ELECTRIFYING TRUCK FLEETS: UTILITY INFRASTRUCTURE IS CRITICAL

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Contents

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The **American Council for an Energy-Efficient Economy** (ACEEE), a nonprofit research organization, develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

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Abstract

As electric grids get cleaner, the use of electric vehicles—trucks and passenger vehicles—becomes a central decarbonization strategy. In the United States, buses and freight trucks account for less than 5% of vehicles but approximately 28% of greenhouse gas emissions. Many trucks are part of fleets, including fleets of delivery vehicles, buses, garbage trucks, and tractor-trailers. Discussions with electric truck manufacturers indicate that a large barrier to fleet electrification is the need for adequate power on site to charge vehicles. Power is typically a greater issue for trucks and buses than for cars for two reasons: Trucks often have larger batteries, and trucks and buses are often part of multi-vehicle fleets that charge at the same location and often at the same time. Depending on the number and size of chargers, fleet charging can require several megawatts of power, with loads up to 40 MW (which is similar to the power needs of many large factories). To supply this power, utilities need to assess customer charging needs and incorporate their findings into the planning of local distribution grids. Needed utility updates will often include new transformers, sometimes new feeders and substation upgrades, and at times, entirely new substations. Because substations typically take 2–4 years or longer to plan and build, planning should begin now for any new substations needed to serve electric trucks. Further, while distribution plans typically look five years ahead, given the large infrastructure needs for electrification, much longer-term plans should be considered—such as 10–20-year planning, with updates every 1–2 years. In the United States, a few utilities and states are proactively preparing for fleet electrification, yet most have barely started. Here, we analyze this emerging issue and provide case studies of several leading utilities and states that are promoting and preparing for electric fleets, offering useful models for others to follow.

Key Takeaways

- Electric truck availability and sales are growing; this momentum is steadily building, particularly for categories such as delivery vans and transit and school buses.
- Policies are already driving fleet electrification. Examples of these policies include zero-emission vehicle requirements in California and other states, and mandates in Connecticut, Maine, Maryland, and New York State that school bus purchases be zero emission starting later this decade.
- To charge their fleets, some individual sites may require megawatts of power—in many cases, this will be equivalent to the power needs of a large factory. Many local substations and distribution feeders will require upgrades to handle these loads.
- Fleet owners, electric utilities, and utility regulators need to start planning for these impacts now, so that grid improvements can be made steadily as electric fleets grow. Fleet and grid planning should happen in parallel so that grid upgrades do not happen too soon or later than needed. If grid upgrades are delayed, it will slow vehicle purchases.

- Given the rapid changes taking place in fleet markets, distribution plans should look 10–20 years into the future and be updated annually. In locations where utilities are not planning for fleet loads, regulators should encourage them to undertake this planning.
- This paper profiles leading states and utilities that offer programs to assist fleets and that lead grid planning for fleet loads. California utilities are leaders in such fleet programs, and Massachusetts and New York State each have promising processes underway to proactively address fleet loads. As we describe here, states and utilities can assist fleets and help manage and plan for the related grid impacts. Given the growing momentum on fleet electrification, the time to begin these efforts is now.

Introduction

In the United States, buses and freight trucks account for less than 5% of vehicles, yet they also account for approximately 28% of greenhouse gas (GHG) emissions from all vehicles (see figure 1). Many trucks are part of fleets, including fleets of delivery vehicles, buses, garbage trucks, and tractor-trailers. As we describe here, recent product developments offer growing opportunities to electrify trucks and buses and slash their emissions, and many countries, states, and cities are adopting policies to encourage bus and truck electrification. As an increasingly number of electric buses and trucks travel the roads, however, fleets will require a lot of electricity for charging. Utilities must be ready to power electric fleets. As our examples later show, doing so often requires improvements to distribution systems. Furthermore, growth in electrified fleets will be uneven: some circuits will need to double or triple their capacity, while others will barely be affected. As our case studies describe, some utilities in California, Massachusetts, and New York are planning for an increase in power demand, yet from our observations, most utilities have yet to do so and need to get started post haste.

