhouse Gas
GP	General Purpose lane
HCM	Highway Capacity Manual
HOT	High Occupancy Toll lane
HOV	High Occupancy Vehicle lane
HPMS	Highway Performance Monitoring System database hosted by Federal Highway Administration and maintained by Caltrans Division of Research, Innovation, and System Information
IS	Initial Study
MPO	Metropolitan Planning Organization
MTP	Metropolitan Transportation Plan or Metropolitan Transportation Program
MSA	Metropolitan Statistical Area
NCST	National Center for Sustainable Transportation, University of California, Davis
ND	Negative Declaration
NEPA	National Environmental Policy Act
OPR	Governor’s Office of Planning and Research
PA&ED	Project Approval and Environmental Document
PDT	Project Development Team
PEAR	Preliminary Environmental Analysis Report
PRC	California Public Resources Code
SB	Senate Bill
SHS	State Highway System
SOV	Single Occupancy Vehicle
TA	Office of Planning and Research Technical Advisory on Evaluating Transportation Impacts in CEQA (2018)
TAC	*Transportation Analysis under CEQA* (Caltrans guidance document for implementing SB 743)
TAF	*Transportation Analysis Framework* (Caltrans guidance document for implementing SB 743)
TBM	Trip-Based Model
TDM	Travel Demand Model

TMIP	Travel Model Improvement Program
VMT	Vehicle Miles Traveled
Elasticity	Elasticity is a measure of a variable's sensitivity to a change in another variable. In economics, elasticity is the measurement of the percentage change of one economic variable in response to a change in another. In transportation forecasting, an example is elasticity of travel demand, which can be expressed as the percent change in regional VMT divided by the percent change in regional lane-miles of state highways.
Induced Travel	Induced travel (or the VMT attributable to a transportation capacity increase) is the increased amount of vehicle travel on the transportation network that is caused by travel behavior changes associated with decreased cost of travel due to improved travel times, improved reliability, or reduced price of travel. Over the short run, travel behavior changes including longer trips, more trips, mode shift, and route shift all tend to occur as a result of a highway capacity increase. Over the long run, these effects intensify (e.g. as people shift job or residential location to benefit from the infrastructure), and also land use development may become more dispersed, adding additional vehicle travel; for these reasons, long run induced travel is generally greater than short run induced travel.
Latent Demand	Latent demand is the travel that would occur on the transportation network if travel times (or costs) were reduced. Much like any public utility (e.g. electricity or water), consumers will use more of it when its cost or impedance of use is reduced or made free. Note that unless the current price of travel is zero (instantaneous travel at will at no cost), there is always latent demand.
Metropolitan Statistical Area	A U.S. metropolitan statistical area (MSA) is a geographical region with a relatively high population density at its core and close economic ties throughout the area, as defined by the U.S. Office of Management and Budget and used by the Census Bureau and other federal government agencies for statistical purposes.
Transit	Transit generally includes all forms of shared common carrier passenger ground transportation in moderate to high capacity vehicles ranging from dial-a-ride vans to buses, trolleys, light rail, commuter rail, and intercity rail transportation.
Travel Demand Model	A travel demand model is any relatively complex computerized set of procedures for predicting future trip making as a function of land use, demographics, travel costs, the road system, and the transit system. These models may cover an entire metropolitan area, a single city or county, or the entire State..

Trip-Based Model	Trip-based travel models use the individual person trip as the fundamental unit of analysis. Trip-based models are often referred to as "4-step" models because they split the trip making decision process into 4 discrete steps: trip generation by time of day, destination choice, mode choice, and route choice (traffic assignment).
Trucks	Trucks are a subtype of the heavy vehicles category which includes trucks, intercity buses, and recreational vehicles. This Framework follows the Highway Capacity Manual definition of what constitutes a heavy vehicle: "A vehicle with more than four wheels touching the pavement during normal operation." This is consistent with the Caltrans Traffic Census definition of a truck: "The two-axle (truck) class includes 1-1/2-ton trucks with dual rear tires and excludes pickups and vans with only four tires."
Vehicle Miles Traveled	The number of miles traveled by motor vehicles on roadways in a given area over a given time period. VMT may be subdivided for reporting and analysis purposes into single occupant passenger vehicles (SOVs), high occupancy vehicles (HOV's), buses, trains, light duty trucks, and heavy-duty trucks. For example, an air quality analysis may require daily VMT by vehicle class and average speed or vehicle operating mode (idle, acceleration, cruise, deceleration, etc.). For a CEQA compliant transportation impact analysis, automobile VMT (cars and light trucks) may be evaluated.
VMT Attributable to a Project	In the context of a CEQA analysis, the VMT attributable to a transportation project, or induced travel, is the difference in passenger VMT between the with project and without project alternatives. VMT attributable to a project is equivalent to induced travel in this context.

APPENDIX D. ACKNOWLEDGEMENTS

TECHNICAL ROUNDTABLE

Made up of over 35 practitioners and stakeholders, the following participants met three times to provide detailed technical input for the development of the guidance documents:

- Saravana Suthanthira, Alameda County Transportation Commission
- Maura Twomey, Association of Monterey Bay Area of Governments
- Liza Zorn, Bay Area Metropolitan Transportation Commission
- Bill Higgins, California Association of Councils of Government
- Tanisha Taylor, California Transportation Commission
- Emily Ehlers, City of Oakland
- Audrey Harris, City of Oakland
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- Dan Phu, Orange County Transportation Authority
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- Stephanie Blanco, Riverside County Transportation Commission
- Bruce Griesenbeck, Sacramento Area Council of Governments
- Steve Smith, San Bernardino County Transportation Authority
- Ann Calnan, Santa Clara Valley Transportation Authority
- Gene Gonzalo, Santa Clara Valley Transportation Authority
- Keith Dunn, Self Help Counties Coalition
- Carl Haack, Self Help Counties Coalition
- Chris Barney, Sonoma County Transportation Authority
- Suzanne Smith, Sonoma County Transportation Authority
- Michael Zeller, Transportation Agency for Monterey County
- Kiana Valentine, Transportation California

- Erik Ruehr, VRPA Technologies

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Throughout the development of this guidance, the Caltrans team worked closely with technical and policy experts from partner State agencies.

California State Transportation Agency:

- Darwin Moosavi

Office of Planning and Research:

- Chris Ganson
- Natalie Kuffel
- William Walker

California Air Resources Board:

- Nicole Dolney
- Heather King
- Ian Peterson

CALTRANS TEAM MEMBERS

The District SB 743 Liaisons support implementation of this guidance within Caltrans Districts:

- Jesse Robertson, District 1
- Kathy Grah, District 2
- Kelly McNally, District 3
- Phillip Rodriguez, District 4
- John Olejnik, District 5
- Michael Navarro, District 6
- Barbara Marquez, District 7
- Tracey D'Aoust Roberts, District 8
- Gayle Rosander, District 9
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The interdisciplinary SB 743 Implementation Team coordinated to support the development of the guidance:

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- Chris Schmidt, SB 743 Implementation Program Manager

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- Glenn Mueller, Legal
- Jeremy Ketchum, DEA
- Jennifer Heichel, DEA
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- Charles “Muggs” Stoll, Sustainability
- Marlo Tinney, Division of Traffic Operations
- Troy Bucko, Division of Safety
- Tyler Monson, Division of Research, Innovation and Systems Information

CONSULTANTS

Substantial contributions were made by the following organizations in a consulting role to Caltrans:

- Alta Vista Solutions
- Emergent Transportation Concepts
- Kittelson and Associates, Inc.
- MIG, Inc.
- P & D Consulting

Exhibit J

Transportation Analysis under CEQA

First Edition

Evaluating Transportation Impacts of State Highway System Projects

California Department of Transportation
Sacramento, California
September 2020

ACKNOWLEDGEMENTS

The *Transportation Analysis Framework* (TAF) and *Transportation Analysis Under CEQA* (TAC) were prepared by the California Department of Transportation working with State Administration partners and Stakeholders from the public, private and non-profit sectors. Contributors within the Department included staff and management from the Headquarters Divisions of Environmental Analysis, Transportation Planning, Traffic Operations, and Legal, as well as from the Director's Office Sustainability Team. The Headquarters team benefitted from input provided by the Caltrans Executive Team as well as by staff and management from Caltrans districts.

The documents are the products of a collaboration among State government partners. Throughout the development of the documents, the Caltrans team worked closely with technical and policy experts from the Governor's Office of Policy and Research and the California Air Resources Board.

A list of the individuals who contributed to the preparation of the TAF and TAC is included at the end of this document. We are grateful for the time and effort that they generously gave to develop and document the Department's new approach to analyzing and evaluating transportation impacts of projects on the State Highway System.

LETTER FROM THE DIRECTOR

To Caltrans staff, partners, and stakeholders,

I am pleased to issue the enclosed guidance document: *Transportation Analysis under the California Environmental Quality Act (CEQA) for Projects on the State Highway System* (TAC) as part of the California Department of Transportation's (Caltrans) continuing commitment to implement the California Environmental Quality Act in alignment with State goals and policies. The TAC, and its companion document, *Transportation Analysis Framework* (TAF), provides Caltrans policy along with guidance for implementing Senate Bill (SB) 743 (Steinberg, 2013) codified at Public Resources Code section 21099.

The new processes implemented through Caltrans' environmental program are a key part of Caltrans' increasingly important work to confront the challenge of climate change and build more livable communities. Caltrans is actively implementing strategies to reduce emission of greenhouse gases, including initiatives to use clean fuels and vehicles, and to reduce waste. Perhaps most importantly, we are rethinking the way we invest so people can drive less.

Reducing total driving, or vehicle miles traveled, is the focus of the TAC, TAF and the associated changes to transportation impact analysis under CEQA for projects on the State Highway System. In plain terms, the more we drive our cars, the more damage we cause to the environment and our health—and the less time we spend with our families and communities. A vehicle miles traveled-based approach supports transportation projects that create more travel choices, such as new rail lines, improved bus service, trails, paths, and safer streets for walking and bicycling. As these modes of transportation grow, we can reduce the dependence and burden on our already congested highway system.

Thank you to our partners and stakeholders, as well as to Caltrans staff, whose contributions have helped to shape this document. I look forward to your continued partnership as we make the changes needed to meet California's goals for climate, air quality, and public health. It's an exciting time to continue our commitment to provide more transportation options to Californians and reduce our dependence on driving.

Sincerely,

Toks Omishakin
Director, Caltrans

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FOREWORD

The *Transportation Analysis Framework* (TAF) and *Transportation Analysis under CEQA* (TAC) guide transportation impact analysis for projects on the State Highway System (SHS) as part of the California Environmental Quality Act (CEQA) process. The California Department of Transportation (Caltrans) has prepared these documents to guide implementation of Senate Bill (SB) 743 (Steinberg, 2013). The TAF and TAC establish Caltrans guidance on how to analyze induced travel associated with transportation projects and how to determine impact significance under CEQA, respectively. These documents guide transportation impact analysis for projects on the SHS only. The non-capacity-increasing maintenance projects like re-paving and filling potholes are unaffected, as are many safety improvements, including traffic calming measures to slow traffic, and transportation projects that create facilities for pedestrians and cyclists and transit projects.

In response to a high level of interest in the guidance from Caltrans' transportation partners, climate and environmental advocates and others, Caltrans has hosted a total of 130 meetings with stakeholders and provided a 60-day informal feedback period on the draft documents. Statewide outreach events included two external webinars attended by over 850 participants and three external technical roundtables attended by more than 150 participants. These Caltrans events were supplemented by OPR's webinar and Office Hours outreach which reached over 3,500 participants. Additionally, Caltrans met regularly through the guidance development process with key stakeholders including the Self-help Counties Coalition, the ClimatePlan coalition, and the Rural Counties Task Force.

Caltrans received feedback on the drafts from 37 agencies including counties, cities, and MPOs as well as from consultants, advocates, coalitions and other State agencies. Throughout the process, a small number of controversial issues stood out. To address the difference of opinions around key technical issues, Caltrans convened an expert panel of academics and practitioners through UC Berkeley Tech Transfer. The panel chair presented the group's conclusions to stakeholders at a virtual Technical Roundtable prior to finalizing the group's recommendations. Caltrans and State partners have accepted the panel's recommendations, which are reflected in the guidance documents.

The Caltrans TAF and TAC guidance documents reflect a cultural shift in how Caltrans interprets, analyzes and mitigates transportation impacts. This shift will impact the entire project delivery process and shape the future of California's transportation system. The September 2020 TAF and TAC are the first versions of these materials, and we anticipate future improvement as our understanding and expertise deepens through implementation. Your continuing input and partnership with Caltrans will help further improve the guidance. Your commitment and participation in this ongoing work is appreciated.

1 INTRODUCTION/BACKGROUND

The intent of this guidance is to provide information to support Caltrans' CEQA practitioners in making CEQA significance determinations for transportation impacts of projects on the SHS.

With the passage of Senate Bill (SB) 743 (Steinberg, 2013) codified at Public Resources Code (PRC) section 21099, California embarked on a new approach for analyzing transportation impacts under CEQA. These changes require updates to both the Caltrans Local Development-Intergovernmental Review (LD-IGR) function and project delivery for projects on the SHS.

