EXECUTIVE SUMMARY

# Delivering Opportunity

## *How Electric Buses and Trucks Can Create Jobs and Improve Public Health in California*


**HIGHLIGHTS**

*In California, transportation is the largest source of air pollution and global warming emissions. While significant progress has been made to electrify passenger vehicles, action must be taken to bring the same technology and policies to heavy-duty trucks and buses. These vehicles produce not only the heat-trapping emissions that lead to climate change, but also produce significant amounts of particulate matter and smog that endangers public health, especially in communities of color and low-income communities that are located near busy roads. With policies, investments in clean technology, and equitable job training, electric trucks and buses can deliver clean air, reduce global warming emissions, and create job opportunities.*


Heavy-duty vehicles are a significant source of local air pollution and global warming emissions in California. These emissions endanger public health, especially in low-income communities and communities of color, which are more likely to be located near busy roads and other sources of pollution. While clean air and climate policies across the country have sparked sales of passenger electric vehicles, deployment of similar technologies for heavy-duty trucks and buses has been slower. California is shifting this balance, with policies and investments to bring electric trucks and buses to market.

This report examines the state of technology for electric trucks and buses, their life cycle emissions, and job opportunities presented by an expanding market for electric heavy-duty vehicles. With recent innovation, these vehicles can meet the requirements of many demanding applications. And with the right job-training and equitable hiring policies and programs, California's emerging electric truck and bus sector can provide opportunities to increase employment in underserved communities.

## Public Health Assessment

Heavy-duty vehicles are a significant source of the state's global warming emissions, accounting for 7 percent of the total—a proportion estimated to increase over the next 30 years, according to the California Air Resources Board (CARB). They are the single largest source of nitrogen oxides ($NO_x$) in California (emitting 33 percent of the state's total) and produce more particulate matter than all of the


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*California should support electric heavy-duty vehicles and invest in training a workforce for the production and maintenance of electric trucks and buses. Such investments will lead to cleaner air that improves public health and an increase in opportunities for skilled jobs.*


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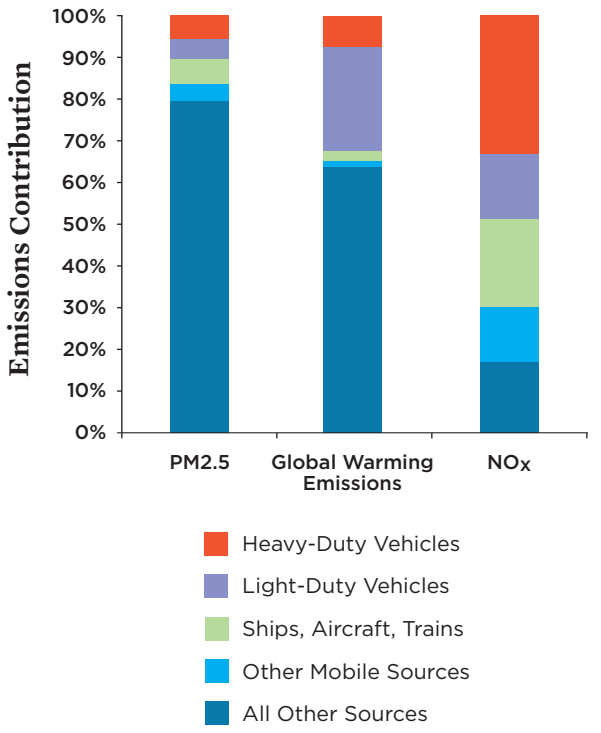
state's power plants combined (23 tons per day versus 7 tons per day, respectively) (Figure ES-1). Particulate matter from the combustion of diesel fuel is an especially toxic type of particulate matter and has been identified by the World Health Organization as a carcinogen. Heavy-duty vehicles emit nearly 40 percent of this dangerous type of particulate matter in California. These large contributions to air pollution come despite the fact that heavy-duty vehicles make up just 7 percent of all vehicles in California.

