JANUARY 2015
IB:14-12-C

National Freight Pathways

Moving Toward a Cleaner System to Reduce Emissions, Improve Air Quality, and Create Healthier Communities

Our national freight transportation system that delivers our iPads, jeans, and bananas exerts a serious toll on communities near highways, rail yards, warehouses, and marine shipping terminals. Containers carrying our goods also create soot, smog, and global warming pollution that disproportionately falls on "freight-impacted" communities. These freight-impacted areas are often communities of color that tend to have lower incomes. They usually have disproportionately high pollution rates combined with a legacy of burdens from historic pollution—and higher asthma rates, creating environmental justice toxic hotspots all along the freight system that impact millions of Americans. This summary compares conventional and advanced transportation options, so impacted communities have more information to choose from or advocate for the cleanest freight pathways that relieve their pollution burdens.

In 2013, NRDC worked with the California Cleaner Freight Coalition and Gladstein Neandross and Associates (GNA) to evaluate a range of measures that could help clean up California's freight system. GNA has reevaluated a similar set of measures in the national context to illustrate smarter ways to move goods throughout the United States to minimize air pollution, protect freight-impacted communities, and reduce greenhouse gas emissions. The following summary highlights detailed emissions analyses of our nationwide freight system, focusing on local examples, and considering regional freight networks and opportunities for the broader national freight system to reduce emissions.[1] The study compares conventional diesel-based transportation to zero tailpipe emissions, low emissions, and advanced technology alternatives for both shorter and longer trips. The analysis shows how alternatives to conventional diesel vehicles can provide significant air quality, health, and climate benefits, measured in reduced emissions of particulate matter ($PM_{2.5}$), oxides of nitrogen (NOx), and greenhouse gases (GHG).[2]

The key report findings include:

- Many alternatives to conventional diesel are available and already used in some freight applications, dramatically reducing PM, NOx, and GHG emissions.
- Non-fossil fuel alternatives, including different types of electric engines, provide the greatest overall reduction in pollutants and can eliminate tailpipe emissions in communities where freight movement occurs. These technologies work best in the local and short regional haul freight context.
- Moving goods long distances by train and ship can be much more efficient than trucks, saving considerable GHG emissions. However, PM and NOx emissions can increase by these modes if cleaner engine technologies (e.g., Tier 4) are not used. In some cases with short distances, alternative modes are less competitive with conventional trucks. Moving containers by rail or water-borne transport (e.g., short sea shipping) can yield significant environmental benefits, but it must be done with very careful consideration of residential proximity to rail yards and lines, shipping lanes, and terminals.

This analysis identifies the potential emission reductions from various strategies under specific assumptions. Some of our key considerations include:

- total emissions of key pollutants;
- evaluating each freight pathway, including all of the components such as the equipment needed to lift containers on and off trains;
- geographic scope of freight movements, including local, regional, and national routes;
- upstream impacts from electrical power sources and fuel production; and
- the state of the technology, including only those freight pathways that are market-ready.

The impact of freight transportation, however, goes well beyond NOx, PM, and GHG emissions. In practice, freight strategies must also be evaluated for a much broader set of impacts on public health, local communities, and the environment to determine the best solution for a particular freight project.[3] Each freight project or pathway requires careful consideration of the neighboring communities. For additional information on the best practices for reducing air pollution from ships, trucks, and trains, please see NRDC's *Clean Cargo Guide*.[4]

LOCAL HAUL

We define a local haul freight pathway as one that moves freight by short distances (e.g., 80 miles or less per work shift), typically by truck, between freight hubs. Examples of local haul distances include from port facilities or airport cargo terminals to local warehouses, across the U.S.-Mexico border, or from marine port terminals to off-dock rail yards. The analysis shows that the short distances of these pathways make electrification a superior option for heavy-duty truck trips, and that, in certain areas, on-dock rail can eliminate local freight truck hauls altogether.