In SB 743, the California State Legislature (Legislature) found and declared the following:

> *(1) With the adoption of Chapter 728 of the Statutes of 2008, popularly known as the Sustainable Communities and Climate Protection Act of 2008, the Legislature signaled its commitment to encouraging land use and transportation planning decisions and investments that reduce vehicle miles traveled and contribute to the reductions in greenhouse gas emissions required in the California Global Warming Solutions Act of 2006 (Division 25.5 (commencing with Section 38500) of the Health and Safety Code). Similarly, the California Complete Streets Act of 2008 (Chapter 657 of the Statutes of 2008) requires local governments to plan for a balanced, multimodal transportation network that meets the needs of all users of streets, roads, and highways for safe and convenient travel.*
>
> *(2) Transportation analyses under the California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) typically study changes in automobile delay. New methodologies under the California Environmental Quality Act are needed for evaluating transportation impacts that are better able to promote the state's goals of reducing greenhouse gas emissions and traffic-related air pollution, promoting the development of a multimodal transportation system, and providing clean, efficient access to destinations.*

The legislative intent of SB 743 is to do both of the following:

1) Ensure that the environmental impacts of traffic, such as noise, air pollution, and safety concerns, continue to be properly addressed and mitigated through the CEQA.
2) More appropriately balance the needs of congestion management with statewide goals related to infill development, promotion of public health through active transportation, and reduction of greenhouse gas (GHG) emissions.

In December 2018, the Office of Administrative Law approved updates to the formal CEQA regulations prepared by OPR. The formal regulations are generally referred to as the CEQA "Guidelines." The update contained, among other things, a new section 15064.3 addressing transportation impacts. OPR also released the *Technical Advisory on Evaluating Transportation Impacts in CEQA* which contains recommendations on assessing vehicle miles traveled (VMT), significance, and mitigation measures.[1]

Section 15064.3 of the Guidelines separately addresses the analysis of transportation impacts arising from land use projects and those arising from transportation projects. For Caltrans, SB 743 means major changes in two activities:

1) Review of a proposed land use project's or a proposed plan's potential impact to the SHS, which are generally addressed through the Caltrans Local Development-Intergovernmental Review Program.
2) CEQA analysis of capacity-increasing transportation projects on the SHS.

These changes are consistent with both the CEQA Guidelines and OPR's Technical Advisory. Together, they aim to reduce automobile use while increasing use of more sustainable modes of transportation that are essential to supporting our growing population and economy, while also meeting climate goals. Reducing VMT corresponds with the goals detailed in Caltrans' Strategic Management Plan. It is also consistent with and will aid Caltrans in continuing to meet its policy aims for the Environment (Director's Policy [DP-004]); Freeway System Management (DP-08); Energy Efficiency, Conservation, and Climate Change (DP-023-R1); Climate Change (DP-30); and Sustainability (DP-033), among others.

This guidance establishes Caltrans' process for analyzing a transportation project's impacts under CEQA due to increases in VMT attributable to that project and offers an initial list of potential mitigation measures for significant impacts. This guidance augments but does not change any of the basic processes currently in place for evaluating projects under CEQA and other applicable laws or regulations. This guidance is not intended to address transportation impacts resulting from land-use projects which are addressed in the separate *Transportation Impact Study Guide* (TISG). Nor is this guidance intended to provide detailed instruction on performing the induced travel analysis itself, which can instead be found in the *Transportation Analysis Framework* (TAF).

The TAC is to be used in conjunction with the guidance provided in the TAF. The flow chart provided as Figure 1 illustrates the relationship between the TAC and TAF.

[1] Office of Planning and Research, *Technical Advisory on Evaluating Transportation Impacts in CEQA* (December 2018).

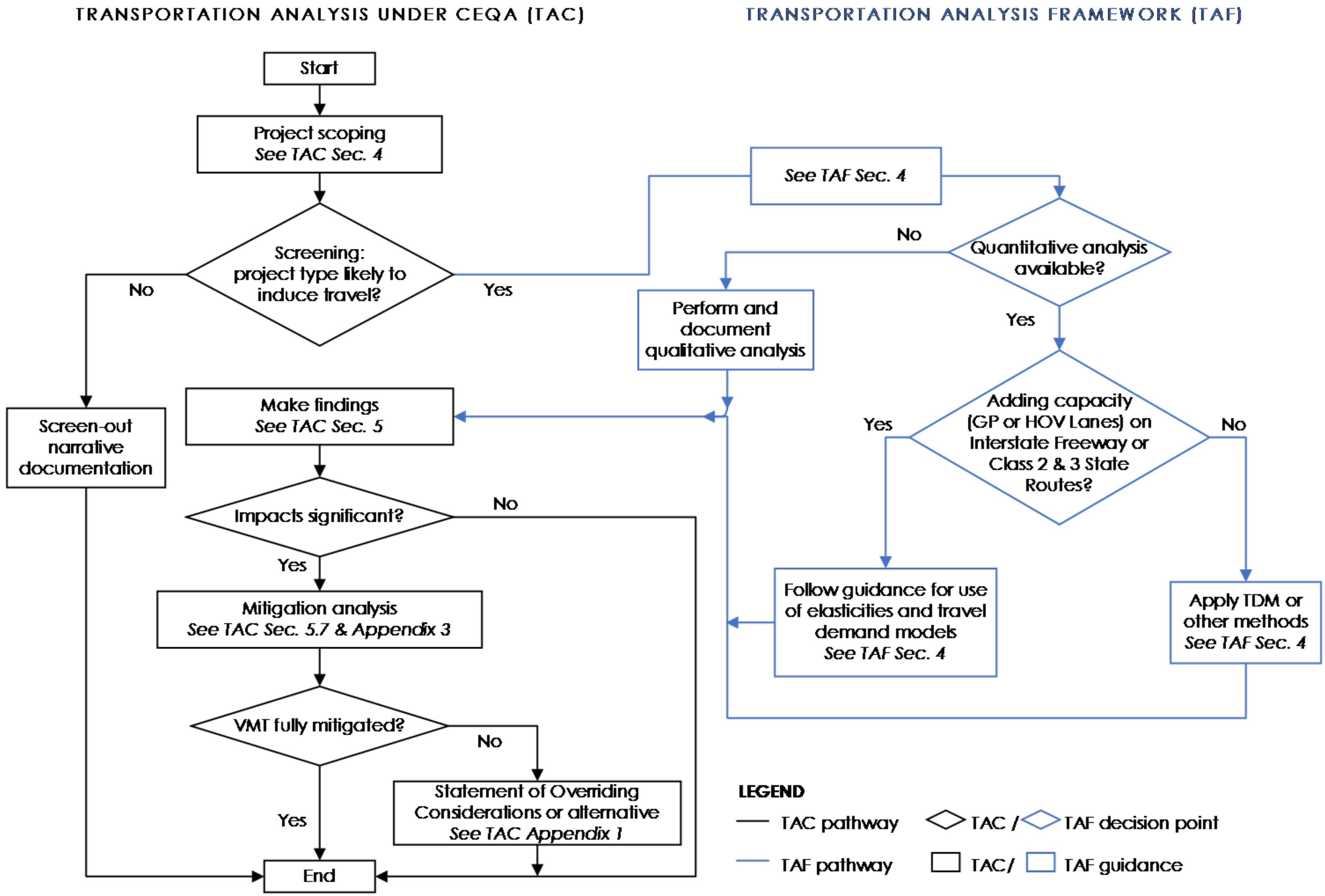

Figure 1. Relationship Between the TAC and TAF Documents

2 REGULATORY SETTING

This section contains a listing of relevant laws, regulations, documents, and references for project-level VMT analysis.

Regional VMT analysis takes place during the development of the Regional Transportation Plans (RTPs), which are prepared and adopted every five years by the 26 rural Regional Transportation Planning Agencies (RTPAs), and every four years for the 18 Metropolitan Planning Organizations (MPOs) located in air quality non-attainment areas and at least every five years for MPOs located in air quality attainment areas. An RTP is a long-range, fiscally constrained plan prepared subject to federal and State requirements. It provides a vision for regional transportation investments over a period of 20 years or more and analyzes the transportation system and its relationships to a region's economy, environment, livability, and more.

2.1 SUSTAINABLE COMMUNITIES AND CLIMATE PROTECTION ACT OF 2008

Senate Bill 375 (Steinberg), known as the Sustainable Communities and Climate Protection Act, was enacted in 2008. SB 375 directed the California Air Resources Board (CARB) to adopt regional GHG emissions reduction targets applicable to each MPO region. SB 375 also required the State's 18 MPOs to: 1) prepare a sustainable communities strategy (SCS) to achieve the GHG-reduction target as part of the RTP; or 2) prepare an "alternative planning strategy" if the SCS does not achieve the reductions called for by the regional targets.

Senate Bill 375 also required the California Transportation Commission, in conjunction with CARB, to maintain guidelines for the travel demand models used in the development of RTPs.

Each RTPA or MPO must also complete an environmental analysis of its RTP pursuant to CEQA. These environmental documents analyze the anticipated environmental effects arising from the implementation of the region's RTP, including transportation impacts. The environmental documents prepared by the RTPAs and MPOs report a variety of VMT-related metrics or performance measures in their analyses including total annual VMT, per capita VMT, and congested VMT.

2.2 CEQA GUIDELINES

Section 15064.3 of the CEQA Guidelines (Guidelines) addresses *Project-level VMT analysis* under CEQA.

The portion of the Guidelines that address transportation projects (rather than land use projects), begins at section 15064.3(b) and reads:

> *(2) Transportation Projects. Transportation projects that reduce, or have no impact on, vehicle miles traveled should be presumed to cause a less than significant transportation impact. For roadway capacity projects, agencies have discretion to determine the appropriate measure of transportation impact consistent with CEQA and other applicable requirements. To the extent that such impacts have already been adequately addressed at a programmatic level, such as in a regional transportation plan EIR, a lead agency may tier from that analysis as provided in Section 15152.*
>
> *(3) Qualitative Analysis. If existing models or methods are not available to estimate the vehicle miles traveled for the particular project being considered, a lead agency may analyze the project's vehicle miles traveled qualitatively. Such a qualitative analysis would evaluate factors such as the availability of transit, proximity to other destinations, etc. For many projects, a qualitative analysis of construction traffic may be appropriate.*
>
> *(4) Methodology. A lead agency has discretion to choose the most appropriate methodology to evaluate a project's vehicle miles traveled, including whether to express the change in absolute terms, per capita, per household or in any other measure. A lead agency may use models to estimate a project's vehicle miles traveled, and may revise those estimates to reflect professional judgment based on substantial evidence. Any assumptions used to estimate vehicle miles traveled and any revisions to model outputs should be documented and explained in the environmental document prepared for the project. The standard of adequacy in Section 15151 shall apply to the analysis described in this section.*

Several broader observations about section 15064.3 and how it relates to this guidance are important to note:

- Per section 15064.3, VMT is "Generally the most appropriate measure of transportation impacts." The simplest definition of VMT, or vehicle mile traveled, is "One vehicle traveling on a roadway for one mile" (Sacramento Area Council of Governments 2016 MTP/SCS). Section 15064.3(a) defines "vehicle miles traveled" as "The amount and distance of automobile travel attributable to a project." This is a significant change from previous methodologies which typically analyzed Level of Service (LOS)[2], a travel time and congestion metric, as the most important consideration in transportation impacts analysis. When evaluating transportation impacts on the SHS, Caltrans will now evaluate the "induced travel," or the change in VMT attributable to an individual transportation project.

- Certain project types, primarily those which are non-capacity increasing, are presumed to result in a less than significant transportation impact and therefore generally do not require analysis of vehicle miles traveled. Those project types are discussed in section 5.1 of this document and are also described in the OPR Technical Advisory.
- A lead agency may in some cases tier its transportation impact analysis, as appropriate, from the environmental impact reports (EIRs) prepared for regional transportation plans/sustainable community strategies (RTP/SCS).[3] See the discussion in section 5.1.2. of this document to assess whether transportation impacts have been adequately analyzed at the programmatic level, and whether tiering from an RTP/SCS EIR or other analysis may be appropriate.
- Quantitative analysis is most appropriate for transportation projects which increase roadway capacity. Please refer to Section 4 of the TAF for further discussion.
- Qualitative analysis may be appropriate for certain transportation projects, particularly when technical models are not available, as discussed in TAF Section 4. The use of a qualitative analysis should generally be limited to those situations in which quantitative tools are unable to adequately assess a transportation project's impacts. Please refer to Section 4 of the *Transportation Analysis Framework: Induced Travel Analysis* (TAF) for more details.

Caltrans has chosen to express change in VMT in absolute terms.

[2] The Highway Capacity Manual, which first introduced the concept of LOS in 1965, defines LOS as follows: "Level of service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. Safety is not included in the measures that establish service levels." Additionally, "each facility type that has a defined method for assessing capacity and level of service also has performance measures that can be calculated. These measures reflect the operating conditions of a facility, given a set of roadway, traffic, and control conditions. Travel speed and density on freeways, delay at signalized intersections, and walking speed for pedestrians are examples of performance measures that characterize flow conditions on a facility" (Highway Capacity Manual, 2000).

