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ISSUE BRIEF

THE BIDEN ADMINISTRATION MUST SWIFTLY COMMIT TO CUTTING CLIMATE POLLUTION AT LEAST 50 PERCENT BY 2030

TECHNICAL APPENDIX

This Technical Appendix describes in detail the assumptions underlying the NRDC analysis evaluating scenarios that achieve net-zero by midcentury along with a 53 percent reduction in net GHG emissions below 2005 levels by 2030. The analysis was conducted with Evolved Energy Research using its RIO-Pathways model representing the U.S. energy system.

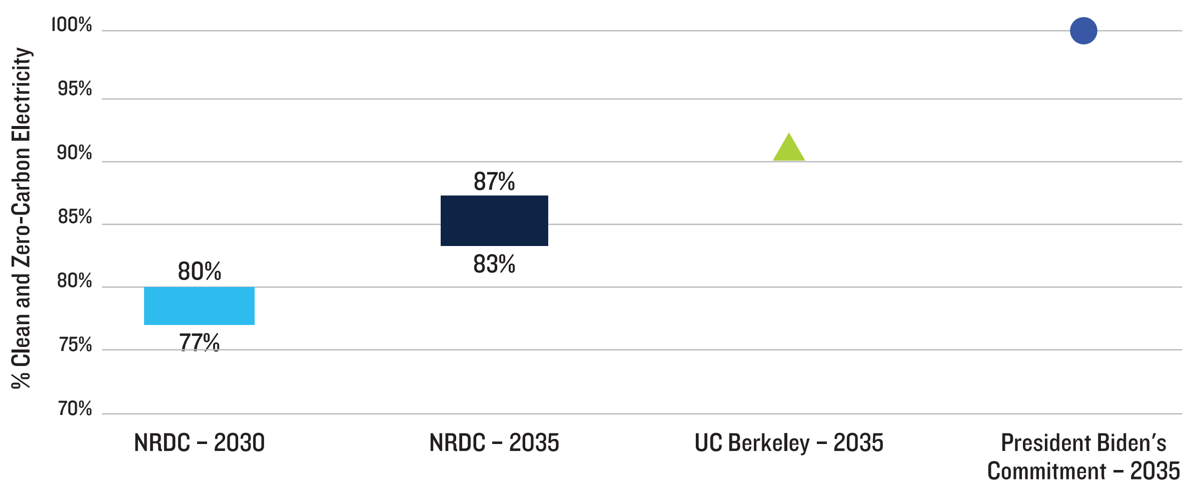
ACHIEVABLE LEVEL OF AMBITION ASSUMED ACROSS SECTORS BY 2030

The sector-level ambition that we adopt is well within both the range of feasibility demonstrated by technical analyses and the range of ambition reflected in the host of published net-zero studies and existing subnational policies and corporate commitments. Our analysis relies on the following assumptions.

About 80 percent of electricity is sourced using clean and zero-carbon electricity by 2030.

Similar to published decarbonization studies, our analysis finds that the power sector is the mainstay of rapid emissions reductions in this decade, owing to the unique opportunities manifested by plummeting renewable energy costs. Wind, solar, and battery storage costs have plummeted by 70 percent, 90 percent, and 85 percent in the past decade, respectively, and are projected to continue their decline.[1] Wind and solar are now the lowest-cost forms of new electricity generation in many parts of the country and have become cheaper than running existing coal plants.[2] Our modeling estimates that about 80 percent of electricity would need to be sourced from clean and zero-emissions energy—wind, solar, hydro, and nuclear—by 2030 to achieve the economy-wide goal. Of this total, **renewable generation makes up between 63 and 67 percent of total generation**, while **nuclear accounts for around 14 percent**. The share of clean and zero-carbon generation is between 83 and 87 percent by 2035. This is well within the range of feasibility estimated by the literature, with a host of studies demonstrating that a 90 percent clean power sector is cost-effective and possible by 2035 with existing technologies.[3] For example, a 2020 study by the University of California, Berkeley, demonstrates that a 90 percent clean power sector by 2035 is feasible and cost-effective.[4] Our estimate is also below President Biden's commitment to a 100 percent clean power sector by 2035, which would be feasible with technological advancement (Figure A1).[5]

FIGURE A1: PERCENT CLEAN ELECTRICITY GENERATION IN BOTH 2030 AND 2035



Consumer investment choices shift rapidly toward zero-emission vehicles (ZEVs) and electric heating equipment in buildings. Industrial steam production is electrified where feasible.