As compared to conventional diesel trucks meeting the U.S. Environmental Protection Agency's (EPA) 2010 highway standards:

- Several electric and fuel cell technologies would have zero tailpipe emissions:[5] battery electricity, plug-in hybrid electricity,[6] fuel cell, electrified freight shuttle, or fixed guideway and catenary electric trucks.
  - Even considering the "upstream" pollution associated with power plants that supply electricity, the electric technologies would still reduce emissions roughly 70 percent or more for PM, NOx, and GHGs, considering the average power supply mix in the United States.[7] In regions utilizing less coal power and more renewable power, such as the New York City – New Jersey area, emission reductions from electric trucks are roughly 90 percent cleaner than both conventional "clean" diesel and natural gas trucks.[8]
  - Fuel cell trucks that use hydrogen produced primarily from natural gas can lower net PM emissions by roughly 40 percent compared to new diesel trucks, while NOx and GHG emissions would be cut by approximately 75 percent. Greater use of renewable hydrogen or improved hydrogen production methods could cut fuel cell emissions even more compared to conventional technology.
- Natural gas trucks that meet the latest heavy-duty engine standards can reduce net PM emissions by 50 percent but can also slightly increase NOx emissions (5 percent) and only modestly reduce GHG emissions (14 percent). Natural gas and diesel trucks are subject to the same engine standards for criteria pollutants. The differences in total NOx, PM, and GHG emissions between natural gas and diesel trucks are largely due to the upstream emissions, which are estimated based on a complex set of factors that are the subject of vigorous debate. Although natural gas may be able to reduce tailpipe NOx and PM emissions with alternative certifications and advances currently underway, natural gas is essentially a fossil fuel in the same league as diesel. Extracting natural gas raises significant environmental and public health concerns due to unconventional drilling practices including "fracking."[9]
- The on-dock rail strategy at marine terminals loads containers directly from ship to train, instead of the more typical multi-step process of unloading containers from ships, onto trucks, transporting them to nearby rail yards, and then loading them onto trains. This approach can eliminate the use of traditional cargo handling and local haul trucking and associated pollution. In this case, we compared an ideal application of on-dock rail with containers sent by truck to "near-dock" rail yards five miles from a port, finding significant emission reductions at the terminals.[10] What this would mean:

- Containers are loaded directly from ship to rail (with locomotives meeting the most modern EPA "Tier 4" emission standards)—instead of being carried five miles by truck before being lifted onto rail cars at an off-site rail yard. These efficiencies reduce emissions by roughly 90 percent or more.
- As it is currently done at many ports, on-dock rail can include some process inefficiencies such as unloading containers from ships, transporting them with diesel yard tractors to other terminals, and separately loading them onto railcars in other areas. This still saves a longer truck trip to an off-site rail yard but can limit the emission savings of the effort. However, even this type of on-dock rail operation limits truck traffic to and from port terminals, reducing local traffic congestion and truck parking or queuing in nearby neighborhoods. It is difficult to make direct comparisons due to insufficient emissions data from on-dock rail operations.

REGIONAL FREIGHT PATHWAYS

Regional freight pathways capture the movement of goods across or between regions, and may be carried out by truck, rail, or ship. Examples of these pathways include transporting containers from a port terminal to a distribution center or rail yard via rail, barge, or trucks.[11] The analysis finds that rail and shipping modes are more efficient—and produce far less pollution—if the cleanest technology is used; however, the emissions standards for rail and particularly barges lag behind on-road trucks.

The analysis finds that relative to conventional diesel trucks meeting the EPA's 2010 highway standards:

- Transporting containers by rail, even for relatively short distances, can dramatically reduce emissions if containers are double-stacked. For example, on a 25-mile rail route:
  - Diesel locomotives can reduce GHGs by 50 percent. Depending on whether older switcher and line haul locomotives (Tier 2) are used or newer (Tier 4) locomotives, however, PM and NOx emissions can be higher from locomotives relative to modern diesel trucks. For example, in the case of tier 2 locomotives, they can produce up to 6 times more NOx and almost twice the PM emissions as 2010 diesel trucks on a 25-mile route. Tier 4 locomotives can cut PM emissions in half but release 20 percent more NOx than modern diesel trucks over a 25-mile route.[12]
  - Electrifying a short rail line, for instance through an urban area, would bring local tailpipe emissions to zero, with total emission reductions of 75 to 85 percent.[13]
- Short-sea shipping (on barges), where possible, can significantly reduce GHG emissions, though other emissions may increase over short routes.