[3] It should be noted that some RTPs/SCSs are not consistent with the state's climate goals, according to CARB. See CARB, "CARB 2017 Scoping Plan," 4. A close review of the applicable EIR for the RTP will be required in order to "tier" from its analysis.

3 OTHER RELEVANT DOCUMENTS AND REFERENCES

3.1 TECHNICAL ADVISORY ON EVALUATING TRANSPORTATION IMPACTS IN CEQA (OPR TECHNICAL ADVISORY)

The OPR Technical Advisory provides recommendations on assessing VMT, significance, and mitigation measures. Practitioners should consult the OPR Technical Advisory when evaluating transportation impacts of projects on the SHS.

3.2 CALIFORNIA AIR RESOURCES BOARD CLIMATE CHANGE SCOPING PLAN

In 2006, the Legislature passed Assembly Bill 32 (AB 32, Nunez), known as the California Global Warming Solutions Act of 2006. which created a comprehensive, multi-year program to reduce GHG emissions in California. AB 32 required CARB to develop the Scoping Plan to describe the approach California would take to reduce GHGs to meet the target of reducing emissions to 1990 levels by 2020. The Scoping Plan was first approved by CARB in 2008 and updated in 2014 and again in 2017. [4]

In 2016, the Legislature passed SB 32 (Pavley), which codified a statewide 2030 GHG emissions-reduction target of 40 percent below 1990 levels. Along with SB 32, the Legislature passed companion legislation, AB 197 (Eduardo Garcia), which provided additional direction for updating the Scoping Plan. These changes were reflected in the second update to the Scoping Plan completed in 2017.

3.3 CALIFORNIA AIR RESOURCES BOARD'S MOBILE SOURCE STRATEGY

In May 2016, CARB released the updated Mobile Source Strategy which demonstrates how the State can simultaneously meet air quality standards, achieve GHG emissions reduction targets, decrease health risk, and reduce petroleum consumption from the transportation sector through a modeling scenario—the "Cleaner Technologies and Fuels Scenario" (CTF). Although the majority of GHG reductions in the scenario are assumed to be attributable to new vehicle technologies and low carbon fuels, the CTF also demonstrates the need for a 15 percent reduction in total light-duty VMT by 2050 as compared to baseline 2050 levels. This scenario would require light-duty VMT growth of only five percent by 2030, compared to the current growth trajectory of approximately 11 percent.[5] The combined strategies within the CTF scenario, including VMT reduction, would achieve a 45 percent reduction in on-road GHG emissions by 2030, and an

[4] California Air Resources Board, "2017 Scoping Plan Documents." Available at https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2017-scoping-plan-documents.

[5] California Air Resources Board, "Mobile Source Strategy," (May 2016), 37.

approximately fifty percent reduction in on-road petroleum demand by 2050, meeting both climate targets. CARB continues to implement the 2016 Mobile Source Strategy and in 2020 is in the process of updating the Strategy, as required by Senate Bill 44 (Skinner).[6]

3.4 California Air Resources Board's Sustainable Communities and Climate Protection Act Progress Report

In November of 2018, CARB published the "2018 Progress Report: California's Sustainable Communities and Climate Protection Act" (Progress Report). The Progress Report indicates California is not on track to meet the GHG reductions expected under SB 375. According to the Progress Report, actual statewide per capita VMT had not declined as expected under SB 375 but at the time the report was written, was increasing. The fundamental finding in CARB's Progress Report is that California is not on track to meet GHG emissions reductions expected under SB 375 and will not meet SB 32 GHG emissions targets without significant changes to how communities and transportation systems are planned, funded, and built.[7]

[6] California Air Resources Board, "2020 Mobile Source Strategy." Available at https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy.

[7] California Air Resources Board, "2018 Progress Report: Sustainable Communities and Climate Protection Act". (November 2018), 3, 5.

4 PROJECT SCOPING

Formal scoping will continue to follow established procedures identified under CEQA, including preparation of a Notice of Preparation for an EIR. Scoping a project on the SHS is a collaborative process.

Preliminary environmental scoping occurs even earlier, during the "Project Initiation Phase" and this phase culminates in the "programming" of transportation projects. Transportation programming is the commitment of transportation funds to particular projects, to be available over a period of several years. Separate programming documents, prepared and adopted for somewhat different purposes, are required under both federal and State law.

Deviating from the programmed scope, schedule or budget is an uncertain process, and represents a potential risk to a project's successful delivery. Projects that do not have an accurate scope may face cost increases and schedule delays. Because of fiscal and schedule constraints, it may become increasingly difficult to achieve feasible and proportional project-level VMT mitigation as a roadway capacity-increasing project proceeds from initial scoping to final design. Therefore, it is important to thoroughly consider a range of feasible project alternatives and/or mitigation which meet the purpose and need of the project, as well as feasible mitigation which can potentially minimize, or avoid altogether, the additional VMT from capacity-increasing projects.

The following options, and others which may avoid VMT impacts, require close coordination with federal, state, and regional transportation partners, and should be considered as early as possible in the planning process, as part of the range of VMT-reducing alternatives to capacity-increasing projects.

- Invest in multimodal transportation infrastructure: Caltrans and/or partnering agencies could directly invest in infrastructure likely to support VMT reduction in order to mitigate the impacts of capacity increasing projects.
- Expand toll lane use or develop other pricing-based strategy options: This option would consist of expanding the use of toll lanes or developing other pricing strategies, such as increasing parking prices in an area, to reduce VMT.

Other potential options to reduce project-level VMT impacts are discussed in the mitigation section of this document (section 5.7).

In addition to mitigation, another consideration during the preliminary scoping of project involves the determination of the appropriate level of environmental document. For new projects, Project Development Teams (PDTs) should consider the likelihood of a potentially significant environmental impact (applying the methods in Section 5) when determining the appropriate level of document. PDTs should also evaluate whether projects initially determined to require a Negative Declaration/Mitigated Negative Declaration (ND/MND) may instead require an EIR if there is a potential for a significant impact, and, if no feasible alternative or mitigation substantially reduces that impact, a Statement of Overriding Considerations may be appropriate.

5 THE CEQA ANALYSIS

This guidance document is primarily intended to address the following question on the CEQA checklist found in Guidelines Appendix G, section XVII(b):

Would the project conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?

The portion of section 15064.3(b) of the CEQA Guidelines pertaining to transportation projects provides that for roadway capacity projects "…agencies have the discretion to determine the appropriate measure of transportation impact consistent with CEQA and other applicable requirements." Consistent with the language of Section 15064.3 of the CEQA Guidelines, Caltrans concurs that VMT is the most appropriate measure of transportation impacts under CEQA. The determination of significance of a VMT impact will require a supporting induced travel analysis for capacity-increasing transportation projects on the SHS when Caltrans is lead agency or when another entity acts as the lead agency.

Whether a project is in conflict or inconsistent with CEQA Guidelines section 15064.3(b) will be evaluated by practitioners based on its potential to increase VMT attributable to the project, (i.e., induced travel), as discussed in the Section 5.6 below. The guidance in this document further explains the types of projects and impacts that would be considered significant within this context.

The remaining CEQA checklist questions generally associated with transportation impacts are listed in Appendix G of the CEQA Guidelines and are addressed in Appendix B of this document. Each question should be analyzed independently. If other potential impacts are identified for a particular project, the standard CEQA analytical process would apply and significance determinations made for each, as appropriate.

5.1 SCREENING

The use of VMT as the CEQA transportation metric will, in many cases, lead to a determination that roadway capacity-increasing projects result in significant transportation impacts. For many other types of transportation projects, however, a VMT impact analysis beyond the screening process is not necessary. Generally, there are two reasons such an analysis may not be warranted. The first is because the type of project would not be likely to lead to a measurable and substantial increase in VMT. The second is because the project's VMT impacts have already been analyzed and, when necessary, mitigated to the extent feasible in an earlier CEQA document. In the latter case the analysis may "tier" from or otherwise rely on that earlier analysis.

5.1.1 SCREENING BY PROJECT TYPE: NON-CAPACITY-INCREASING VS. CAPACITY-INCREASING PROJECTS

Understanding the purpose and scope of the proposed project will assist the practitioner in determining which project types have the potential for a significant transportation impact. Determination of the project type usually occurs early in the project development process and is supported by the “purpose and need” of the project. A key consideration for the practitioner which is addressed below is determining whether a project type has the potential to induce travel.

If a project increases capacity, it will generally require an analysis to determine if there will be a significant transportation impact caused the increase in VMT attributable to the project. Many projects Caltrans regularly undertakes such as maintenance projects including culvert repairs, overlays, and restriping, do not increase capacity. During the screening review, practitioners should examine the specific project circumstances to ensure that there are no unusual circumstances which could otherwise lead to an increase in VMT. Then, practitioners should provide a brief discussion in the environmental document that describes why the project is not expected to increase VMT.

Taken directly from OPR’s Technical Advisory, the following excerpt describes types of projects likely to lead to measurable and substantial increases in VMT***:***

> **i)** ***Project Types Likely to Lead to a Measurable and Substantial Increase in Vehicle Travel***[8]
>
> *Addition of through lanes on existing or new highways, including general purpose lanes, HOV lanes, peak period lanes, auxiliary lanes, or lanes through grade-separated interchanges, and other projects adding capacity to the State Highway System.*

These are project types that include the construction of new facilities or expansion of existing ones. These are common types of capacity-increasing projects that Caltrans constructs. These projects are likely to lead to a measurable and substantial increase in VMT. Therefore, an induced travel analysis is required to determine how much of the increase in VMT is attributable to the project (versus other variables such as the economy and population growth), and where impacts are significant, whether mitigation can reduce the impacts to a less than significant impact. Only the VMT that is directly attributable to the project should be analyzed (See TAC Figure 2). The TAF provides guidance for analyzing induced travel.

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[8] Office of Planning and Research, *Technical Advisory on Evaluating Impacts in Transportation* (OPR December 2018), 20.

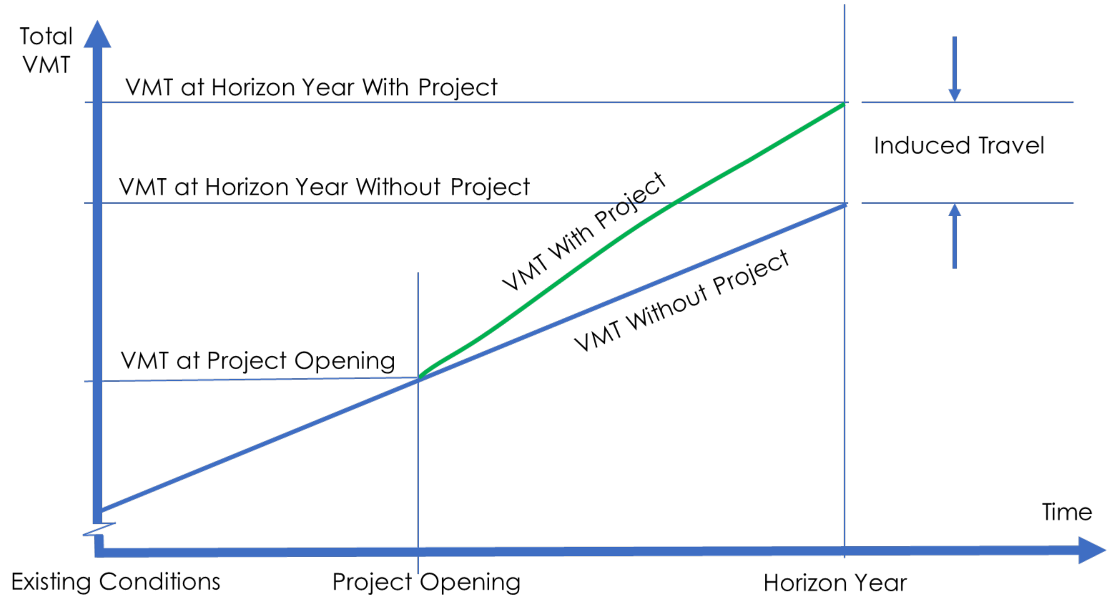

Figure 2. Identification of Induced Travel
(VMT Attributable to a Transportation Project)

The emphasis of this guidance is to identify those projects that will lead to a measurable and substantial increase in vehicle travel. The following describes projects not likely to lead to a measurable and substantial increase in VMT and which therefore generally should not require an induced travel analysis per OPR's Technical Advisory. The final six bullets on the list of project types not likely to lead to a measurable and substantial increase, beginning with "HOV bypass lanes on on-ramps" were added based on discussion with OPR. These are expected to be added to OPR's list of project types in a future update of the Technical Advisory. Note the deletion of the category of project described as "Addition of tolled lanes, where tolls are sufficient to mitigate VMT increase," which was also an outcome of discussion between Caltrans and OPR during the course of producing the TAC and TAF.

ii) Project Types Not Likely to Lead to a Measurable and Substantial Increase in Vehicle Travel[9]

- *Rehabilitation, maintenance, replacement, safety, and repair projects designed to improve the condition of existing transportation assets (e.g., highways; roadways; bridges; culverts; Transportation Management System field elements such as cameras, message signs, detection, or signals; tunnels; transit systems; and assets that serve bicycle and pedestrian facilities) and that do not add additional motor vehicle capacity*

[9] OPR, *Technical Advisory on Evaluating Transportation Impacts in CEQA* (December 2018), 20-21.