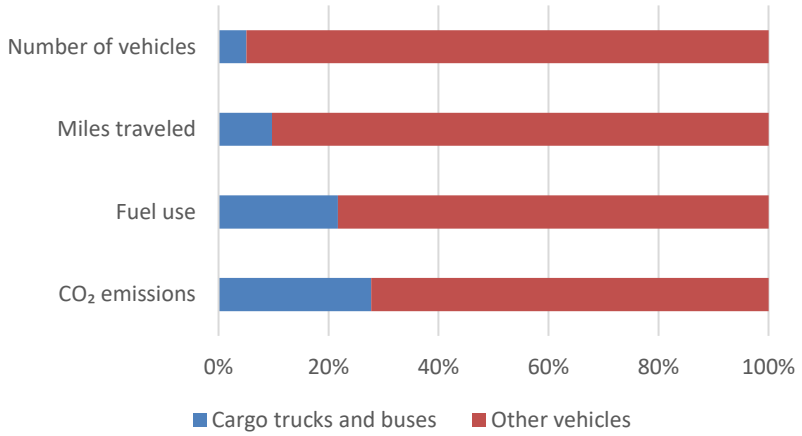

Figure 1. Freight trucks and buses (vehicle classes 3–8) as a proportion of all U.S. vehicles. Source: Nadel and Huether 2021.

This paper draws from extensive data on these issues in the United States, but all countries planning to electrify substantial portions of their bus and truck fleets will need to address these issues.

Why Electric Trucks and Buses?

Electric trucks and buses are growing in availability and sales because they have substantially lower emissions than diesel and gasoline vehicles, and they increasingly provide lifecycle cost savings. As we describe below, growing use of these vehicles is also being driven by various policies that are motivated by a need to reduce carbon emissions. Figure 2 illustrates the carbon emissions benefits of electric trucks and buses. In addition to high carbon

emissions, heavy-duty trucks are also responsible for 45% of on-road nitrogen oxide (NOx) emissions and 57% of on-road, direct PM2.5 emissions—that is, particulate matter less than 2.5 micrometers in diameter—according to data compiled by the Union of Concerned Scientists (O'Dea, 2019). NOx and PM2.5 cause significant health risks. Because interstates and other truck routes frequently cut through communities of color and low-income communities, the highest concentrations of these pollutants are often found in those areas. Figure 3 shows this, using Massachusetts Institute of Technology (MIT) researchers' compilation of sensor data from satellites.

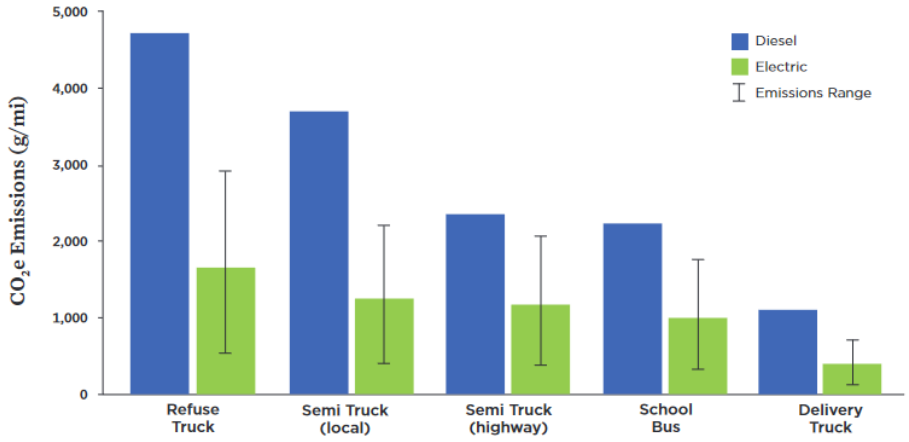

Figure 2. Lifecycle greenhouse gas emissions from different vehicle types. For electric emissions, the green bar is for average 2016 emissions per kWh; the whisker is based on the range of emissions per kWh across regions. Source: O'Dea 2019.