Our analysis assumes a rapid uptake of electric alternatives to fossil-fuel equipment in applications where these alternatives have been proven feasible and cost-effective for consumers. Electric cars already outcompete conventional internal combustion engine cars on a cost-of-ownership basis and are projected to achieve purchase-price parity well before 2030, owing to the remarkable advancements in battery technology.[6] We assume **57 percent ZEV sales by 2030 for light-duty vehicles (LDVs).** We plan to revise the LDV sales share upward to better align with the 100 percent ZEV sales target by 2035, which is becoming a widely used benchmark in light of laudable industry trends and state policies (Figure A2).[7] While the adoption of zero-emission trucks still faces barriers, their operating costs are already on the verge of outcompeting conventional diesel trucks, and the building blocks for a rapid step-up in ZEV adoption are already in place in the form of concrete policies and actions that leading states such as California have recently adopted (Figure A3).[8] Accordingly, we assume **55 percent ZEV sales for medium- and heavy-duty vehicles (MDVs and HDVs) by 2030.**

FIGURE A2: ZEVs AS A PERCENTAGE OF LDV SALES BY 2030 AND 2035, NRDC ASSUMPTION COMPARED TO ASSUMPTIONS IN OTHER STUDIES, EXISTING POLICIES, AND CORPORATE COMMITMENTS[9]

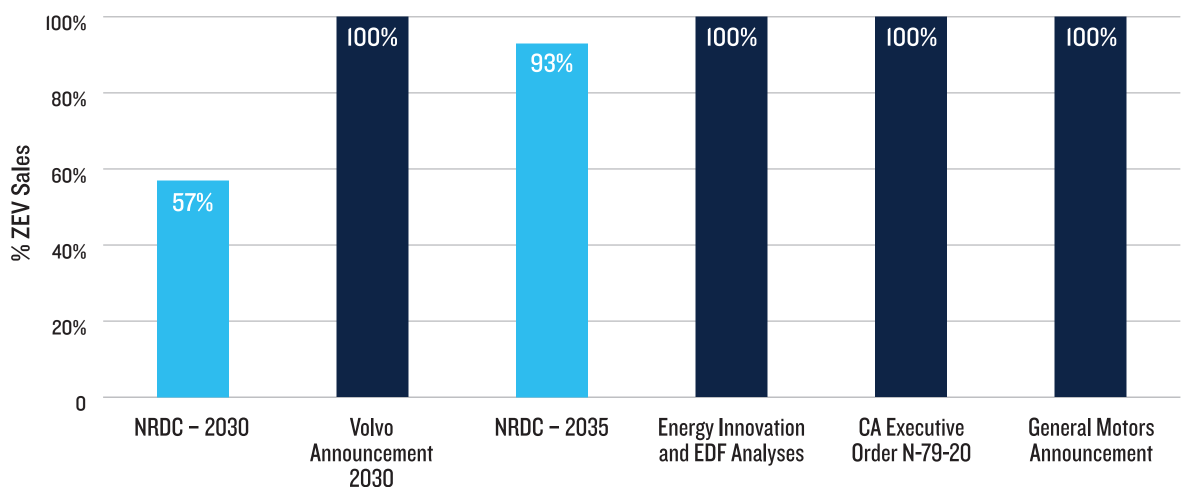
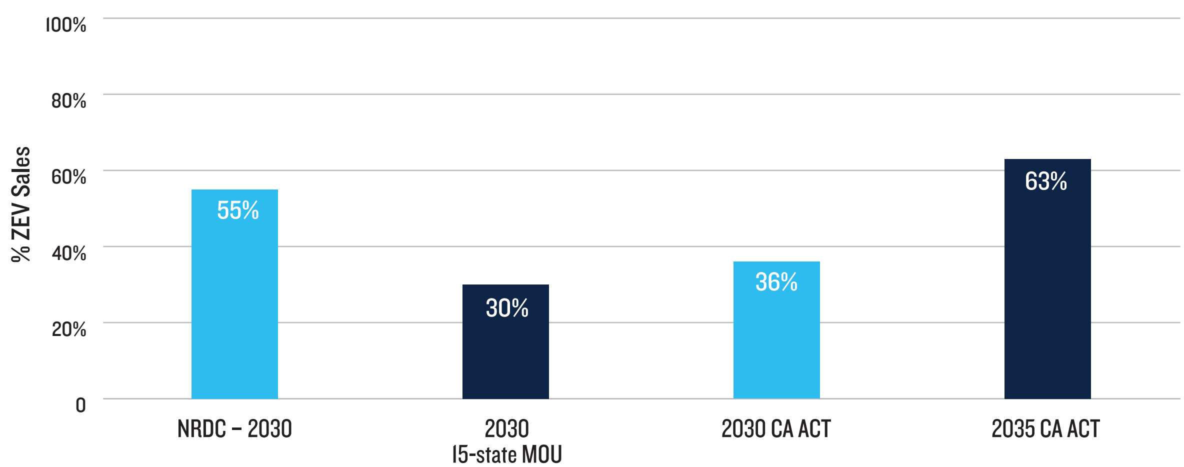
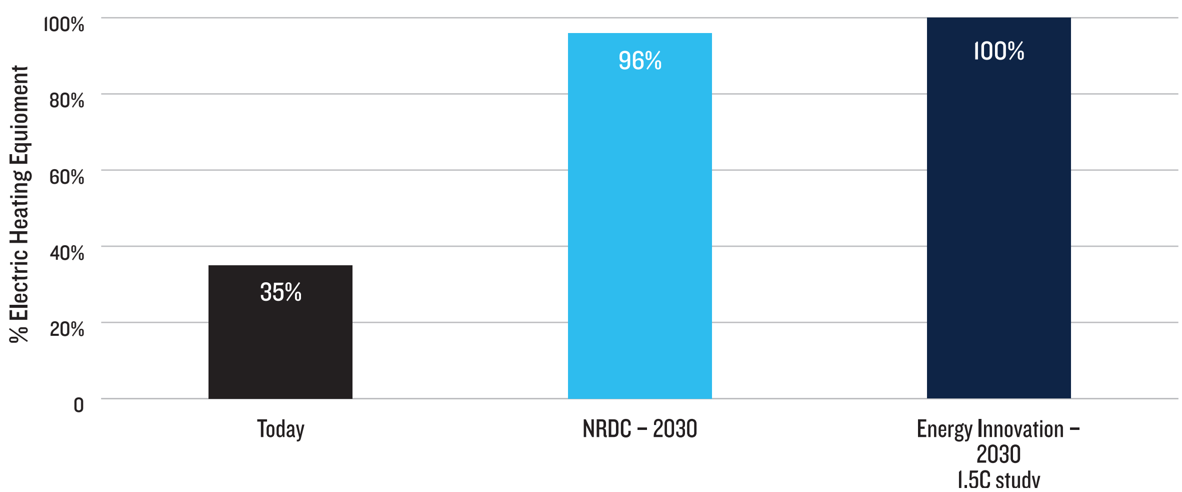