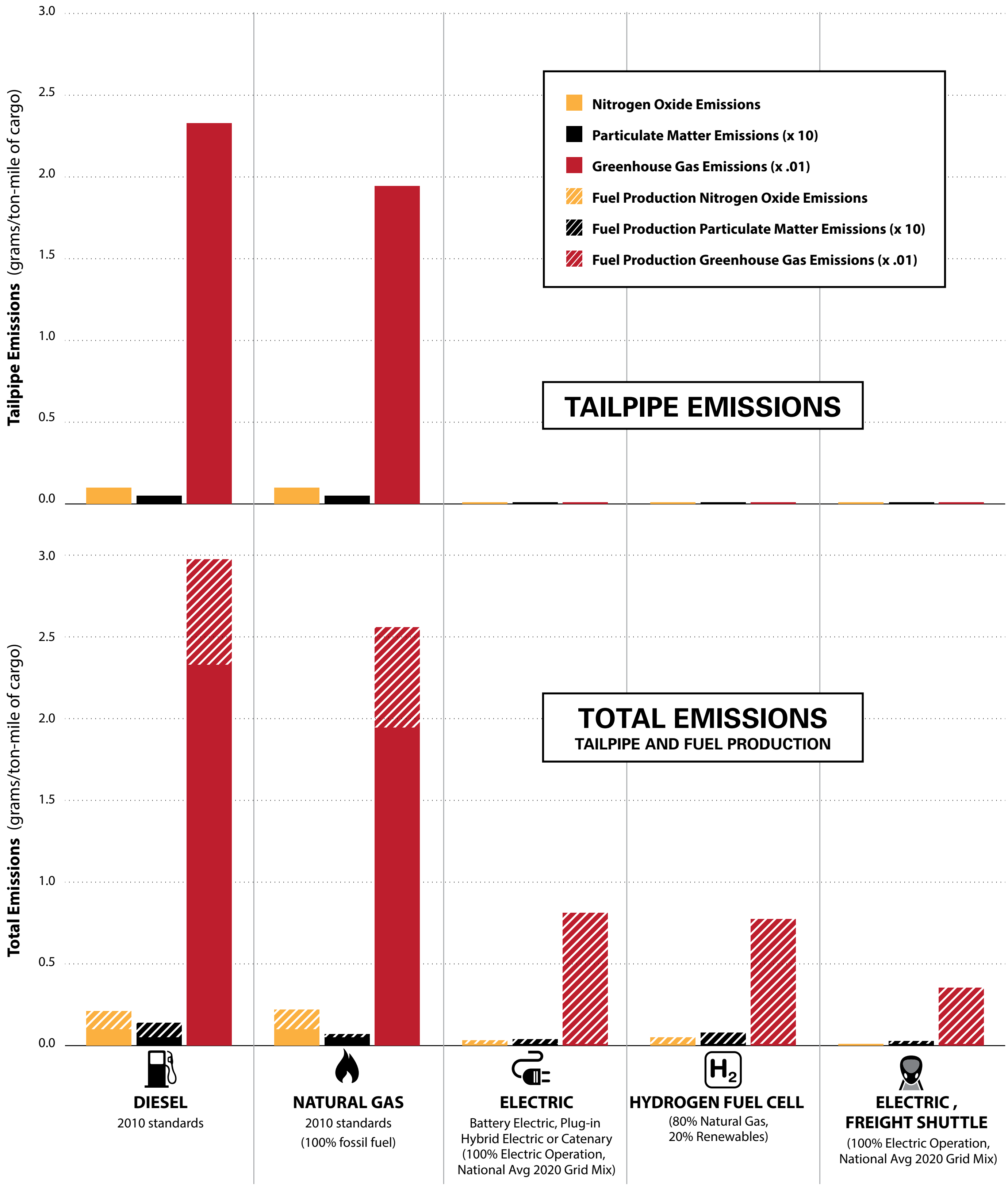
  - Using a barge instead of a new diesel truck along a 70- to 80-mile route can reduce GHG emissions by 80 percent, but NOx and PM emissions increase by up to 80 percent and 50 percent respectively, depending on the age of the barge.
  - Similarly, compared to rail transport along the same 70- to 80-mile route using a new locomotive (Tier 4), a new barge (Tier 4) will cut GHGs roughly in half but will emit more NOx and PM emissions (by 20 percent percent and more than twice as much,respectively).