- *Roadside safety devices or hardware installation such as median barriers and guardrails*
- *Roadway shoulder enhancements to provide "breakdown space," dedicated space for use only by transit vehicles, to provide bicycle access, or to otherwise improve safety, but which will not be used as automobile vehicle travel lanes*
- *Addition of an auxiliary lane of less than one mile in length designed to improve roadway safety*
- *Installation, removal, or reconfiguration of traffic lanes that are not for through traffic, such as left, right, and U-turn pockets, two-way left turn lanes, emergency truck pullovers, or emergency breakdown lanes that are not utilized as through lanes*
- *Addition of roadway capacity on local or collector streets provided the project also substantially improves conditions for pedestrians, cyclists, and, if applicable, transit*
- *Conversion of existing general-purpose lanes (including ramps) to managed lanes or transit lanes, or changing lane management in a manner that would not substantially increase vehicle travel*
- *Addition of a new lane that is permanently restricted to use only by transit vehicles*
- *Reduction in number of through lanes*
- *Grade separation to separate vehicles from rail, transit, pedestrians or bicycles, or to replace a lane in order to separate preferential vehicles (e.g., HOV, HOT, or trucks) from general vehicles*
- *Installation, removal, or reconfiguration of traffic control devices, including Transit Signal Priority (TSP) features*
- *Installation of traffic metering systems, detection systems, cameras, changeable message signs and other electronics designed to optimize vehicle, bicycle, or pedestrian flow*
- *Timing of signals to optimize vehicle, bicycle, or pedestrian flow*
- *Installation of roundabouts or traffic circles*
- *Installation or reconfiguration of traffic calming devices*
- *Adoption of or increase in tolls*
- *Initiation of new transit service*
- *Conversion of streets from one-way to two-way operation with no net increase in number of general purpose or continuous through traffic lanes*
- *Removal or relocation of off-street or on-street parking spaces*
- *Adoption or modification of on-street parking or loading restrictions (including meters, time limits, accessible spaces, and preferential/reserved parking permit programs)*
- *Addition of traffic wayfinding signage*
- *Rehabilitation and maintenance projects that do not add motor vehicle capacity*
- *Addition of new or enhanced bike or pedestrian facilities on existing streets/highways or within existing public rights-of -way*

- *Addition of Class I bike paths, trails, multi-use paths, or other off-road facilities that serve non-motorized travel*
- *Installation of publicly available alternative fuel/charging infrastructure*
- *Addition of passing lanes, truck climbing lanes, or truck brake-check lanes in rural areas that do not increase overall vehicle capacity along the corridor*
- *HOV bypass lanes on on-ramps*
- *Local and collector roads in rural areas that don't include sidewalks where there would be no pedestrian traffic to use them*
- *Lanes through grade-separated interchanges without additional receiving lanes downstream*
- *Adding vehicle storage to a ramp without further reconfiguration*
- *Park and Ride facilities*
- *Truck size and weight inspection stations*

While the above list is thorough, it is not necessarily comprehensive. There may be types of projects in addition to those listed that would not lead to a measurable and substantial increase in VMT. When concluding that a particular project may be screened out from further analysis, the practitioner should review and fully document the rationale supporting the conclusion that the particular project would not likely lead to a measurable and substantial increase in VMT.

5.1.2 TIERING

As outlined in PRC sections 21068.5, 21093 and 21094, as well as Guidelines sections 15152 and 15385, tiering is a means of reducing redundancy, focusing analysis and ensuring consistency with earlier CEQA analyses. As defined in the PRC, tiering "…refers to using the analysis of general matters contained in a broader EIR (such as one prepared for a general plan or policy statement) with later EIRs and negative declarations on narrower projects; incorporating by reference the general discussions from the broader EIR; and concentrating the later EIR or negative declaration solely on the issues specific to the later project."

Tiering the project-level analysis from the regional analysis completed for the RTP/SCS EIR, or another EIR such as one prepared for a general plan or specific plan, would be the ideal method of determining the significance of transportation impacts. This is particularly true for an EIR prepared for an RTP/SCS, because if the regional modeling performed for a particular suite of projects (those that increase VMT and those that reduce VMT) has already accounted to some extent for the individual project's contributions, then the effects of the proposed project ideally would have already been mitigated entirely or in part. Although current RTP/SCS EIRs have limited utility for tiering transportation impact analysis, over time, tiering may become more available. Considerations to ensure that transportation impacts have been adequately evaluated and mitigated at the programmatic level include:

- The EIR must adequately evaluate the phenomenon of induced travel. The modeling performed for the suite of transportation projects and initiatives in a region must accurately capture the induced VMT from land use effects of those projects.
- If tiering from an RTP/SCS EIR, the EIR must demonstrate consistency with the State's GHG reduction targets because meeting the current SB 375 targets alone is not enough to demonstrate broad consistency between the RTP/SCS's VMT analysis and state climate goals. A transportation project which substantially increases VMT may conflict with State climate goals, even if the project was included in an RTP/SCS that meets the applicable GHG reduction targets called for by SB 375[10]. This is because the current RTPs/SCSs are anticipated to achieve an 18 percent reduction in statewide per capita, on-road light-duty, transportation-related GHG emissions relative to 2005 by 2035, if those RTP/SCSs are fully implemented. However, the State forecasts a 25 percent reduction is needed to meet the State's climate goals[11].
- All feasible mitigation measures normally considered at the project level must be fully considered and properly applied at the plan level.

Note that even when tiering is not available, the CEQA Guidelines allow for the "incorporation by reference" of materials from a broader EIR. For example, the "environmental setting" for a project could be incorporated by reference from a broader EIR, thus streamlining the project-level analysis. Please see Guidelines §15150 for more information and the requirements for incorporation by reference.

5.2 BASELINE DETERMINATION

CEQA requires the comparison of impacts caused by a project to a "baseline" to determine whether those impacts are significant (Guidelines §15125).

Normally, future conditions with the project are compared to a baseline of "existing conditions." However, alternatives to an existing conditions baseline may be appropriate in certain circumstances, as included in the recent CEQA Guidelines update that reflects case law on determining the baseline to use in CEQA documents:

> *Generally, the lead agency should describe physical environmental conditions as they exist at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, from both a local and regional perspective. Where existing conditions change or fluctuate over time, and where necessary to provide the most accurate picture practically possible of the project's impacts, a lead*

[10] California Air Resources Board, "CARB 2017 Scoping Plan-identified VMT Reductions and Relationship to State Climate Goals," (January 2019), 4.
[11] California Air Resources Board, "CARB 2017 Scoping Plan-identified VMT Reductions and Relationship to State Climate Goals," (January 2019), 3.

> *agency may define existing conditions by referencing historic conditions, or conditions expected when the project becomes operational, or both, that are supported with substantial evidence. In addition, a lead agency may also use baselines consisting of both existing conditions and projected future conditions that are supported by reliable projections based on substantial evidence in the record (Guidelines § 15125(a)(1)).*
>
> *A lead agency may also use projected future conditions (beyond the date of project operations) baseline as the sole baseline for analysis only if it demonstrates with substantial evidence that use of existing conditions would be either misleading or without informative value to decision-makers and the public. Use of projected future conditions as the only baseline must be supported by reliable projections based on substantial evidence in the record (Guidelines §15125(a)(2)).*

Transportation projects are typically built years after the CEQA analysis is completed, and comparing to existing conditions would combine the project's VMT effects with other effects on VMT that occur over time, such as increases in population or economic activity, in effect misleading the public and decision-makers by obscuring the impacts of the project itself. When comparing future build conditions to future no-build conditions, the difference is the addition of the project itself and associated changes that may occur to land use and travel behavior. The environmental document will need to include information on the traffic modeling, including the planning projections included in the model.

Regardless of whether a quantitative or qualitative analysis is performed, in order to fully provide context and information, beyond the future build condition, the CEQA analysis for VMT must also include the current condition and the future no-build condition. In other words, the future build alternative should be compared to the future no-build conditions (i.e., the conditions expected to exist in the future absent the project) to determine the amount of VMT attributable to the project per the CEQA Guidelines and the Technical Advisory. Additionally, and for informational purposes, the comparison to the existing condition should also be provided. However, a comparison only to existing conditions would not provide an accurate picture of the project's effects. Only by taking into account other variables not caused by the project, such as the projected future regional transportation system, population growth, economic growth and land use changes, can the *VMT that is attributable to the project* be separated from a general increase or decrease in VMT in a region overall. In order to fully apprise the reader of the total change in VMT anticipated, VMT for existing conditions should also be provided.

5.3 Direct Impacts to Vehicle Miles Traveled, Including Induced Travel

Any analysis of VMT impacts must 1) determine whether the project will cause a significant transportation impact, and 2) be supported by "substantial evidence" as defined in Guidelines §15384. The CEQA Guidelines allow a qualitative approach to analyzing transportation impacts when quantitative methods are unavailable. A qualitative analysis describes why or why not an increase in VMT is likely; how much induced travel is created, if any; and whether that increase, if any, will have a significant impact.

5.3.1 INDUCED TRAVEL

Some projects have the potential to result in a significant transportation impact because they are likely to induce vehicle travel. Induced travel, or induced vehicle travel, is the "Additional vehicle travel that occurs when the cost [for travel] is lower," after travel constraints, such as congestion, are reduced.[12] It is the increase in travel that occurs when auto travel is made more convenient by new roadway capacity. The extent that this occurs due to new roadway capacity versus other variables such as the economy (wage changes, gas prices, parking prices) and population growth varies across the body of research, but in general, changes in travel times and costs affect demand and therefore VMT. For this reason, capacity-increasing projects generally need to be evaluated for their potential induced travel. The mechanisms by which induced travel occur include:

- Route changes (may increase or decrease overall VMT)
- Mode shift to automobile use (increases overall VMT)
- Longer trips (increases overall VMT)
- More trips (increases overall VMT)
- Location and land use changes (increases overall VMT)

Induced travel can reduce the benefits of capacity expansion projects and increase VMT over time. While a project may reduce trip duration and increase travel speed on a short-term basis, this effect may be temporary as drivers may change their travel behavior in response to the newly expanded facility, particularly during peak periods of travel (work commutes). In the long run, an expanded facility may also facilitate land development around the project. Ultimately, induced demand can lead to more and longer trips, increasing VMT; thereby, reducing travel time benefits of capacity increasing projects.[13] See Section 2.2 of the TAF for further details on induced travel.

[12] Ronald T. Milam and Jerry Walters, et al., "Induced Travel Technical Investigation Final," Prepared For Caltrans (April 24, 2016), 1.
[13] This discussion is adapted from Cervero, "Road Expansion, Urban Growth, and Induced Travel," *Journal of the American Planning* Association Vol. 69, No. 2 (Spring 2003): 146 and Duranton and Turner, "The Fundamental Law of Road Congestion: Evidence from US Cities," *American Economic*

5.3.2 QUANTITATIVE OR QUALITATIVE ANALYSIS.

TAC Figure 3, reproduced from the TAF, provides insight on when to apply quantitative versus qualitative methods. Users should refer to the TAF for additional guidance regarding analysis of VMT impacts. There are two potential quantitative methods identified below, the travel demand model (TDM) and the National Center for Sustainable Transportation (NCST) Induced Travel Calculator. The NCST calculator is an elasticity-based tool that estimates annual induced VMT for capacity expansion projects. More information on the calculator is available at: https://ncst.ucdavis.edu/research-product/induced-travel-calculator.

Table 1. Selection Matrix for Preferred Induced Travel Assessment Method for Projects on the SHS[1]

<table>
<tr><th>Project Type / Project Location</th><th>GP or HOV Lane Addition to Interstate Freeway</th><th>GP or HOV Lane Addition to Class 2 & 3 State Routes</th><th>Other VMT Inducing Projects and Alternatives</th></tr>
<tr><td>County in MSA with Class I Facility</td><td>Apply the NCST Calculator by MSA and/or TDM[2] benchmarked with NCST Calculator.</td><td rowspan="2">Apply the NCST Calculator by county and/or TDM[2] benchmarked with NCST Calculator.</td><td rowspan="2">Apply TDM[2] or other quantitative methods</td></tr>
<tr><td>Other MSA County</td><td>Apply TDM[2] or other quantitative methods</td></tr>
<tr><td>Rural County</td><td colspan="3">Apply TDM[2] or other quantitative methods</td></tr>
</table>

[1]If preferred methods are not available, qualitative assessment is acceptable as shown in TAF Figure 5.
[2]TDMs must be checked for applicability as described in TAF Sections 4.4 and 4.5.

Travel demand models must be checked for capability to assess induced travel as described in Sections 4.4 and 4.5 of the TAF.