Pollutants from heavy-duty vehicles pose health risks at all stages of life, from premature births to premature deaths. Studies have associated air pollution with adverse effects on nearly every organ system in the body. While air pollution affects us all, low-income communities and communities of color are more likely to be located near ports, rail yards, warehouses, and busy roads, where they suffer disproportionally from the consequences of dirty air. These *localized* inequities are particularly important because mitigation strategies to reduce *regional* air pollution may not address exposure at the local level.

FIGURE ES-1. Heavy-Duty Vehicles Are Significant Contributors to California's Air Pollution and Global Warming Emissions




*Emissions from mobile sources in California include small particulate matter (PM2.5), global warming emissions, and nitrogen oxides ($NO_x$).*

Notes: Particulate matter emissions do not include emissions from wildfires, which are roughly equal to all non-wildfire sources combined. PM2.5—particles with diameters 2.5 micrometers and smaller—are considered particularly dangerous. "Other mobile sources" include off-road equipment, recreational vehicles, and farm equipment.

SOURCE: CARB 2013; CARB 2016A.

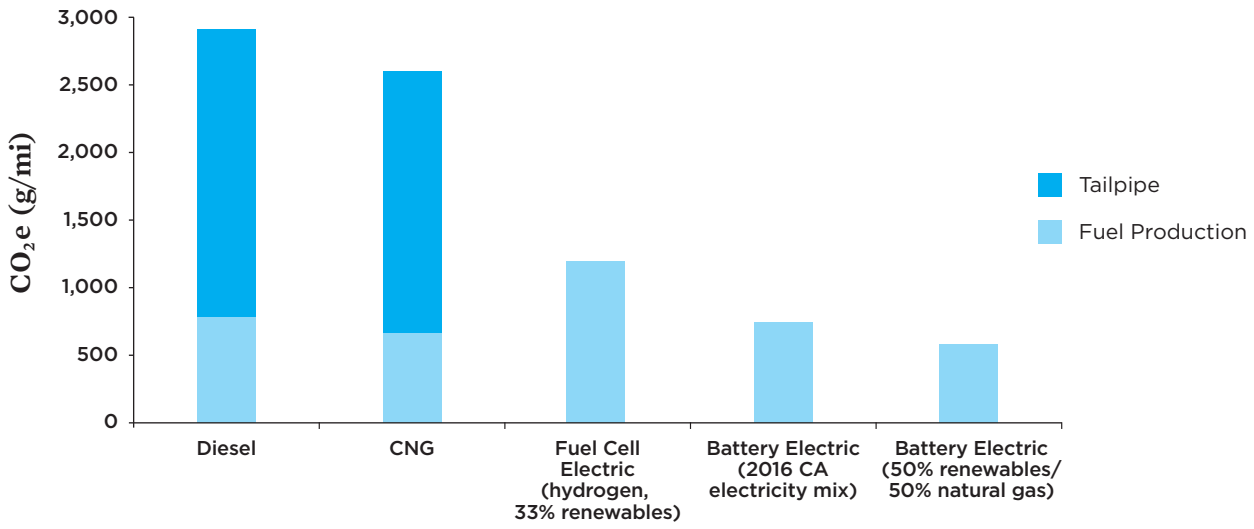
***While air pollution affects us all, low-income communities and communities of color suffer disproportionally from the consequences of dirty air.***

## Emissions Assessment

Adapting models from Argonne National Laboratory and CARB, the Union of Concerned Scientists (UCS), and Life Cycle Associates analyzed the emissions from heavy-duty vehicles. This analysis used transit buses as a case study and considered both tailpipe emissions and emissions from producing the fuel. This "life cycle analysis," which covered global warming emissions, particulate matter, and $NO_x$ emissions for different fuel types, found the following:

- Battery electric buses have no tailpipe emissions and fuel cell electric buses produce only water vapor, eliminating hazardous exhausts where these vehicles operate. Their emissions depend solely on how the electricity and hydrogen fuel are produced.
- Life cycle global warming emissions from fuel cell electric buses are more than 50 percent lower than both compressed natural gas (CNG) or diesel buses (Figure ES-2). Life cycle global warming emissions from battery electric buses are more than 70 percent lower than both CNG and diesel buses.
- Battery and fuel cell electric buses have lower life cycle $NO_x$ emissions than diesel and CNG buses (Figure ES-3). This includes CNG buses with soon to be released engines certified to meet California's voluntary low-$NO_x$ standards (0.02 g $NO_x$/brake horsepower-hour).
- Battery and fuel cell electric buses have lower life cycle particulate matter emissions than diesel buses. Electric buses powered by electricity from sources representative