LONG HAUL PATHWAYS

Transporting containers over longer distances can be done much more efficiently by alternative modes, in most cases shifting truck to rail transport. However, shifting containers from trucks to rail must be done with very careful consideration of residential proximity to rail yards and lines because of the potential for heightened emissions in nearby neighborhoods. Any increase in rail transport must be accompanied by the cleanest equipment including near-zero emission technology where possible. This analysis concludes:

- Over long distances (e.g., a 400-mile route), double-stacked trains can substantially reduce NOx, PM, and CO_2 emissions compared to the same transport of containers via diesel trucks.
- Where Tier 4 locomotives are used, whether powered by diesel or natural gas, NOx is reduced by 75 percent compared to diesel trucks meeting the latest emission standards (over a 400-mile route); similarly PM and CO_2 are reduced by 67 to 77 percent and more than 60 percent respectively (with natural gas comprising the high end of the range of emission reductions).
- Of course, even greater reductions would be possible with electrified rail lines or hybrid-electric locomotives.

POLLUTION FROM LOCAL HAUL TRUCKING



NOTE: Three local trucking technologies have zero tailpipe emissions – Electric, hydrogen and freight shuttles; although these technologies lead to some emissions for electric power and/or fuel production, these emissions are likely to occur outside of freight impacted communities. Emission estimates are for the year 2020. Emissions for diesel and natural gas trucks meeting model year 2010 engine standards were estimated using EPA's SmartWay DrayFleet tool. Tailpipe emissions estimates do not account for possible variations in emissions certification testing data between natural gas and diesel engines. Diesel and natural gas fuel production emissions are based on GREET 2013. The data in these charts is from the June 2014 GNA Memo, figures 2, 3 and 4; See the GNA Memo and Technical Appendices for further details.