FIGURE A3: ZEVs AS A PERCENTAGE OF MEDIUM AND HEAVY-DUTY TRUCK SALES, NRDC ASSUMPTION COMPARED TO POLICY TRENDS[10]



Similarly, our analysis assumes that, by 2030, **more than 95 percent of sales of space heating and nearly 100 percent of sales of water heating** equipment in buildings are electric (Figure A4). While this reflects a rapid trajectory away from today's gas-heavy status quo, it is well justified owing to the substantial performance advancements and cost reductions in high-efficiency heat-pump technology. Highly efficient heat pumps are already more cost-effective than gas heating systems in homes and offices in many parts of the United States.[11] The barriers to widespread heat-pump adoption are therefore driven by neither insurmountable economics nor grave technology shortcomings, but instead mainly relate to failures that can be targeted with policy. Barriers include up-front cost premiums compared to the incumbent gas technology; the lack of experience among the contractor community in handling the equipment; the lack of contractor education on the performance and benefits of modern heat-pump technology; a bias towards piecemeal repairs rather than full system retrofits in the HVAC replacement market; low energy-efficiency standards that hinder economics and innovation; and staunch opposition by gas companies. A committed federal, state, and local policy framework to incentivize uptake of electric technology, spurred by an ambitious 2030 nationally determined contribution, could address those barriers, accelerate further high-efficiency heat-pump technology advancements, and deliver substantial near-term adoption of electric technology in buildings.

FIGURE A4: ELECTRIC SPACE HEATING EQUIPMENT IN HOMES AS A PERCENT OF SALES BY 2030 COMPARED TO TODAY[12]



We also assume deployment of electric boilers to supply low-temperature steam for various industrial processes. When feasible, we assume that electric boilers are installed alongside existing gas boilers, enabling hybrid use of electricity to displace gas when electricity is low-cost and abundant.