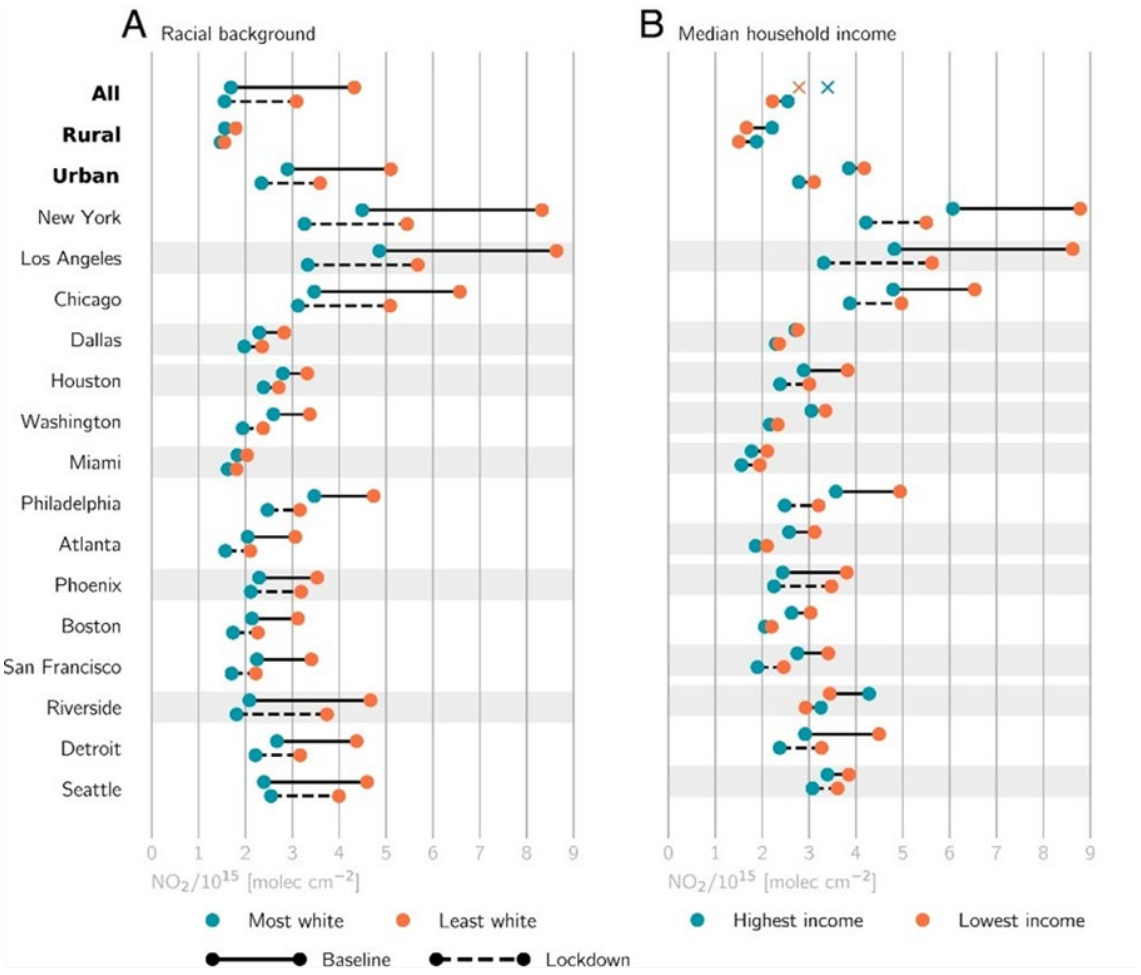

Figure 3. Disparities in baseline and COVID lockdown NO_2 levels for different (A) racial and (B) median household income by major city. Source: Kerr, Goldberg, and Anenberg 2021.