The environmental document should include a discussion of the selection of induced travel methodology utilized in the traffic analysis.

Review Vol. 101, No. 6 (2011), 2616-2617. It should be noted that there may be other benefits to congestion relief and capacity increasing projects.

5.3.3 CONSTRUCTION IMPACTS

Impacts associated with construction of a project may also require VMT analysis, particularly for large projects or projects located a considerable distance from urbanized areas. Generally, a qualitative analysis of VMT impacts associated from the construction of the project would be appropriate. Although in some cases lane closures may result in out-of-direction travel as people seek to avoid the construction area, the reduction in capacity would usually disincentivize highway travel; thereby, possibly reducing VMT. Public information campaigns prior to and during roadway construction periods can effectively alert travelers to options such as available transit services and reducing trips during peak construction periods. Vehicle trips used for construction purposes would be temporary, and any generated VMT would generally be minor and limited to construction equipment and personnel and would not result in long-term trip generation.

5.4 CUMULATIVE AND INDIRECT IMPACTS

The term *cumulative impacts* refers to two or more individual effects which, when considered together, are considerable, compound, or increase other environmental effects. Pursuant to Guidelines section 15064(h), impacts are “cumulatively considerable” when the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.

For transportation impacts and with respect to VMT, a cumulative impact is a project’s potential, when combined with other projects in an area or region, to significantly increase VMT. In other words, a project may contribute to a potential impact through its incremental addition to regional VMT when examined in combination with the effects of other past, present, and probable future projects. A project at an interchange, for example, may not significantly induce new VMT on its own, but when considered cumulatively with other past, present, or future probable projects in a travel corridor or region, it may be cumulatively considerable and therefore significant.

If a project has no potential to induce new VMT, or if it reduces VMT, then a cumulative analysis is not required, as the project could not contribute to a cumulatively considerable transportation impact.

Lead agencies are not required to mitigate for effects caused by other past or future projects—mitigation is required only for the project under consideration. When a project might contribute to a significant cumulative impact, but the contribution will be rendered less than cumulatively considerable through project-specific mitigation, then the impact can be considered less than significant.

A project’s cumulative impacts may also be rendered less than cumulatively considerable if the project was analyzed as part of, and will comply with the requirements of, a previously-approved plan or mitigation program which includes enforceable requirements that will avoid or substantially lessen the cumulative impact within the geographic area in which the project is located (Guidelines §15064(h)(3)). See section 5.1.2. above for considerations related to compliance with a previously approved plan or mitigation program.

5.5 Consistency with Plans

Section 15125(d) of the CEQA Guidelines requires that an EIR,

> *…discuss any inconsistencies between the proposed project and applicable general plans, specific plans, and regional plans. Such regional plans include, but are not limited to, the applicable air quality attainment or maintenance plan or State Implementation Plan, area-wide waste treatment and water quality control plans, regional transportation plans, regional housing allocation plans, regional blueprint plans, plans for the reduction of GHG emissions, habitat conservation plans, natural community conservation plans and regional land use plans for the protection of the Coastal Zone, Lake Tahoe Basin, San Francisco Bay, and Santa Monica Mountains.*

Consistency with CARB's 2017 Scoping Plan as it pertains to both GHG emissions and any increase in VMT attributable to the project should be discussed in the "Consistency with State, Regional, and Local Plans and Programs" section of the environmental document, with references back to the Transportation and Climate Change sections, as needed. Capacity-increasing projects with the potential to lead to a measurable and substantial increase in VMT are likely to be inconsistent with State climate goals. Modeling completed by CARB for the Mobile Source Strategy shows capacity for statewide light-duty VMT growth is only five percent by 2030, as compared to the current growth rate of approximately eleven percent.[14] As stated previously, consistency with an RTP/SCS does not imply consistency with State climate goals.

5.6 Determining Significance

At the project level, the purpose of the CEQA analysis is to determine, and identify feasible mitigation for, adverse environmental impacts, such as increases in VMT attributable to the project. CEQA does not require an improvement over baseline or existing conditions, just that a lead agency consider reasonable project alternatives and mitigate significant environmental effects of the project to the extent feasible. A "significant effect on the environment" means "A substantial, or potentially substantial, adverse change in any of the physical conditions within the area

[14] California Air Resources Board, "Mobile Source Strategy," May 2016, pg. 37

affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance."

5.6.1 DETERMINING SIGNIFICANCE FOR PROJECTS IN RURAL (NON-MPO) COUNTIES

For projects within the rural, non-MPO counties, significance should be addressed on a case-by-case basis, taking into account context and environmental setting.

5.6.2 DETERMINING SIGNIFICANCE FOR PROJECTS IN MPO AREAS

The determination of significance will be based on the projection of induced travel attributable to the project.

Within the MPO areas (including RTPAs within MPOs), a project that results in an increase in VMT when comparing the future build alternative to the future no-build alternative (i.e., the VMT is higher under the future build scenario) will generally be considered significant, and mitigation will be required. Small increases of VMT attributable to a project that are consistent with the level of increase associated with the project types on the screened list (Section 5.1), would likely not be deemed significant.

Determining significance is a three-step process. First, the impact is evaluated without any consideration of mitigation, to determine if the impact is significant or not. If the impact is significant, mitigation is required and then "applied" to the project. The level of induced travel projected generally represents the level of VMT to be mitigated in order to reduce transportation impacts to a level that is less than significant. The remaining impact is then evaluated again to determine if it remains significant or if the mitigation has reduced the impact to a less than significant level. If the impact remains significant after all feasible mitigation has been incorporated, and there are no additional, feasible alternatives which would avoid or lessen the adverse impact, a statement of overriding considerations may be appropriate to approve the project. There are instances in which an element of a project or a project feature may reduce adverse transportation impacts and should be taken into account prior to the initial significance determination.

5.7 MITIGATION

A lead agency under CEQA has the authority to require feasible changes in any or all activities involved in the project in order to substantially lessen or avoid significant adverse impacts on the environment. Where changes to the project or project alternatives cannot avoid or substantially lessen the significant impact, mitigation is required. There must be a rational relationship between the impact and the mitigation for that impact (i.e., "nexus"), and the mitigation must be roughly proportional to the impact (i.e., "proportionality") (Guidelines §15041(a)).

Mitigation must be feasible and enforceable. "Feasible" under CEQA means "Capable of being achieved in a successful manner within a reasonable amount of time, taking into account economic, environmental, legal, social, and technological factors" (Guidelines § 15364). When specific economic, social, or other conditions make mitigation measures or project alternatives infeasible, individual projects may be approved in spite of one or more significant effects of the project (PRC § 21002; see also, Appendix A, "Considerations for Statements of Overriding Considerations").

As noted in the "Project Scoping" section of this document (Section 4), as a project proceeds toward final design it becomes increasingly difficult to achieve feasible, proportional project-level VMT mitigation for a capacity-increasing roadway project. Therefore, for capacity-increasing projects, early coordination and scoping of mitigation opportunities is advisable whether on-system or off-system mitigation is pursued. The following subsections of this document discuss on-system and off-system mitigation. Off-system mitigation, in particular, requires considerable time to identify willing partners and opportunities, perform analyses of the opportunities, and negotiate and execute agreements to fulfill mitigation commitments.

On-system mitigation are measures which can be implemented within the Caltrans right-of-way. On-system mitigation may include mitigation within or outside the initial project limits of any given capacity increasing project. Caltrans, as owner and operator of the SHS and associated right-of-way, exercises more direct authority over on-system measures as opposed to off-system measures. Off-system mitigation, outside Caltrans' right-of-way, requires cooperation with those jurisdictions that have influence over land use and transportation systems outside of Caltrans direct control.

5.7.1 MITIGATION OFF THE SHS

The Caltrans Division of Transportation Planning recently completed a literature review and assessment of VMT and GHG reduction strategies. The measures that resulted in the largest decreases in VMT are generally off-system and not under Caltrans' direct control, such as land use authority, cordon pricing[15] authority, parking management/pricing, and employer-based transportation demand management strategies. Close coordination with federal, state, and regional transportation partners would be required to implement such off-system VMT mitigation.

Similarly, the most cost-effective measures identified in the literature review also tended to be outside of Caltrans' direct control (e.g., transit-oriented development, transportation demand management).

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[15] "Cordon pricing" is a form of zone-based pricing in which drivers are charged either fixed or variable fees to drive within or into a congested area within a city (FHWA, "Zone-Based Pricing" available at: https://ops.fhwa.dot.gov/congestionpricing/strategies/involving_tolls/zone_based.htm.

There will be a need for cost-effective, feasible, and proportional VMT mitigation measures, not just for Caltrans' projects, but for local lead agencies statewide that must comply with CEQA. Caltrans may ultimately develop or participate in a VMT credit or banking and exchange system[16] operated by Caltrans, an MPO, RTPA, or another entity. Under a banking system, Caltrans could purchase mitigation credits to reduce project impacts related to VMT. The revenues from the credit purchases could be utilized by the bank to facilitate the development of VMT-reducing projects. For example, the bank could invest in infrastructure improvements such as pedestrian facilities or aid in the development of regional transportation options, such as light rail. An exchange system might be similarly structured. In exchange for implementing a project that induces VMT, Caltrans would invest in a project identified by a local or regional transportation partner that reduces VMT. One example of a system that relies on VMT reduction as a nexus is the City of Los Angeles Westside Mobility Plan Transportation Impact Fee Program.

VMT-reduction measures in rural areas may benefit from a coordinated approach. OPR has posted a document that includes strategies for different types of rural communities which can be found at: http://opr.ca.gov/docs/Mitigating_Vehicle-Miles_Traveled_(VMT)_in_Rural_Development.pdf.

5.7.2 MITIGATION ON THE SHS

As indicated previously, on-system mitigation tends to be more within Caltrans' direct authority. However, this does not mean that Caltrans may unilaterally decide to implement measures within its right-of-way. For example, tolling strategies will require early coordination or consideration as a project scoping alternative, with appropriate transportation planning agencies and may require approval from other agencies such as the California Transportation Commission or the Federal Highway Administration. In many cases, tolling strategies have the potential to provide substantial VMT reduction.

In addition to the measures noted above, all projects should consider strategies within the direct control of Caltrans and on the SHS. Measures listed in TAC Table 2 may be implemented to reduce VMT. Incorporating these types of measures as early as possible in the project development process will increase their feasibility. In certain circumstances, on-system measures may be able to sufficiently mitigate VMT attributable to a project or provide additional mitigation in situations where strategies beyond Caltrans' direct control are limited.

Additional measures and their approximate VMT-reduction potential can be found in the Caltrans Division of Transportation Planning's *Literature Review and Assessment of VMT and GHG Mitigation Strategies* as well as the transportation measures found in the California Air Pollution Control Officers Association's (CAPCOA) *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess*

[16] Vehicle miles traveled banking and exchange systems are discussed in more detail in papers referenced in Appendix C.

Emission Reductions from Greenhouse Gas Mitigation Measures. See Appendix C in this document for more information on these and other resources related to mitigation.

Table 2. Project-Level Measures to Reduce VMT on the SHS

Description
1. Include detours for bicycles and pedestrians in all areas potentially affected by project construction.
2. Incorporate Complete Streets Elements
3. Consider and accommodate alternate modes of transportation consistent with the purpose and need of the project: • Bicycle paths and facilities • Pedestrian infrastructure and pedestrian-friendly features (wide sidewalks, overpasses on busy roads, signalized intersections with appropriate signal timing, etc.) • Routes connecting to public transportation
4. Include measures to support multi modal transportation that will offset project impacts: additional Park & Ride lots
5. Social marketing efforts and incentives promoting mass transportation and carpooling. (Possible use of Cap and Trade Funds)
6. Social marketing and public education activities to improve awareness of the impacts of driving habits and opportunities to reduce climate change impacts.
7. Incorporate infrastructure electrification into project design (e.g., charging for electric bikes).
8. Implement intelligent transportation systems and transportation demand management elements to smooth traffic flow and increase system efficiency.
9. Implement Traffic Management Strategies: • Modify roadways to allow more efficient bus operation, including bus lanes and signal priority/preemption where necessary. Coordinate improvements on the SHS with arterials roadways. • Create an interconnected transportation system that allows a shift in travel from private passenger vehicles to alternative modes, including public transit, ride sharing, car sharing, bicycling and walking, if determined feasible and applicable by the Lead Agency.

5.8 Related Mitigation

It is important to note that mitigation that reduces VMT may also be identified as mitigation for adverse impacts associated with noise, energy, GHG emissions, criteria air pollutants, or toxic air contaminants resulting from the project.

5.9 Statements of Overriding Considerations

If the lead agency cannot identify and implement feasible and enforceable mitigation to reduce the impact to a level that is less than significant, then it should document and disclose those impacts as significant and unavoidable. Under CEQA, if a lead agency approves a project which will result in significant effects that are identified in the final EIR but are not avoided or substantially lessened, and if those impacts are outweighed by the economic, legal, social, technological, or other benefits of the project, including region-wide or statewide environmental benefits, the lead agency shall state in writing the specific reasons to support its decision based on the final EIR and/or other information in the record. This "statement of overriding considerations" shall be supported by substantial evidence in the record and included in the record of the project approval. It should also be mentioned in the Notice of Determination filed with OPR.