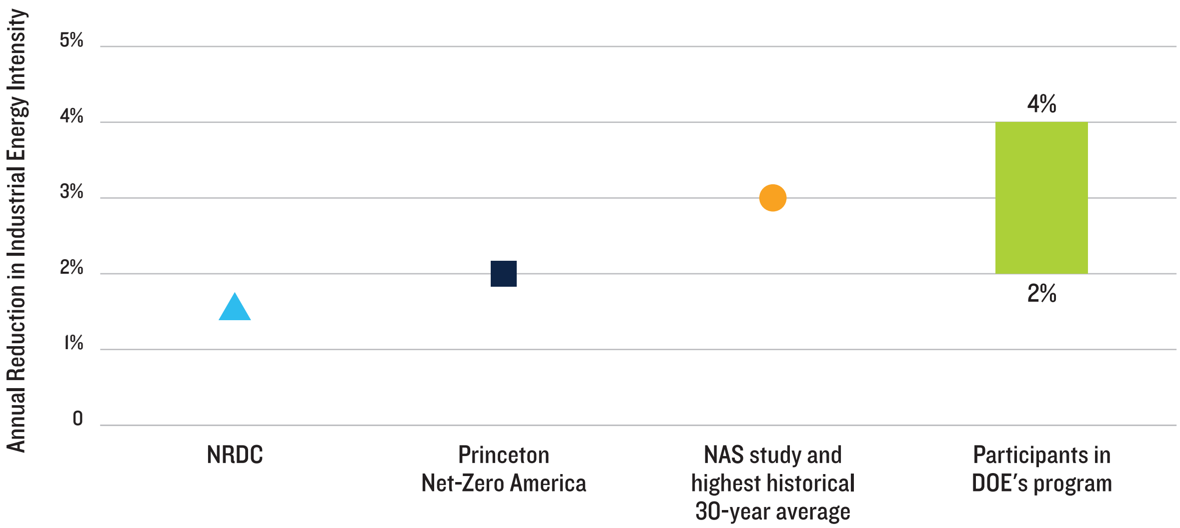
Buildings are weatherized at an achievable rate, and best-in-class efficient appliances are adopted. Industry experiences modest energy-efficiency improvements.

Energy efficiency is one of the most cost-effective near-term approaches to reducing energy demand and associated emissions. Our analysis assumes that in the 2020s, a little over **1 percent of existing buildings** will undertake deep envelope retrofits every year to improve building insulation and air tightness and to curb energy use for space conditioning. This amounts to about 14 million existing housing units retrofitted by 2030. While this rate is more than twice the one committed to by the Biden administration over the next four years, the administration's plan can be feasibly augmented as demonstrated by numerous studies.[13] The administration should step up its commitments and prioritize building efficiency in this decade—especially in the 40 million low-income homes eligible for weatherization—to bolster climate, economic, and public health.[14]

We also assume that retiring appliances and equipment in buildings are replaced with commercially available products with the highest efficiency. This could be achieved by the adoption of next-generation federal minimum energy-efficiency standards reflecting best-in-class and currently available technology, the feasibility of which is well demonstrated in the literature.[15]

There is also large untapped and cost-effective energy-efficiency potential in industry due to policy and market failures.[16] Our analysis assumes a **1.05 percent annual reduction in industrial energy intensity** (measured in energy use per dollar of industrial output) between 2020 and 2050. This reflects the lower bound of industrial efficiency levels adopted in recent net-zero studies and is below the energy intensity gains sustained over multiple years by companies as disparate as Arby's, eBay, HARBEC, Nissan, Havertys, Cummins, and Schneider Electric as part of their participation in the Department of Energy's Better Plants program (Figure A5).[17]