Figure 4 summarizes some studies on electric truck economics. As the figure shows, electric delivery and other small trucks are often cost effective today, while large tractor-trailers will likely be cost effective in a few years. Another study shows that in large and medium-sized cities, electric transit buses are also often cost effective today (Marcacci 2018).

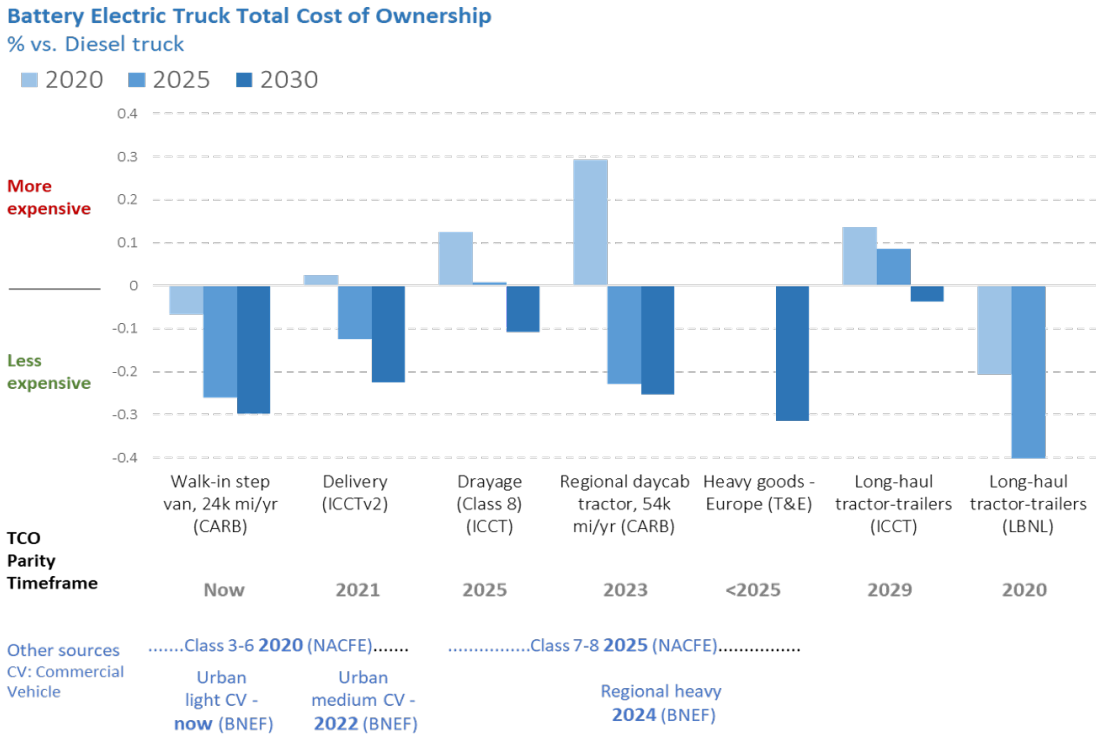

Figure 4. Comparison of diesel and battery-electric trucks on the total cost of ownership (TCO). CARB = California Air Resources Board; ICCT = International Council on Clean Transportation; T&E = Transport and Environment; LBNL = Lawrence Berkeley National Laboratory; BNEF = Bloomberg New Energy Finance; and NACFE = North American Council for Freight Efficiency. Source: Hewlett Foundation 2020.

Since figure 4 was first published in 2020, researchers have conducted many additional studies on the economics of electric trucks, and their results are broadly similar to these earlier results. For example, Roush Industries, under contract to the Environmental Defense Fund, looked at seven specific types of medium and heavy vehicles and estimates that in 2022, the average total cost of ownership was at parity with diesel vehicles for school buses, refuse haulers, and class 5 delivery trucks, and will be at parity in 1–3 years for shuttle and transit buses, class 3 delivery vans, and class 7 delivery trucks (EDF 2022). A 2023 International Council on Clean Transportation (ICCT) study found that by 2030, long-haul class 8 electric trucks will have a lower total cost of ownership[1] than diesel trucks in the seven states it examined (California, Florida, Georgia, Illinois, New York, Texas, and Washington) (Basma et al. 2023).