APPENDIX A. CONSIDERATIONS FOR STATEMENTS OF OVERRIDING CONSIDERATIONS

A statement of overriding considerations may be prepared when the project's effects are significant and not fully mitigable. According to Guidelines Section 15021(d):

> *CEQA recognizes that in determining whether and how a project should be approved, a public agency has an obligation to balance a variety of public objectives, including economic, environmental, and social factors and in particular the goal of providing a decent home and satisfying living environment for every Californian.*

The specific requirements for a statement of overriding considerations are found in the Guidelines Section 15093:

> *(a) CEQA requires the decision-making agency to balance, as applicable, the economic, legal, social, technological, or other benefits, including region-wide or statewide environmental benefits, of a proposed project against its unavoidable environmental risks when determining whether to approve the project. If the specific economic, legal, social, technological, or other benefits, including region-wide or statewide environmental benefits, of a proposed project outweigh the unavoidable adverse environmental effects, the adverse environmental effects may be considered "acceptable."*
>
> *(b) When the lead agency approves a project which will result in the occurrence of significant effects which are identified in the final EIR but are not avoided or substantially lessened, the agency shall state in writing the specific reasons to support its action based on the final EIR and/or other information in the record. The statement of overriding considerations shall be supported by substantial evidence in the record.*
>
> *(c) If an agency makes a statement of overriding considerations, the statement should be included in the record of the project approval and should be mentioned in the notice of determination. This statement does not substitute for, and shall be in addition to, findings required pursuant to Section 15091.*

Good places to start for the statement of overriding considerations are both the Purpose and Need statement for the project as well as the rationale used for the selection of the preferred alternative. Beyond the Purpose and Need Statement, lead agencies have substantial discretion in weighing specified economic, environmental and social factors which are relevant to their decision making. Any supporting factors relied upon by the lead agency should be documented in the agency's records relating to the project.

APPENDIX B. CEQA GUIDELINES, APPENDIX G CHECKLIST QUESTIONS

The Traffic and Transportation section of the environmental document should address the following remaining CEQA Checklist questions for each alternative under consideration, including the no-build alternative.

Would the project:

Conflict with a program, plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities?

The practitioner should assess and discuss the consistency of the alternatives with the relevant plans that address the circulation system including any Caltrans plans for the project area, the circulation element of the general plan, area-specific plans, transit planning document, district-specific bicycle and/or pedestrian plans, regional transportation plans, etc. Be certain to discuss the relevant project features (including standardized measures) that have been incorporated into the project to avoid or minimize the project's environmental impacts. If an alternative was modified to achieve consistency with an adopted program, plan, ordinance or policy addressing the circulation system, describe that here. *Please note that consistency with California's 2017 Climate Change Scoping Plan will be addressed in the Greenhouse Gas section of the environmental document under the applicable CEQA Checklist question.*

Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

In general, a transportation project is unlikely to substantially increase hazards.

Include information here from the project's purpose and need and project description to determine how a project will address non-standard geometric features such as horizontal and vertical curves, median width, shoulder width, access control, measures included to reduce flooding events, interchange improvements, separated bike lanes and/or other improvements for bicyclists and/or pedestrians or incompatible uses (for example, including wider shoulders for farm equipment in rural areas).

If the project is a safety project, explain how the project will improve safety. A project-level traffic analysis should include a safety analysis based on the Caltrans Traffic Accident Surveillance and Analysis System or other historical safety performance results. The implementation of performance-based decision-making using the Highway Safety Manual is encouraged to facilitate the integration of quantitative collision frequency and severity performance measures into roadway planning, design, operations, and maintenance decisions.

Result in inadequate emergency access?

In general, most projects either improve, or do not diminish, emergency access and/or response times. For example, projects that provide prioritized signalization to emergency vehicles can decrease emergency response time. Projects that create another means of ingress and egress can also improve emergency access. Projects that widen shoulders can provide additional areas for emergency response vehicle staging. There could be temporary construction impacts related to emergency access. This should be addressed in the Transportation Management Plan for the project and Caltrans should coordinate with local emergency officials as part of the development of that plan.

APPENDIX C. MITIGATION

Strategies to mitigate VMT are available within the following resources. Additional mitigation resources will be added to Caltrans SB 743 Implementation webpage. The following pages include additional information on the CAPCOA report (as referenced in item "a" below) and the literature review (as referenced in item "b" below).

a. California Air Pollution Control Officers Association's (CAPCOA) 2010 Quantifying GHG Mitigation Measures is a current source of VMT reduction by mitigation strategy. (See attached table 6-2 from the CAPCOA report summarizing mitigation options).

b. Literature Review and Assessment of VMT and GHG Mitigation Strategies. Prepared in December 2019 by Caltrans Division of Transportation Planning. (See following page for more information).

c. Governor's Office of Planning and Research's CEQA Guidelines Update and Technical Advisory website has information on VMT reduction strategies, even for rural areas.

d. A 2018 research paper from University of California Berkeley School of Law's Center for Law, Energy & the Environment focuses on two innovative models that could be used to implement programmatic VMT mitigation strategies for land use or transportation projects. VMT mitigation "banks" and "exchanges" are compared, and examples provided of ways to mitigate VMT under CEQA or the mitigation fee act. These models are conceptually similar to existing mitigation frameworks such as regional impact fee programs or habitat conservation banks.

e. A 2020 white paper prepared by Fehr & Peers VMT Mitigation Through Banks and Exchanges: Understanding New Mitigation Approaches highlights potential VMT mitigation programs including impact fee programs, mitigation exchange, and mitigation banks.

f. State Smart Transportation Initiative (SSTI) 2018 report Modernizing Mitigation: A Demand-Centered Approach outlines partnerships possible to reduce the demand for driving.

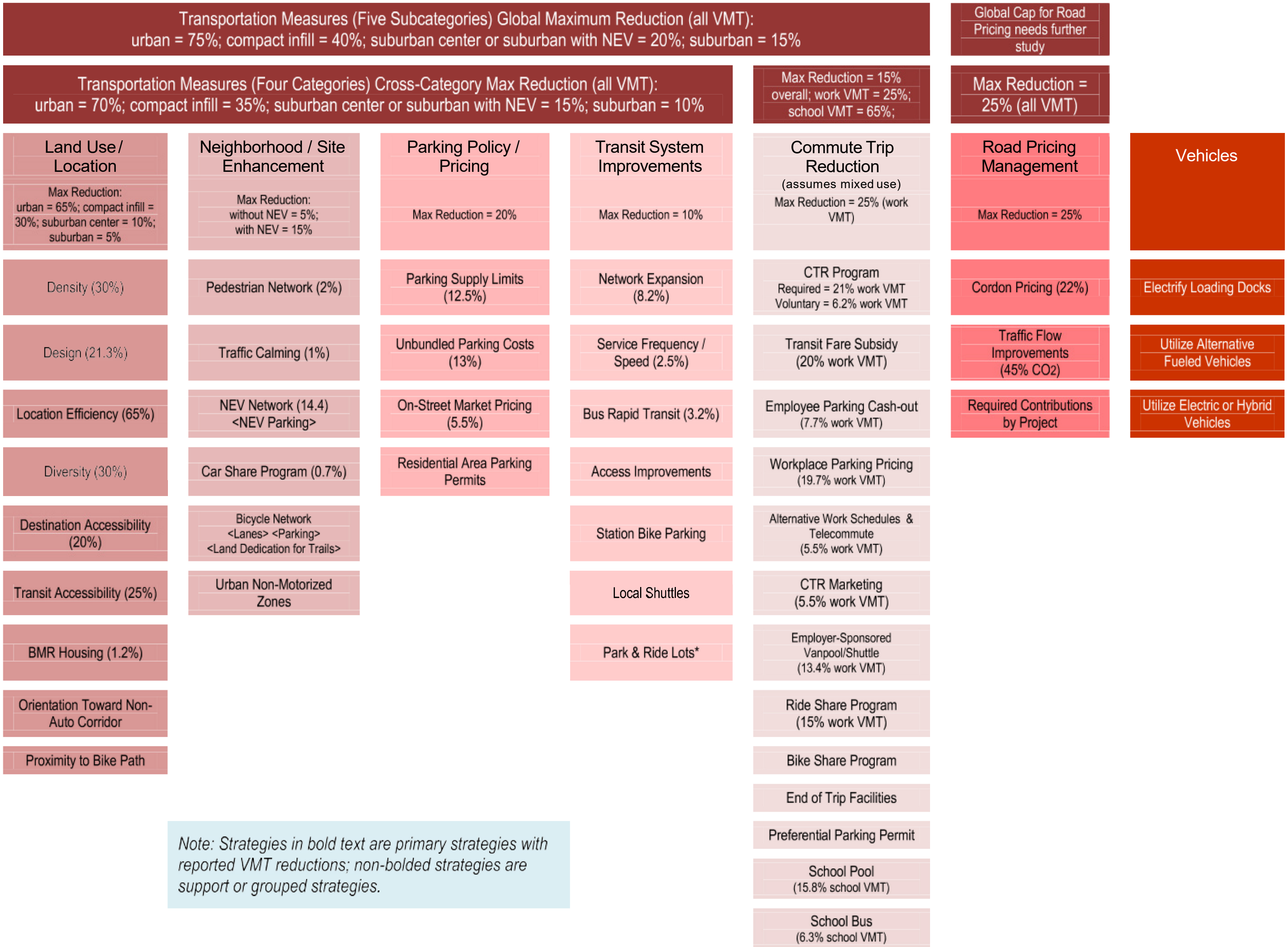

Figure C-1. Chart 6-2 of the CAPCOA Report

LITERATURE REVIEW AND ASSESSMENT OF VMT AND GHG MITIGATION STRATEGIES

Prepared in December 2019 by Caltrans Division of Transportation Planning

This report contains the results of a detailed, comprehensive review and synthesis of literature in order to compile estimates of the impacts of VMT and transportation GHG emission reduction strategies at the program, plan, and project level. The study focused on strategies that influence emissions from users of the transportation system, as opposed to strategies that target transportation project construction and maintenance activity. In addition, the study focused on strategies that can reduce GHG emissions either by reducing VMT or by changing traffic speed or flow; the study did not review strategies that seek to increase the deployment of low emission vehicles or alternative fuels.

METHODOLOGY

This research reviewed a wide variety of sources, including original peer-reviewed literature, previous meta-analyses and compilations, practitioner-oriented guidance documents, plans and feasibility studies, and select calculator tools that provide information on VMT and GHG emissions impacts. The extent and quality of research varies widely across the types of strategies considered. For some types of strategies (e.g., certain land use changes), more than 10 original research studies have quantified effects on VMT. Other types of strategies (e.g., bicycle and pedestrian facilities) have received far less attention from researchers seeking to quantify VMT or GHG emission impacts.

IMPLEMENTATION ROLE FOR CALTRANS

The implementation of VMT and GHG emission reduction strategies can be led by a variety of public and private sector organizations. The scale of strategy implementation can include employer-level, development project, neighborhood, transportation project, corridor, city, metropolitan area, or state-wide. Caltrans may have a lead or supporting role in implementation depending on the type of strategy and scale of application. The table below shows the strategies for which Caltrans has a supporting role and strategies for which Caltrans could lead implementation:

Table C-1. Mitigation Strategies by Caltrans Role

Strategy Category	Strategies for which Caltrans has a Support Role	Strategies for which Caltrans has a Lead or Support Role
Bicycle, Pedestrian, and Urban Design Strategies	Bikeshare	Bikeway network expansion Bike lane/path development Pedestrian facility network expansion Pedestrian facility development Street connectivity
Transit Strategies	Transit system expansion Transit frequency improvements Transit travel time improvements Transit reliability improvements Transit fare reduction	
Land Use and Parking Strategies	Land use mixing Higher density development Transit oriented development Destination accessibility Parking management and pricing	
Transportation Demand Management Strategies	Employer alternative commute option programs Rideshare Carsharing programs Telework Community-based travel marketing	Park and ride lots
Transportation System Management Strategies		Roadway pricing Arterial signal timing Ramp metering Traffic incident management programs HOV and HOT lanes

SUMMARY OF FINDINGS

The following table lists each of the strategies, the number of sources identified within the report that quantify the impact of those strategies with respect to VMT/GHG, and key findings.