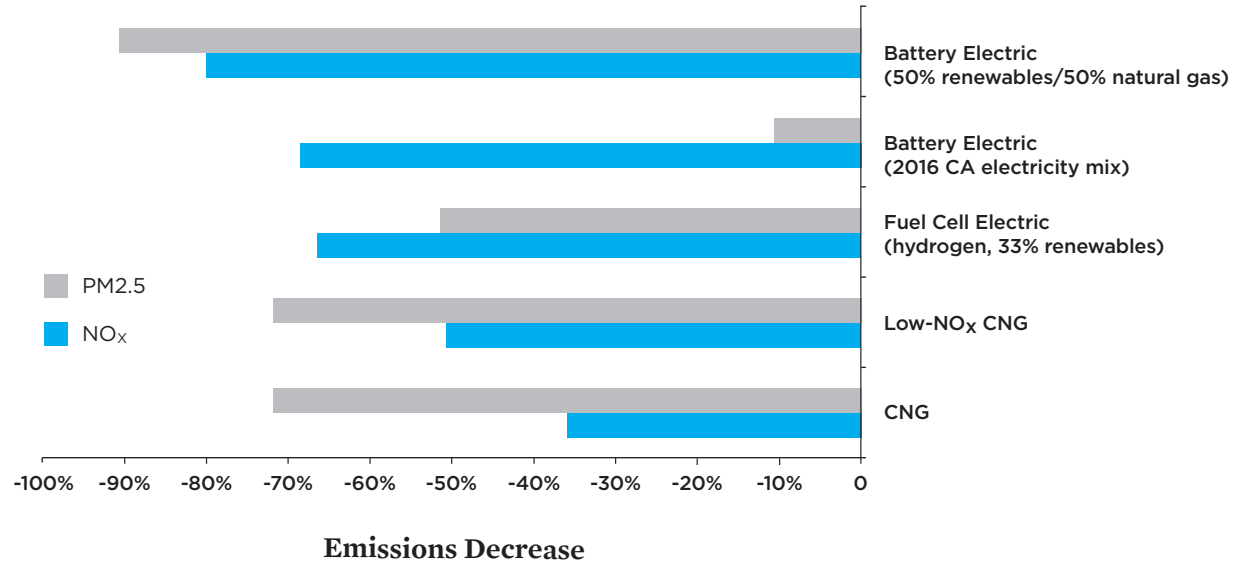
FIGURE ES-2. Reducing Global Warming Emissions by Switching to Electric Buses




*Life cycle global warming emissions from diesel and compressed natural gas (CNG) buses are far higher than those from fuel cell electric buses (fueled by hydrogen, $H_2$) or battery electric buses.*

Note: Comparison based on emissions from 40-foot transit buses. $CO_2e$ stands for carbon dioxide equivalent.

FIGURE ES-3. Reducing Particulate Matter and Nitrogen Oxide Emissions by Switching to Electric Buses




*Life cycle emissions of particulate matter (PM) and nitrogen oxides ($NO_x$) for battery electric, fuel cell electric, and compressed natural gas transit buses are low relative to a diesel bus.*

Notes: PM2.5 emissions refer to particles with diameters 2.5 micrometers and smaller. Comparison based on emissions from 40-foot transit buses.

of California's current power mix (e.g., natural gas, solar, wind, hydroelectric) show less dramatic reductions in particulate matter due to electricity generation from coal and biomass power plants. These emissions will decrease further as California's sources of power become cleaner as required by state law (including no new contracts for electricity generated out of state with coal).