Electric vehicles also have a number of other advantages, including quieter operation, reduced emissions of harmful pollutants such as NOx and fine particles, reduced

[1] In this study, total cost of ownership includes vehicle and infrastructure costs, taxes, fuel and electricity costs, maintenance, insurance, and labor.

maintenance expenses, and higher torque (Nadel and Huether 2021). However, electric vehicles also face challenges. According to a 2018 survey of fleet owners, the top three challenges are high purchase price, inadequate charging infrastructure, and inadequate product availability (UPS and GreenBiz 2018). A major truck manufacturer that we interviewed (who wished to remain unnamed) said that grid limitations were a key obstacle to truck electrification.

Growing Availability and Sales of Electric Trucks and Buses

Availability and sales of electric trucks have increased substantially over the past few years. Amazon contracted to purchase 100,000 electric delivery vans and, as of May 2023, had more than 3,000 of these vehicles on the road (Amazon 2023). United Parcel Service, Federal Express, and Walmart have also placed substantial orders (Nadel 2023). Various other manufacturers have announced new delivery van and medium-duty vocational truck models (Nadel and Huether 2021).

Baltimore, Los Angeles, New York City, Phoenix, Pittsburgh, San Francisco, and the District of Columbia have made commitments to switch all municipal buses from diesel to electric buses by 2030–2040 (varying by city) (Nadel and Huether 2021; Nadel 2023). A California regulation specifies the percentage of transit bus purchases that must be zero emission, ramping up to 100% in 2029 (Kane 2018). New Jersey and Connecticut have similar mandates (for 2032 and 2035, respectively), with substantial policies also in place in Colorado, the District of Columbia, Maryland, Michigan, and Vermont (Huether et al. 2023). Many other transit agencies are gradually introducing electric buses into their fleets. Likewise, school bus purchases are starting to transition to electric, driven in part by concerns about the effect of diesel emissions on children (e.g., see PIRG 2021). More than 5,000 electric school buses are on the road or on order, aided in part by funds from the 2021 Bipartisan Infrastructure Law (Freehafer and Lazer 2023). Maryland legislated that new school bus purchases be zero emissions as of 2020, dependent on the availability of state funding (Peetz 2019). New York State requires that all new school bus purchases be zero emission as of 2025 and, as of 2035, all school buses in operation must be zero emission (NYSERDA 2023a). Similar mandates are also in effect in Connecticut and Maine (Huether et al. 2023). These and many other states used funds from the Volkswagen "Dieselgate" settlement to purchase electric school buses, but recent focus has been on federal, state, and local funds. Substantial federal funding for school buses is available under the 2021 Bipartisan Infrastructure Law.

Refuse (garbage) trucks are also a growing application for electric vehicles. These trucks can be a good early application of electric heavy-duty vehicles because EVs are better suited than diesel or gasoline vehicles to stop-and-go driving at low speeds over short distances. Stop-and-go driving increases diesel maintenance expenses (Daniels and Nelder 2021). Lower operating costs and reduced noise led the publication *Waste Dive* to headline a 2022 article "Electric Evolution Increasingly Seen as Inevitable for Waste and Recycling Fleets" (Rachal 2022).

Finally, efforts are now beginning to electrify the workhorse of American roads, the 18-wheel tractor-trailer (see figure 5). Volvo and Freightliner (a division of Daimler)—the number one and number three U.S. manufacturers of class 8 trucks—are now in commercial production of electric tractors in the United States following several years of real-world use of pre-production vehicles. Tesla, a new entrant to heavy-duty trucks, has begun delivering vehicles to customers and expects to move into commercial-scale production soon. Tesla has two models, one of which can go 500 miles before recharging. In addition to these three leaders, Pacar—currently the second largest U.S. manufacturer of class 8 trucks—is testing and taking orders for electric models under its Peterbilt and Kenworth brands. Lion, a Canadian manufacturer, and BYD, a Chinese firm, are also entering the U.S. market, as is startup Nikola (Nadel 2023).