Table C-2. Quantifiable mitigation strategies with respect to VMT/GHG

Strategy	Number of sources identified that quantify VMT or GHG impacts	Key Findings
Bikeway network expansion	2	Doubling bikeway density (in terms of bikeway miles per square mile or per capita) can reduce city-wide VMT by 0.05% to 0.1%

Strategy	Number of sources identified that quantify VMT or GHG impacts	Key Findings
Bike lane or bike path development	2	A new class 2 or 4 bikeway can reduce GHG emissions by 1 to 85 metric tons (MT) per year. The wide range reflects different assumptions for facility usage.
Bikeshare program expansion	3	The Bay Area Bike Share pilot program reduced GHG emissions by 79 tons in the first year. Several other documents report negligible impacts on VMT and GHG emissions.
Pedestrian facility network expansion	5	A 10% increase in sidewalk coverage can reduce area-wide VMT by 0.2% to 0.5%.
Pedestrian facility development	1	CARB's calculator tool estimates a pedestrian facility project will reduce 4 to 22 MT of GHG emissions per year.
Street connectivity improvement	11	A 10% increase in intersection density (in terms of intersections per square mile) can reduce area-wide VMT by 1.2%
Transit frequency improvements	3	Doubling transit frequency can reduce VMT by 0.5% to 2.5% in affected areas.
Transit travel time reduction	1	One study found that a 10% reduction in transit travel time is associated with an approximately 2.5% reduction in VMT and vehicle GHG emissions in affected areas.
Transit service expansion	3	In larger urban areas, increases in bus route miles of 10-42% were found to reduce region-wide VMT by an average of 0.13%.
Transit fare reduction	2	A calculator tool suggests that a 50% reduction in transit fares would typically reduce community wide VMT by 0.2%.
Land use mixing	8	A 10% increase in land use mixing (measured using an entropy index) is associated with 0.1% to 1.7% lower VMT.
Higher density development	8	A 10% increase in residential density is associated with 0.5% to 1.2% lower VMT.
Transit oriented development	5	Residents of transit-oriented development (TOD) in California are observed to have a transit mode share that is 4.9 times higher than residents of surrounding areas. Residential building in a transit-oriented location can reduce project VMT by up to 15% compared to building the project in a non-TOD location.
Destination accessibility	10	Locating a residential development 10% closer to the central business district is associated with a 2.3% reduction in VMT. A 10% improvement in regional jobs accessibility is associated with a 1.3% to 2.5% reduction in VMT.
Parking management and pricing	11	Doubling of parking prices can reduce VMT by 3% at lower parking price levels and 15% at higher parking price levels. Employer-based parking cash out programs are observed to reduce VMT by 12% for employees who opt in.

Strategy	Number of sources identified that quantify VMT or GHG impacts	Key Findings
Employer alternative commute option programs	8	Implementation of a voluntary employer-based alternative commute option program has been shown to reduce VMT associated with the employer site by 4% to 6%. Larger VMT reductions are reported for programs that involve mandatory monitoring, reporting, and targets.
Rideshare	8	Carpool and vanpool programs can reduce VMT by 3% to 8% at participating employers. Region-wide, rideshare programs are typically estimated to reduce VMT by less than 1%.
Telework	7	Participants in telework programs reduce their daily VMT by 50% to 75% on telecommute days. The community or region-wide VMT and GHG impacts of telecommute programs depend heavily on assumptions regarding levels of participation and have not been studied in recent years.
Carsharing programs	6	Participants in carsharing programs reduce their personal or household VMT and GHG emissions. Studies for MPOs suggest that expansion of carsharing programs can reduce community or region-wide VMT by 0.5% to 2%.
Community-based travel marketing	2	Studies of community-based travel marketing programs have found reductions in SOV trips of roughly 10% in targeted neighborhoods. Large-scale program deployment in the Bay Area was estimated to reduce per capita light duty vehicle GHG emissions by 1.2% to 1.7%.
Park and ride facilities	4	Among park and ride lots serving carpoolers, the observed average annual VMT reduction per lot was 156,000 in New York (7 lots) and 608,000 in Maine (39 lots). The annual VMT reduction per parking lot space is estimated to range from 2,700 to 7,200.
Roadway pricing	8	Tolling of the roadway system for the purpose of VMT and GHG reduction has not been implemented in the U.S., and thus the potential impacts are not well understood. Simulation modeling in the Seattle region found that tolling applied to all freeways would reduce regional VMT by 6%. Implementation of cordon pricing has resulted in a VMT reduction of approximately 15% in several international cities.
Arterial signal timing	5	During the time period of implementation, traffic signal coordination has been shown to reduce GHG emissions by 1% to 10% on the facility affected. Reductions may be over-estimated because they do not account for induced vehicle traffic effects.
Ramp metering	1	A study in South Korea found that ramp metering reduced system-wide GHG emissions by 7.3%.

Strategy	Number of sources identified that quantify VMT or GHG impacts	Key Findings
Traffic incident management programs	6	Statewide incident management programs in Florida and Maryland are estimated to reduce annual GHG emissions by 238,000 and 65,000 MT, respectively. At the corridor level, estimated GHG reductions range from 0.07% to 4%.
HOV and HOT lanes	7	There is little recent academic research regarding the VMT and GHG impacts of HOV and HOT lanes. Projects that added HOV lanes to freeways in the 1980s or 1990s resulted in an increase in average vehicle occupancy (AVO) by an average of 9%. Other research concludes that HOV lanes do not encourage carpooling because HOV travel time savings do not provide a statistically significant carpooling incentive. Conversion of HOV to HOT (express) lanes appears to reduce carpooling. Development of new HOV lanes typically increases VMT and GHG emissions as compared to a no-build alternative.

CONCLUSIONS

This report illustrates the breadth and variety of literature covering VMT and transportation GHG reduction strategies. The relevant documents differ widely in terms of the level of rigor applied for determining results, which can make it challenging to compare and summarize results across multiple sources.

For many of the strategies that Caltrans could lead or support to reduce VMT and GHG emissions, there has been relatively little research to quantify VMT or GHG emissions impacts. Relevant research is particularly limited for bicycle and pedestrian strategies, as well as for transit strategies and some types of transportation system management strategies such as ramp metering. There is generally more VMT and GHG emission impacts research for land use strategies and employer-based transportation demand management strategies.

In addition to the limited sources, several factors can make it challenging to apply research findings to estimate VMT or GHG emissions impacts in the context of Caltrans' decision-making processes. Results are sometimes reported as a wide range, with other factors having a strong influence on the level of VMT or GHG reduction. This can make it difficult to generalize about the effectiveness of one strategy versus another. Research results are also sometimes reported at a scale that is inconsistent with Caltrans' processes.

APPENDIX D-1. EXAMPLE PROJECT 1: CONSTRUCTION OF HIGH-OCCUPANCY VEHICLE (HOV) LANES IN SUNSHINE COUNTY

NOTE: The purpose of this example project is to show the process for determining significance under CEQA for operational impacts resulting from induced vehicle demand. Discussions and analysis are intended to show the basic steps in the process and are not intended to reflect the complexity or detail that may be required for specific projects, including the need to analyze construction impacts and/or cumulative impacts. The VMT provided in this analysis are illustrative only and are not drawn from a specific project.

PROJECT DESCRIPTION:

In this example, Caltrans is proposing to construct 10 miles of high-occupancy (HOV) lanes in each direction (for a total of 20 miles), on a Class I Interstate facility in Sunshine County, California. The purpose of the project is:

- Increase the mode share of high-occupancy vehicles such as carpools, vanpools, and transit;
- Enhance the reliable movement of inter-regional goods and increasing access to jobs and housing in the corridor; and
- Provide greater HOV network connectivity in the Sunshine metropolitan area.

The project as proposed has four alternatives. The HOT lane alternative was added when the project reached the Project Approval and Environmental Document (PA&ED) phase in order to include a priced and revenue-generating alternative as recommended in the Preliminary Environmental Analysis Report (PEAR) for this project (see "Project Scoping" below).

- Alternative 1 would construct 10 new miles of mixed-flow or general-purpose lanes on this facility in each direction from postmile (PM) 10.1 to 20.1.
- Alternative 2 would construct 10 new miles of HOV lanes on this facility in each direction from PM 10.1 to PM 20.1.
- Alternative 3 would construct 10 new miles of HOT lanes on this facility in each direction from PM 10.1 to PM 20.1.

Alternative 4 is the No-Build Alternative. The No-Build Alternative would not add any improvements to the existing facility.

The proposed project is funded by Measure Z. Sunshine County voters passed this ballot measure in the 2016 election. The project is listed in Measure Z and the 2018 Sunshine Metropolitan Transportation Plan (MTP). Among the alternatives, Alternative 2 is the most consistent with Measure Z and is therefore the locally preferred alternative.

See Figure D-1 below depicting the study limits. Note that the project limits depict the physical extent of construction work, traffic study limits will extend beyond this area.

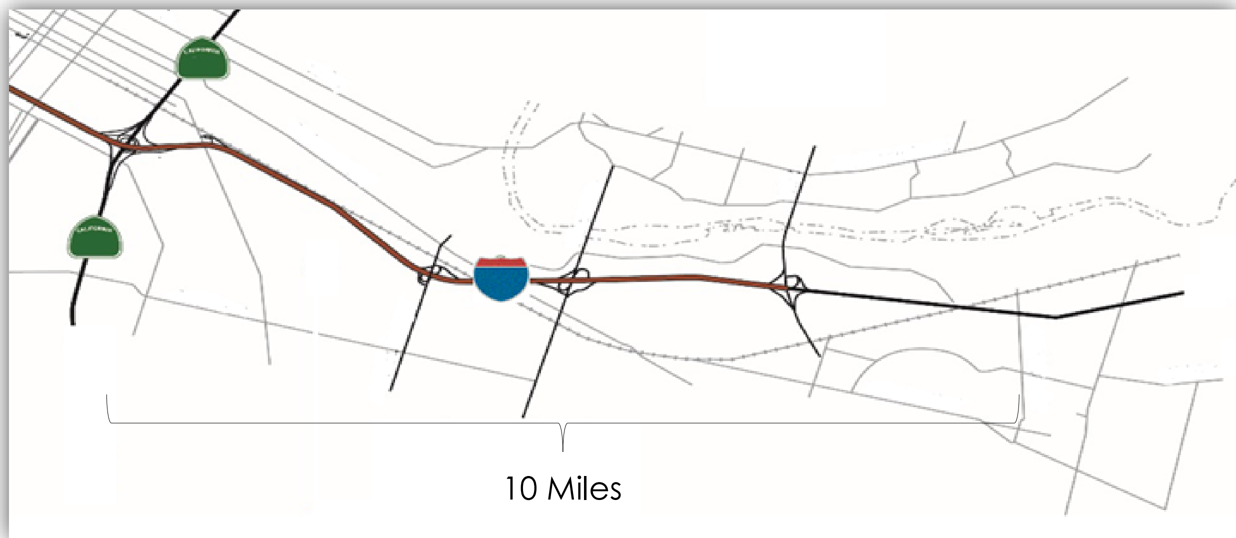

Figure D-1. Example Project Map

THE ANALYSIS:

This section will go through the steps required to determine if an induced travel analysis is required for the proposed project, and if so, the steps needed to carry out the analysis. Each step identifies the relevant section(s) in the *Traffic Analysis Framework* (TAF) or *Transportation Analysis under CEQA* (TAC) where more detailed guidance can be found.

Project Scoping (TAC Section 4)

The PEAR that was prepared for this project indicated that the project would likely require an EIR under CEQA because 1) the project would increase capacity on the SHs and the project type is listed in the Governor's Office of Planning and Research's *Technical Advisory on Evaluating Transportation Impacts in CEQA* as a project type that "would likely lead to a measurable and substantial increase in vehicle travel" and 2), due to anticipated impacts to biological resources. The NCST Induced Travel Calculator was used to provide a benchmark assessment of induced travel and for estimating necessary mitigation in later phases of the project. The PEAR also considered tolled lane alternatives in order to potentially reduce the additional VMT resulting from the project. The PEAR recommended that an express (HOT) lane be evaluated at PA&ED.

Project Screening (TAC Section 5.1.1)

As noted in the PEAR, the project is capacity increasing and will require an induced travel analysis.

Project Tiering (TAC Section 5.1.2)

To determine if the proposed project could possibly tier off the travel analysis prepared for the MTP, the planner examined the MTP but found that it did not meet the requirements for tiering outlined in Section 5.1.2 of the TAC.

Selection of Traffic Analysis Methodology (TAF and TAC Table 1)

Since the project is located on a Class I Interstate Facility in an urban area, the Selection Matrix for Preferred Induced Travel Assessment Methods for Projects on the SHS indicates that a quantitative analysis is required and that the NCST calculator should be applied, and that the Sunshine County Travel Demand Model (TDM) could be used if it meets checklist requirements for assessing induced travel and the model results are within 20 percent of the NCST calculator results. In this example, the Sunshine County TDM was chosen because the Sunshine County TDM is able to output link volumetric speed bin data, which will be useful for analysis of other impacts. The Sunshine County TDM was evaluated for its ability to model induced travel using the checklist in the TAF and it was determined that with a few modifications, the model could likely assess induced travel with reasonable accuracy so long as it was provided with likely land use changes. A Delphi panel of land use experts would determine the likely land use changes that would be attributable to the project in the horizon year. Existing conditions (2020) and the design/horizon year (2042) were assessed, applying the model with land use inputs from the panel of land use experts. For the General-Purpose Lane and HOV Lane Alternatives (Alternatives 1 and 2), the NCST calculator is applicable, and was used to estimate induced travel. The NCST calculator provides a long-run estimate of induced travel for the added lane miles. Modeling results are shown in Table D-1. For the HOT Lane Alternative (Alternative 3), the NCST Calculator is not applicable, and only the results from the TDM were included.