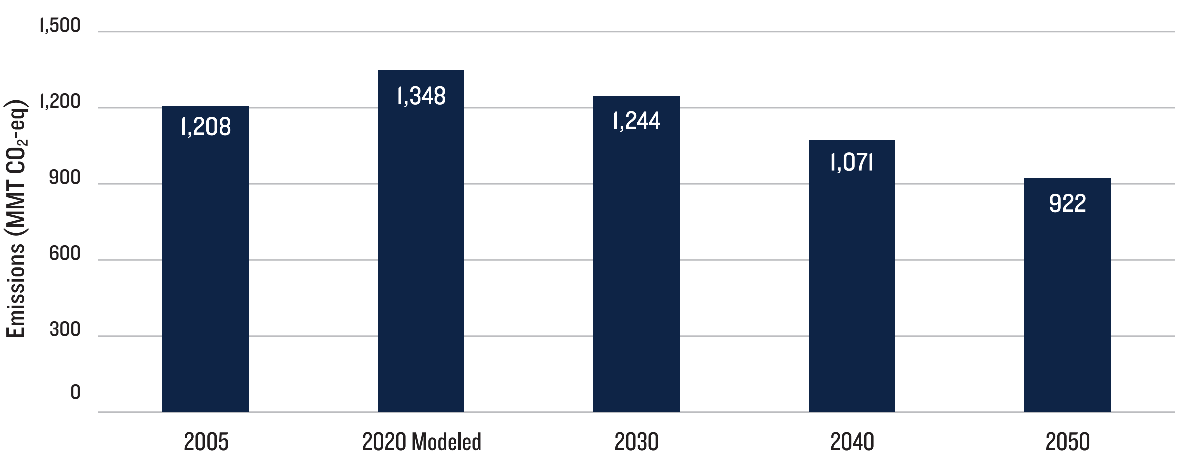
FIGURE A5: ANNUAL REDUCTION IN INDUSTRIAL ENERGY INTENSITY, NRDC ASSUMPTION COMPARED TO PUBLISHED STUDIES AND HISTORICAL ACHIEVEMENTS[18]



Reduce non-CO_2 emissions and invest in preserving and enhancing land carbon sinks.

Achieving an ambitious 2030 target also involves tackling non-CO_2 greenhouse gasses (GHGs) and preserving and enhancing natural carbon sinks. We assume an **8 percent reduction in non-CO_2 GHGs**—methane, nitrous oxides, and fluorinated gases—by 2030, compared to today's levels (Figure A6).[19]

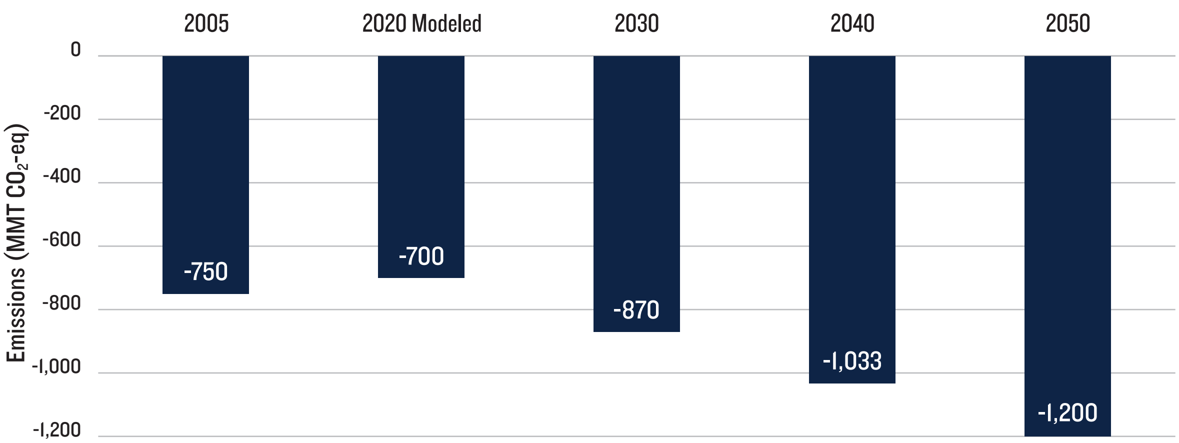
FIGURE A6: REDUCTIONS IN NON-CO_2 EMISSIONS (MILLION METRIC TONS OF CO_2-EQUIVALENT)



This assumes a set of measures and policies promoting sustainable livestock grazing, reduced methane leaks from oil and gas production, improved agricultural practices, and others. This is a modest target relative to the abatement potential estimated by other groups, with the Environmental Defense Fund evaluating that a 40 percent reduction in economy-wide methane emissions below 2005 levels would be achievable and cost-effective by 2030.[20]

We also investigate two levels of expansion in natural carbon sinks to align with the range examined in a portion of recently published studies: **a 7 percent and a 24 percent expansion compared to today,** by 2030 (Figure A7).[21]

FIGURE A7: INCREASE IN NEGATIVE EMISSIONS LINKED TO THE EXPANSION OF NATURAL CARBON SINKS (MILLION METRIC TONS OF CO_2-EQUIVALENT)



This assumes a host of measures and policies bolstering reforestation, afforestation, and improved soil management. It bears noting that the two estimates are conservative relative to a number of recently published studies that assume a markedly larger expansion in natural land sinks by 2030 to align with the abounding literature that quantifies their technological and economic potential.[22]

The finding around the technological feasibility and affordability of the 53 percent target is robust across both levels of land sink investigated. The size of the natural carbon sink is a more influential factor in the later years—2030 onward—and the relevant dynamics will be treated in greater detail in the final report.