Overall, as of December 31, 2022, CalSTART (2023) estimates that more than 5,000 zero-emission medium- and heavy-duty vehicles are on U.S. roads, including 3,510 vehicles deployed in 2022 alone.

Figure 5. Freightliner e-Cascadia (left) and Tesla Semi (right). Sources: Morgan 2021; Seabaugh and Lim 2023.

Policies Will Drive Substantial Sales Growth

In many countries, policies are driving growth in electric truck and bus sales. In the United States, three policies in particular are worth noting. First, the California Air Resources Board (CARB) has adopted the Advanced Clean Truck (ACT) rule, which sets minimum requirements for the percentage of zero-emission truck sales. As figure 6 shows, these percentages vary by vehicle type and year. Fifteen other states and the District of Columbia have committed to exploring similar rules (NESCAUM 2021). In addition to California, six other states—Colorado, Massachusetts, New Jersey, New York, Oregon, Vermont, and Washington—have adopted these standards as of June 2023. And, in May 2023, California strengthened its standards for medium- and heavy-duty trucks from the values that figure 6 shows. The state now requires, as part of its Advanced Clean Fleets (ACF) rule, that new yard and local delivery trucks be zero emission by 2035; new work trucks and day cab tractors be zero emission by 2039; and new sleeper cab tractors and specialty vehicles be zero emission by 2042 (CARB 2023). Since other states are thus far adopting the standards shown in figure 6, and since California will need a federal Environmental Protection Agency (EPA) waiver for other states to adopt the ACF standards, we offer the ACT figure as a reference in this paper.

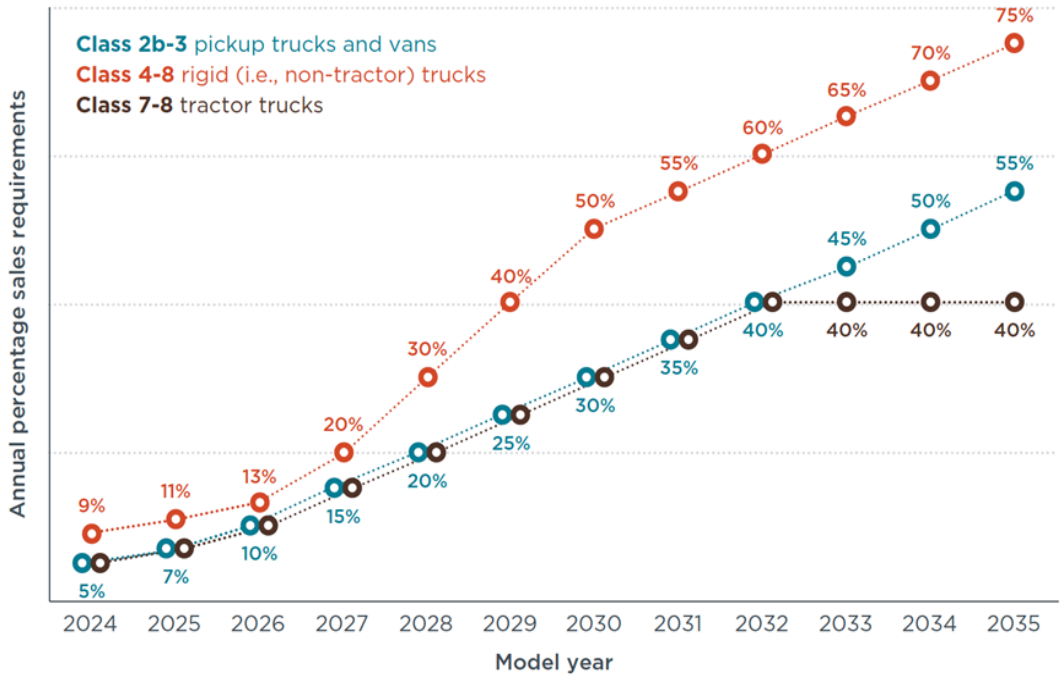

Figure 6. The original California zero-emissions sales percentage schedule by vehicle group and model year (Buysse and Sharpe 2020). Several other states have since adopted these standards. In May 2023, California tightened its standards to require all new covered trucks to be zero emission by 2042.