Table D-1[17]. Project Alternatives and VMT Evaluation

Project Alternative	County TDM Model Estimated Absolute Annual Million VMT[18]	County TDM Model Estimated Project Induced Annual Million VMT	NCST Estimated Project Induced Annual Million VMT[19][20][21]
Existing Conditions 2020	5,000	N/A	N/A
No Build Alternative 2042	5,950	0	0
Add General Purpose Lanes 2042	6,080	130	132
Add HOV Lanes 2042	6,064	114	132
Add HOT Lanes 2042	6,072	122	N/A

The NCST is the benchmark Caltrans uses for induced travel analysis when it is applicable. Where travel model results are within 20 percent of the NCST calculator, they may be used in its place. In this case, the travel model results are within 20 percent of the NCST calculator, so the project team utilized these results for determining significance.

[17] The numbers in the table are based on a regional/county type assessment.
[18] Vehicle-miles of travel for the forecast year.
[19] Note that the NCST calculator uses a "baseline" year of 2016 for the metropolitan statistical area.
[20] For purposes of analysis the NCST calculator result in utilized for the horizon year. Note that the NCST calculator does not use a specific forecast year, but instead produces a "long-run estimate of induced VMT, the additional annual VMT that could be expected 5 to 10 years after facility installation."
[21] Note that the NCST calculator does not distinguish between general purpose and HOV lanes, so the same numbers are used for both alternatives.

Analyze Impacts and Determine CEQA Significance (TAC Sections 5.3 through 5.6)

As shown by Table D-1, each of the build alternatives results in an increase in VMT over both the existing conditions and when compared to the future No-Build Alternative. The change in VMT from the future no-build alternative (i.e., the conditions expected to exist in the future absent the project) to the future build alternatives is the amount of VMT that is directly attributable to the project so that is the induced VMT. This is the impact that is the basis of the determination of significance.

The project is located in a metropolitan area and each alternative increases VMT over both existing conditions and compared to future conditions without the project. Therefore, according to the guidance in the TAC, each build alternative is found to have a significant effect on the environment and each alternative is found to conflict with CEQA Guidelines Section 15064.3(b).

It was also determined that the negligible and temporary increase in construction vehicles during construction of the project would be less than significant for each build alternative.

In the "Consistency with State, Regional, and Local Plans and Programs" section of the environmental document, each build alternative was also found to have a significant impact because the project was found to be inconsistent with state climate goals which call for a 15 percent reduction in total light-duty VMT by 2050 as compared to baseline 2050 levels.

Finally, each alternative was found to have a significant cumulative impact, because when combined with other past, current, and probable future projects in the region, the project would result in a significant increase in VMT.

Mitigation (TAC Section 5.7)

Mitigation was required for this project because the PDT determined that each of the build alternatives would result in a significant transportation impact under CEQA. Various mitigation options were considered for this project. Some were determined to be infeasible or ineffective and this determination was documented in the project file. For this example project, the PDT is proposing to add a 100-space Park and Ride lot near the southern end of the project limits. The addition of a Park and Ride lot is both feasible because is within Caltrans' jurisdiction and enforceable as Caltrans has direct control over on-system mitigation. According to a literature review conducted by Caltrans Division of Transportation Planning, Park and Ride lots have been estimated to reduce annual VMT by 2,700 to 7,200 per parking space, so Caltrans utilized the mid-point of that range for an annual VMT reduction of 4,950 per parking space for a total of 495,000 VMT. This amount of VMT will be subtracted from the total amount of VMT generated by each build alternative in order to make a final CEQA conclusion for the project.

Final CEQA Conclusion

Although the PDT was able to incorporate mitigation measures to reduce VMT, the impact will remain significant and unavoidable, because the remaining annual induced VMT is still significant. Because the mitigation was unable to reduce the impact to less than significant, a statement of overriding considerations will be considered. More guidance on the statement of overriding considerations can be found in Section 5.9 of the TAC.

APPENDIX D-2. EXAMPLE PROJECT 2: CONSTRUCTION OF TRUCK CLIMBING LANES IN RAINBOW COUNTY

NOTE: The purpose of this example project is to show the process for determining significance under CEQA for operational impacts resulting from induced vehicle demand. Discussions and analysis are intended to show the basic steps in the process and are not intended to reflect the complexity or detail that may be required for specific projects, including the need to analyze construction impacts and/or cumulative impacts.

PROJECT DESCRIPTION:

In this example project, Caltrans is proposing to construct four miles of continuous truck climbing lanes in the westbound direction of a State highway in northern rural California that is part of the National Highway System and considered essential to Rainbow County's economy, defense, and mobility. The purpose of the project is to:

- Improve safety and operations by separating slower moving vehicles and trucks from faster moving passenger vehicles that are climbing the existing grade.

The proposed project has two alternatives:

- Alternative 1 would add four miles of continuous truck climbing lanes in the westbound direction from postmile (PM) 13.4 to 17.4.
- Alternative 2 is the No Build Alternative.

The proposed project is included in the 2018 Rainbow County Regional Transportation Plan. Rainbow County is not within the limits of an MPO or MSA.

THE ANALYSIS:

This section will go through the steps required to determine if an induced travel analysis is required for the proposed project, and if so, the steps to complete the analysis. Each step will include the relevant section(s) in the *Traffic Analysis Framework* (TAF) or *Transportation Analysis under CEQA* (TAC) where more detailed guidance can be found.

Project Scoping (TAC Section 4)

The PEAR that was prepared for this project indicated that the project would likely require an Initial Study (IS) and probable Negative Declaration (ND) under CEQA. Although the project type is listed in the OPR *Technical Advisory on Evaluating Transportation Impacts in CEQA* as the type of project that "would not likely lead to a measurable and substantial increase in vehicle travel" (e.g., addition of passing lanes, truck climbing lanes, or truck brake-check lanes in rural areas that do not increase overall vehicle capacity along the corridor), it was also believed that four continuous miles of truck climbing lanes could potentially be viewed as a project that would “increase overall vehicle capacity along the corridor” and the determination was made to prepare an IS. Furthermore, an IS was recommended due to potential biological impacts resulting from the construction of the project.

Project Screening (TAC Section 5.1.1)

The project type is identified as being unlikely to lead to a measurable and substantial increase in VMT, per the OPR Technical Advisory and Section 5.1.1 of the TAC. Specifically, Caltrans’ TAF and OPR’s Technical Advisory each indicate that the addition of passing lanes, truck climbing lanes, or truck brake-check lanes in rural areas that do not increase overall vehicle capacity along the corridor, are unlikely to lead to a measurable and substantial increase in VMT. However, because a fair argument might be made that a four-mile addition of truck climbing lanes may increase overall vehicle capacity, the PDT determined that a qualitative analysis was a reasonable approach during the PA&ED phase in order to the support the conclusion that the project would not likely lead to a measurable and substantial increase in VMT, because overall capacity of the corridor is not increased and overall speeds will not change substantially.

Project Tiering (TAC Section 5.1.2)

To determine if the proposed project could possibly tier off the travel analysis prepared for the RTP, the planner examined the RTP but found that it did not meet the requirements for tiering outlined in Section 5.1.2 of the TAC.

Selection of Traffic Analysis Methodology (TAF and TAC Table 1)

Since the project is located outside an MSA on a State highway in rural northern California, the Induced Travel Assessment Method Selection Matrix for Projects on the SHS indicates that a qualitative analysis can be completed. To determine existing and projected conditions in the vicinity of the project, the RTP and the county’s general plan were consulted. Traffic data in the RTP indicated that congested areas were limited to the one “town center within the county,” some 30 miles west of the project area. The general plan indicated that very little growth is expected in the county overall for the next 20 years, and that no land use changes are anticipated near the project that could increase overall congestion. Note that even in the absence of congestion, roads that simply provide greater access may facilitate development in locations that lead to induced travel. However, it was determined that demand for development in this location is considered unlikely and the truck climbing lanes would not provide greater access.

Analyze Impacts and Determine CEQA Significance (TAC Sections 5.3 through 5.6)

It was determined from the qualitative analysis that the transportation impacts of the project would be "no impact" and that the build alternative would not be in conflict with CEQA Guidelines Section 15064.3(b). In this instance, although four miles of truck climbing lanes could be viewed as a project that would "increase the overall vehicle capacity along the corridor," the project would not induce travel (despite the added capacity) because there is no present or forecasted demand for the capacity and the project would not lead to substantially decreased travel times. Additionally, the demand for development in this location is considered unlikely and the truck climbing lanes would not provide greater access to land uses likely to induce additional travel.

It was also determined that the negligible and temporary increase in construction vehicles during construction of the project would be less than significant for the Build Alternative.

In the "Consistency with State, Regional, and Local Plans and Programs" of the environmental document, the build alternative was found to have "no impact" because the project would not result in induced travel.

Finally, because the build alternative was found to have "no impact," it will not contribute to a cumulative impact.

Mitigation (TAC Section 5.7)

No mitigation is required because the PDT determined that the project would result in "no impact.

APPENDIX E. GLOSSARY OF ACRONYMS AND TERMS

AB	Assembly Bill
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
CTF	Cleaner Technologies and Fuels Scenario
EIR	Environmental Impact Report (state)
FHWA	Federal Highway Administration
GHG	Greenhouse gas
HCM	Highway Capacity Manual
HOV	High Occupancy Vehicle
HOT	High Occupancy Toll
HSM	Highway Safety Manual
IS	Initial Study (state)
LD-IGR	Local Development-Intergovernmental Review
LOS	Level of Service
MND	Mitigated Negative Declaration (state)
MPO	Metropolitan Planning Organization
MTP	Metropolitan Transportation Plan
NCST	National Center for Sustainable Transportation
ND	Negative Declaration (state)
NEPA	National Environmental Policy Act
OPR	Governor's Office of Planning and Research
PDT	Project Development Team
PRC	Public Resources Code (state)
RTP	Regional Transportation Plan
RTPA	Regional Transportation Planning Agency
SB	Senate Bill
SCS	Sustainable Communities Strategy
SHS	State Highway System
TAF	Caltrans Transportation Analysis Framework
TISG	Transportation Impact Study Guide
VMT	Vehicle Miles Traveled
Capacity	The Sixth Edition of the Highway Capacity Manual defines capacity as: The maximum sustainable hourly flow rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, environmental, traffic, and control conditions.

Elasticity	Elasticity is a measure of a variable's sensitivity to a change in another variable. In economics, elasticity is the measurement of the percentage change of one economic variable in response to a change in another. In transportation forecasting, an example is elasticity of travel demand, which can be expressed as the percent change in regional VMT divided by the percent change in regional lane-miles of state highways.
Induced Travel (VMT)	Induced travel (or the VMT attributable to a transportation capacity increase) is the increased amount of vehicle travel on the transportation network that is caused by travel behavior changes associated with decreased cost of travel due to improved travel times, improved reliability, or reduced price of travel. Over the short run, travel behavior changes including longer trips, more trips, mode shift, and route shift all tend to occur as a result of a highway capacity increase. Over the long run, these effects intensify (e.g. as people shift job or residential location to benefit from the infrastructure), and also land use development may become more dispersed, adding additional vehicle travel; for these reasons, long run induced travel is generally greater than short run induced travel.
Network	The connectivity of a transportation system. Changes in connectivity may change travel time and cost. Travel demand models will usually represent network connectivity within modes and across modes through a set of links connecting nodes.
Travel Demand Model	A travel demand model is any relatively complex computerized set of procedures for predicting future trip making as a function of land use, demographics, travel costs, the road system, and the transit system. These models often cover an entire metropolitan area or the entire State, but may also focus on a single city or county.
Transit	Transit generally includes all forms of shared common carrier passenger ground transportation in moderate to high capacity vehicles ranging from dial-a-ride vans to buses, trolleys, light rail, commuter rail, and intercity rail transportation.

Trucks	Trucks are a subtype of the heavy vehicles category which includes trucks, intercity buses, and recreational vehicles. This Framework follows the Highway Capacity Manual definition of what constitutes a heavy vehicle: "A vehicle with more than four wheels touching the pavement during normal operation." This is consistent with the Caltrans Traffic Census definition of a truck: "The two-axle (truck) class includes 1-1/2-ton trucks with dual rear tires and excludes pickups and vans with only four tires."
Vehicle Miles Traveled (VMT)	The number of miles traveled by motor vehicles on roadways in a given area over a given time period. VMT may be subdivided for reporting and analysis purposes into single occupant passenger vehicles (SOVs), high occupancy vehicles (HOV's), buses, trains, light duty trucks, and heavy-duty trucks. For example, an air quality analysis may require daily VMT by vehicle class and average speed or vehicle operating mode (idle, acceleration, cruise, deceleration, etc.). For a CEQA compliant transportation impact analysis, automobile VMT (cars and light trucks) may be evaluated.
VMT Attributable to a Project.	In the context of a CEQA analysis, the VMT attributable to a transportation project, or induced travel, is the difference in passenger VMT between the with project and without project alternatives. VMT attributable to a project is equivalent to induced travel in this context.

APPENDIX F. ACKNOWLEDGEMENTS

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