EVOLVED ENERGY RESEARCH'S MODELING PLATFORM

The analysis is conducted using two sophisticated modeling tools developed by Evolved Energy Research, EnergyPATHWAYS and RIO, providing detailed energy accounting and optimal energy system investment and operations.[23] The tools have high resolution across sectors of the economy (more than 60 U.S. energy system subsectors), time (annual turnover of equipment stocks coupled with an hourly electricity-dispatch model), and geography (16 different regions of the United States along with the transmission connecting them). The modeling tools are employed to conduct a rigorous technical quantification of the infrastructure upgrades and technology investments needed across all sectors of the energy system, including cross-sectoral opportunities, to achieve both near- and long-term climate goals while meeting projected demand for energy services.

KEY ECONOMIC GROWTH, COST, AND FUEL-PRICE PROJECTIONS

These are grounded in the best available government and industry projections, outlined below.[24]

Assumption	Source
Projected demand for energy services and economic growth[25]	Annual Energy Outlook (AEO) 2019, Reference Case
Fuel-price projections	AEO 2019 and Environmental Protection Agency Gas Market Module (EPA Platform v6)
Renewable energy cost projections	National Renewable Energy Laboratory (NREL) Annual Technology Baseline (ATB) 2019, mid-case projections. Low-case projections adopted for offshore wind resources.
Cost projections for building appliances and shell retrofits	Energy Information Administration, Updated Building Sector Appliance and Equipment Costs and Efficiencies, 2016; NREL, Electrification Futures Study, 2018
Electric vehicle and hydrogen fuel cell vehicle costs	Battery cost and hydrogen fuel cell projections based on Bloomberg (2019) and International Council on Clean Transportation (ICCT), Update on electric vehicle costs in the United States through 2030, 2019. LDV costs based on the ICCT's "Update on Electric Vehicle Costs in the United States Through 2030," 2019. MDV and HDV cost projections based on the ICCT's "Zero-Emissions Trucks: An Overview of State-of-the-Art Technologies and Their Potential," 2013.

SCENARIOS EVALUATED

We investigate four main scenarios designed to explore the effects of societal choices and resource constraints on decarbonization strategies and outcomes. The final report will include a broader set of scenarios.

a. Reference Case

A business-as-usual case reflecting existing federal and state policies and capturing technology and market trends across the U.S. energy system linked to the current policy landscape.

b. 53x30

A case where the United States is assumed to achieve the net-zero GHG target by 2050 and a 53 percent reduction in net GHGs by 2030 below 2005 levels. A 24 percent expansion in natural sinks is assumed by 2030 compared to today.

c. 53x30 – Low Land Sink

Similar specifications to the 53x30 case, except that a 7 percent expansion in natural sinks is assumed by 2030 compared to today.

d. 53x30 – No Fossil

Similar specifications to the 53x30 case, expect that fossil fuels are fully phased out of the economy by 2050.

PROJECTIONS AND TARGETS ACCOUNTING

Targets in the 53x30 and 53x30 – No Fossil cases (Gigatonnes)

	Non-CO_2 Emissions	Land Sink	CO_2 (Energy, Industry, and Agriculture)	Net GHGs
2005	1.21	-0.76	6.13	6.58
2010	1.24	-0.70	5.70	6.24
2020	1.35	-0.70	5.27	5.92
2030	1.24	-0.87	2.74	3.12
2050	0.92	-1.20	0.28	0.00

Targets in the 53x30 – Low Land Sink case

	Non-CO_2 Emissions	Land Sink	CO_2 (Energy, Industry, and Agriculture)	Net GHGs
2005	1.21	-0.76	6.13	6.58
2010	1.24	-0.70	5.70	6.24
2020	1.35	-0.70	5.27	5.92
2030	1.24	-0.75	2.63	3.12
2050	0.92	-0.85	-0.07	0.00

ENDNOTES

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