CONCLUSION

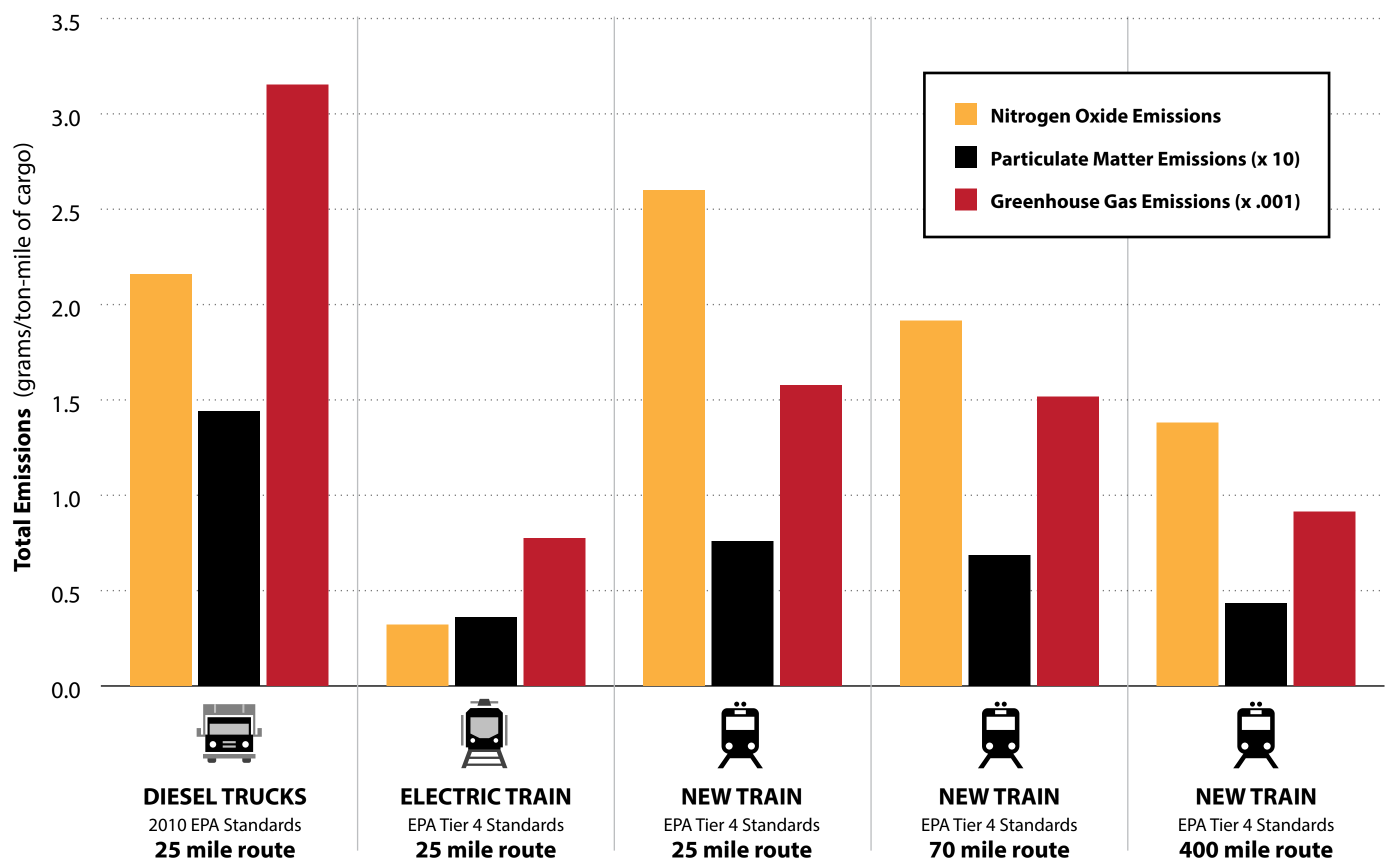
Given the millions of Americans living near freight infrastructure, it is imperative that the freight system transition away from dirty fossil fuels toward the cleanest, zero tailpipe emission technology where possible. Cleaner and more efficient alternatives to conventional diesel freight transportation are available today. When implemented, these alternatives can significantly reduce emissions within each segment of the freight system (e.g., local, regional, and long hauls).[14]

Cleaner alternatives to diesel- and natural gas-powered trucks exist today that can reduce PM, NOx, and GHG emissions. In the local drayage haul "last mile" of freight movement, electric vehicles are the superior choice, even when the local grid-based power supply includes coal-fired power plants. And clean rail and barges offer significant environmental benefits over trucking when the cleanest technology is used, particularly over longer distances.

It is important to note that the emissions estimates in this analysis were limited to NOx, PM, and GHGs. Efforts should be made to build on this research to include other health, environmental, and quality of life impacts from freight transport. For example, short-sea shipping may significantly impact water quality or fragile ecosystems. Increased rail utilization could, in turn, increase vehicle congestion in the absence of new grade separations. Further, freight projects or strategies will affect regions differently. Thus, it is imperative that decision-makers understand where freight impacts are expected so that impacts are identified comprehensively and addressed holistically.

This analysis allows advocates, planners, and officials to make more informed choices about cleaner freight measures and make clean investments in the future.

FREIGHT POLLUTION FROM TRAINS AND TRUCKS



NOTE: Emission estimates include both those from the tailpipe and from fuel production or upstream electric power generation (in the case of electric rail). Emissions from rail are lower on a per container-mile basis over longer routes because the railyard switching (e.g. train-building) emissions are averaged across the route. The data in this chart is from the June 2014 GNA Memo, figures 9, 13 and 21; See the GNA Memo and Technical Appendices for further details.