## Technology Assessment

Battery electric and fuel cell electric heavy-duty vehicles meet the specifications of many transit bus and urban truck operations. Today's electric vehicle (EV) technology includes vehicles with ranges of more than 100 miles per charge and charging and refueling times under 15 minutes (Figure ES-4). Heavy-duty EVs are also up to four times more efficient than diesel and natural gas engines, while being quieter and boasting similar if not better acceleration times and ability to climb hills. Hundreds of electric trucks and buses have already been deployed in California, including more than 400 battery electric delivery trucks and nearly 100 battery and fuel cell electric transit buses. Nearly 40 electric drayage trucks (semi-trucks that move cargo to and from ports and rail yards) are also planned for demonstration projects in California.

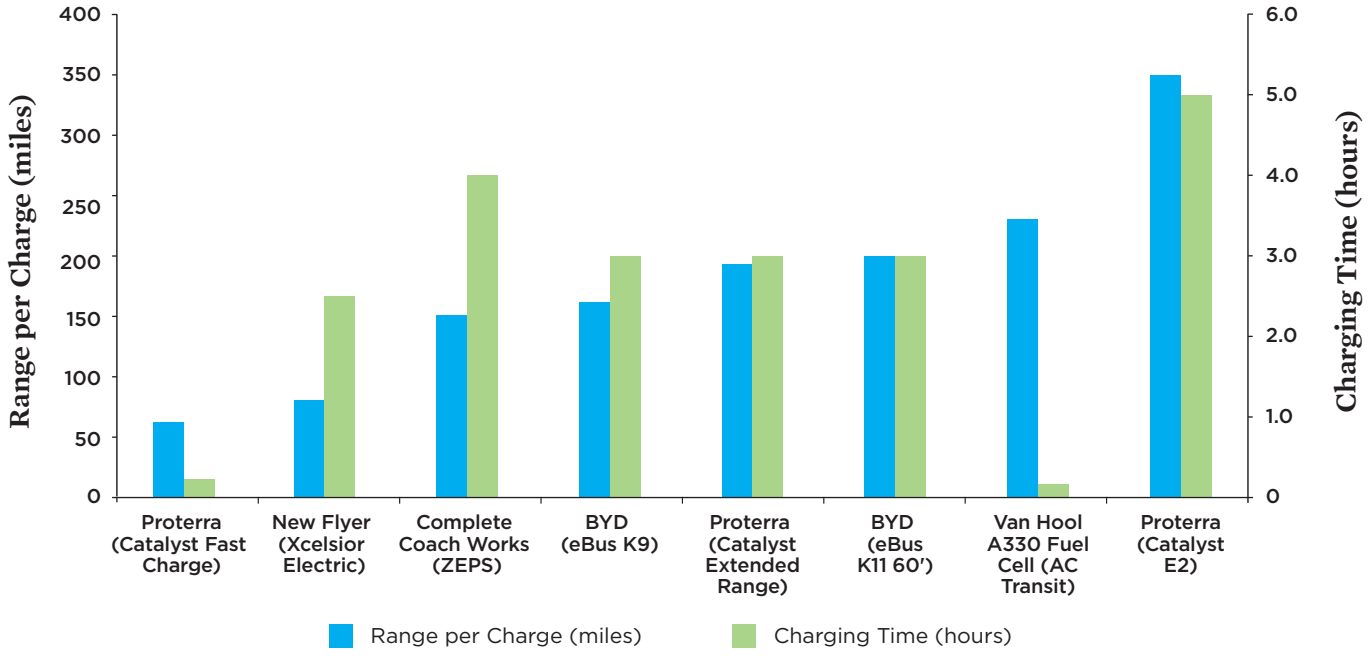
> ***Heavy-duty EVs are up to four times more efficient than diesel and natural gas engines.***

## Jobs and Workforce Training Assessment

California's heavy-duty EV sector has great potential for job growth. Jobs in both heavy-duty EV manufacturing and EV-charging infrastructure/maintenance are moderately accessible for underserved communities.