Second, the U.S. Congress, as part of the Inflation Reduction Act of 2022, enacted a 30% federal tax credit for purchases of zero-emission medium- and heavy-duty vehicles up to a maximum of $40,000 per vehicle. This cap essentially means that the credit for class 8 vehicles covers only approximately 10% of the total vehicle cost, which is typically around $400,000 (the approximate midpoint, from Wang 2022). A recent study by the ICCT found that the battery pack often constitutes most of an electric truck's cost. It also estimated that as battery costs come down, electric semi-cab costs will be reduced by about 23% in 2025 and 40% in 2030 (Sharpe and Basma 2022).

Some states and utilities also provide incentives for medium- and heavy-duty electric trucks, including California (up to $120,000) and New York (up to $185,000 for trucks, and even more for buses) (California HVIP 2023; NYSERDA 2023b). Commonwealth Edison in Illinois recently proposed incentives of up to $75,000 for electric trucks and up to $180,000 for electric buses purchased by its customers (Com Ed 2023a). In total, 24 states have some type of fleet-related utility program (Huether et al. 2023). All of these incentive programs are designed to help the market get started and are not for the long term.

Third, the U.S. Environmental Protection Agency (EPA) has proposed GHG emissions standards that could result in more than 40% of medium- and heavy-vehicle sales being electric by the early 2030s (EPA 2023). A final decision on the standards will be made in spring 2024, with the new standards taking effect in model year 2027. These standards will

update the previously finalized 2027 heavy-duty vehicle emission targets and propose a completely new set of GHG targets for vehicle model years 2028–2032. The EPA expects the proposed heavy-duty standards to cumulatively reduce 1.8 billion metric tons of carbon emissions between 2027–2055, mainly due to an increase in zero-emission heavy-duty vehicles. The success of the Phase 3 standards will depend on the actions of multiple stakeholders—including utilities, few of which have engaged with the proposed rule. Early planning and grid investment from the utility-side will be critical in ensuring the timely build-out of the infrastructure needed to support the increase in zero-emission heavy-duty vehicles that will result from these new standards over the next decade.

Electric Truck and Bus Fleets Need Substantial Power; Distribution Planning Will be Critical

DISTRIBUTION NEEDS AND COSTS

Electric vehicles add a substantial load to power grids, which will affect the need for generation, transmission, and distribution infrastructure. The overall growth in power needed is probably moderate relative to power demand for all uses. For example, a Eurelectric study (2018) estimated that if 80% of all passenger cars become electric, this would lead to a total increase of 10–15% in European electricity consumption by 2050. Electric trucks and buses would add additional power needs. A report by the U.S. Department of Energy (DOE) found roughly similar impacts in the United States, noting that this growth in electricity demand is less than power plant build rates during the late 20th century (USDRIVE 2019).

More substantial power needs are estimated in a 2023 analysis by the firm Kevala on electrification impacts in California if the state meets its ambitious decarbonization goals across both transportation and buildings. This study estimated a 56% increase in peak load over the 2025–2035 period for the state's three large investor-owned utilities, of which 60% is due to light-duty EVs. This study did not include any potential future mitigation strategies such as new time-variant or dynamic rates or flexible load management strategies. The researchers note that, in particular, this new load will require substantial electric distribution grid improvements beyond current plans. They estimate costs up to $50 billion for distribution investments including feeders, transformer banks, and substations. They also note that traditional five-year distribution planning cycles are too short and recommend 15-year plans (Kevala 2023).