Endnotes

1 Gladstein, Neandross & Associates (GNA) authored this report under a contract with the Natural Resources Defense Council, made possible by a grant from The Kresge Foundation, and continuing previous work in contract with the California Clean Freight Coalition (see Moving California Forward: Zero- and Low-emission Freight Pathways). See the initial memo from GNA for explanations of transportation technologies, examples of use and information on technology maturity, availability, cost examples where available and local considerations. http://docs.nrdc.org/health/files/hea_15010501a.pdf.

2 Emissions estimates are projected for the year 2020. Units are in grams of pollution for every short ton of goods hauled one mile: g/ton-mile.

3 These impacts include toxic air emissions, noise, night-lights, potential negative impacts to community cohesiveness, character and safety, ecological impacts and many other factors.

4 Bailey, D., Perrella, M.L., Hanning, C., Clean Cargo: A Guide to Reducing Diesel Air Pollution from the Frieght Industry in Your Community, NRDC, http://www.nrdc.org/air/diesel-exhaust/files/clean-cargo-toolkit.pdf.

5 Electric vehicles with zero tailpipe emissions would still generate fugitive dust emissions from re-entrained roadway dust, and brake and tire wear.

6 Plug-in hybrid electric trucks would have zero tailpipe emissions in the short-haul setting because they would be operating within the range of their electric batteries. They may rely partly on a fossil fuel-powered motor if operated beyond that range.

7 Emission rates for electricity generation are based on the U.S. average power supply including a fair amount of "controlled" coal, according to the Department of Energy (Argonne National Laboratories) model, GREET 2013. Actual upstream emissions will vary in each region based on the local power supply.

8 The power mix available in New Jersey is currently even cleaner than that available in New York City; together the regions average a 90 percent benefit from electric vehicles versus conventional trucks in this context, considering upstream power used to charge the vehicles. The New York City Power Mix includes: 56 percent natural gas, 41 percent nuclear, and 3 percent coal. The New Jersey Power Mix includes: 57 percent nuclear, 37 percent natural gas, 4 percent coal, and 2 percent renewables.

9 For more information on how natural gas and diesel emissions were calculated, please see the GNA memo including a full discussion on modeling issues and differences between this report and previous work done in California. http://docs.nrdc.org/health/files/hea_15010501a.pdf.

10 Note that the five-mile distance was chosen to assess this pathway because it is a typical distance for off port railyards in California. Distances are likely to vary in other regions.

11 A 25-mile distance for this pathway is modeled in the analysis comparing baseline, Tier 4, and electrified rail to 2020 diesel trucks. A 70- to 80-mile pathway was modeled to compare barge transport to rail and trucking.

12 Locomotives are more efficient and produce much less pollution than diesel trucks per container over longer distances, because switching locomotive emissions can be significant. Accounting for these rail yard emissions becomes less significant over greater distances.

13 Note that emissions from electric rail come from the upstream generation of electricity used by the locomotives.

14 Note, however, that there are several additional freight strategies that were not considered within this study. For example, the analysis did not examine low-carbon, non-food based biofuels, system-wide efficiency measures, or operational changes in the trucking sector (e.g., higher weight limits, reclassifying drivers as employees instead of independent contractors, longer trailers, or truck-only lanes).

Acknowledgments

NRDC thanks Diane Bailey and Melissa Lin Perrella for writing this summary, as well as Andrea Spacht for graphics, and Mary Annaïse Heglar for editing and production. We are grateful for the hard work of Patrick Couch and Rich Kassel at Gladstein Neandross & Associates, who produced the technical research report by the same name. Staff at the California Air Resources Board and the South Coast Air Quality Management District provided helpful feedback on the analysis methodology, as did several other experts including Don Anair at the Union of Concerned Scientists and Luke Tonachel at NRDC. We also thank additional reviewers: Morgan Wyenn, David Pettit, Andrea Hricko, Martha Matsuoka, and George Peridas.

This work is part of our Clean Cargo series, made possible by the generous support of The Kresge Foundation, which is dedicated to improving the health of communities and workers affected by the freight transportation industry. We are also grateful for the financial support of the Hewlett Foundation for the preceding California Cleaner Freight Coalition analysis, *Moving California Forward: Zero- and Low-emission Freight Pathways*.