Entry-level jobs with the greatest growth potential are middle-skill occupations requiring some experience and training. Incumbent workers in conventional automotive manufacturing and maintenance, including workers from

FIGURE ES-4. Electric Bus Ranges Are Increasing While Charging and Refueling Times Are Decreasing




*Electric transit buses travel from 60 miles to 350 miles on a single charge, and charging times vary from 10 minutes to five hours. All buses listed are 40 feet long except for BYD Motors' 60-foot K11 bus.*

underserved communities, might find clear paths to these job opportunities. In addition, robust job training policies and programs will make it possible for low-skill underserved community members to enter pathways to these jobs.

Two key findings relate to jobs in this sector:

- The heavy-duty EV sector is just emerging, with no effective, equitable workforce policies or programs. More resources are needed to improve access to jobs in this field.
- Occupations associated with heavy-duty vehicle electrification have an increased need for electrical skills. This restricts entry for low-skilled workers from underserved communities, but good training programs can overcome this barrier.

## Recommendations: California's Road to Health, Jobs, and Cleaner Air

California policies and investments are driving growth in the heavy-duty electric vehicle sector. California must take a number of actions to sustain that growth *and* ensure that underserved communities benefit first from healthier air and job growth.

### DEPLOY CLEAN TECHNOLOGIES TO IMPROVE PUBLIC HEALTH

Smart policies and incentives have been critical to the penetration of electric technologies in the light-duty vehicle sector; heavy-duty vehicles will benefit from similar actions, many of which are underway or beginning to take shape in California. We make the following policy recommendations:

- Continue and expand the use of financial incentives to offset the incremental capital and infrastructure costs associated with clean vehicle technologies.
- Direct funding for heavy-duty EVs toward communities most affected by pollution from heavy-duty vehicles and to small businesses most burdened by the costs of transitioning to clean technologies.
- Design electricity rates and make investments in charging infrastructure that facilitate a transition to electric trucks and buses.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*California's heavy-duty EV sector has great potential for job growth, but strong training programs are needed to make these job opportunities available to underserved communities.*

- Implement regulatory measures to increase sales volumes and reduce technology costs so that heavy-duty EVs become the norm and not the exception.
- Provide technical assistance to small businesses and fleet managers to facilitate their adoption of EVs, which come with different operating considerations than do traditional vehicles.

### ASSESS JOBS AND WORKFORCE TRAINING

The following recommendations highlight actions and considerations for government, heavy-duty EV companies, and job-training programs to ensure that workers from underserved communities gain access to the growing job opportunities in the heavy-duty EV sector.

- California's electric truck and bus manufacturers should support the development of formal training pathways for new workers from underserved communities so they can access employment in this emerging field. Manufacturers can partner with workforce training organizations, workforce development boards, and community colleges to establish pathways for training and certifying workers from these communities and place them in quality jobs.
- California's government agencies should invest in skill-development programs aimed at training jobseekers in underserved communities to fill the emerging employment needs in the heavy-duty EV industry and related transportation electrification fields.
- Job training organizations should evaluate the heavy-duty EV sector—and the larger transportation electrification sector—for the potential to establish formal job-training programs, especially if investments supporting this sector continue to grow.

California's emerging electric truck and bus sector provides a significant opportunity to improve public health in areas most affected by traffic-related pollution, while bringing jobs to communities that need them most. With the right private- and public-sector policies and investments, electric trucks and buses can deliver cleaner air, reduce global warming emissions, and create a more equitable economy in California.

### A NOTE ON THE UPDATED MAY 2017 VERSION

This report was updated in May 2017 to incorporate vehicle charging efficiency in the life cycle emissions analysis of electric buses. A charging efficiency of 90 percent was chosen based on data from The Altoona Bus Research and Testing Center. This represents a conservative value compared to the 95 percent efficiency cited in the California Air Resources Board's *Technology Assessment: Medium- and Heavy-Duty Battery Electric Trucks and Buses* and conversations with industry representatives. The life cycle emissions from battery electric buses changed only slightly with this update. All conclusions regarding the emissions of battery electric buses compared to other buses remained unchanged.

FIND THE FULL REPORT ONLINE: www.ucsusa.org/ElectricTrucks
AND AT: www.greenlining.org/issues/2016/delivering-opportunity-electric-trucks

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