While total power demand is important, a bigger issue is probably that this power demand is not evenly distributed; instead, it will be concentrated in locations with many chargers, such as fleet depots. Utilities need to plan their distribution systems to meet this localized need for more power.

Power for trucks and buses is generally more of an issue than for cars, because trucks typically have larger batteries, and trucks and buses are often part of fleets with many

vehicles that charge at the same location and often at the same time. For example, a Tesla Model 3 sedan battery stores 82 kWh; a Proterra transit bus battery stores 220–660 kWh (Lambert 2020; Proterra 2021). In Amsterdam, a 100-bus transit fleet at the airport is powered by a set of slow and fast chargers that together have a peak load of 13 MW (Manthey 2018), which is equivalent to the power that a large factory might use. The airport is thinking of expanding the fleet to 250 buses (Manthey 2018).

Many other fleets will also need a lot of "juice." For example, a rough estimate of the power needed to serve a fleet of 200 delivery vans at an Amazon fulfilment center is about 4 MW (Kellison 2019). For electric 18-wheelers, current trucks from three manufacturers draw a maximum of about 250 kW, but the Tesla Semi draws about 1 MW (1,000 kW) (Kahn et al. 2023).[2] The CharIN group is developing a new MW-scale charging standard with participation by most of the major industry players. This will make 1 MW charging common, and sometimes even 2 MW per vehicle (CharIN 2023). A recent proposal calls for charging stations located every 100 miles along the U.S. West Coast's I-5 corridor, each with a peak load of 23.5 MW (HDR et al. 2020). A study by National Grid on its Massachusetts and New York service territories examined 71 highway truck stop sites and estimated that by 2045, many of these will require at least 5 MW of power and a few might need as much as 40 MW (Katsh et al. 2022).

As these examples show, the need for more power at a given site is more than most utilities can provide without substantial planning and investment. Meeting these needs will often require changes to primary and secondary power distribution systems (feeders that deliver power both to distribution transformers and end customers) and substation upgrades. For large loads, new substations may be needed. A California Electric Transportation Coalition (CalETC) paper (2020a) estimates that loads of more than 5 MW will generally require distribution system and substation upgrades. As table 1 summarizes, Black & Veatch (2019, 2022) and Borlaug et al. (2021) also provide general guidance on electric fleet upgrades, while recognizing that each site is unique.

[2] All four vehicles are battery-electric vehicles. Due to the higher load, the Tesla can charge more quickly.

Table 1. Distribution upgrades typically needed as a function of new load

New load amount (MW)	Upgrade typically needed	Example timeframe
20	New substation	24–48 months or more
10	New transformer bank/substation upgrade	12–24 months or more
5	New circuit	6–26 months
2	Customer needs higher voltage service	3–6 months
1	Upsizing wire or cable to the site or reconductoring	6–14 months

Source: Black & Veatch, 2019, 2022, with some edits by ACEEE based on Borlaug et al. 2021

Table 2 summarizes estimated system upgrade costs from Borlaug et al. (2021).

Table 2. Typical costs of electricity distribution upgrades for depot charging

Item	Typical cost
New substation	$4–35 million
Substation upgrade	$3–5 million
Install/upgrade feeder circuit	$2–12 million
Install distribution transformer	$12,000–175,000
Install/upgrade feeder circuit	$2–12 million
Substation upgrade	$3–5 million
New substation	$4–35 million

Source: Borlaug et al. 2021

INSTALLING CHARGERS

Choosing the correct type and number of chargers, and where to install them, will affect distribution planning needs. This involves several major considerations. First, the type of vehicle and how it is used will determine the battery's size and capacity. Next, characteristics of the business or fleet and how quickly a vehicle must return to the road will determine the charging level. Finally, and perhaps most importantly, selecting a site for chargers will require consideration both of where the vehicles will be used and stored, and of the availability of sufficient grid infrastructure to meet the expected electrical demand.

For delivery vehicles and transit busses, business owners, and fleet operators generally prefer charging to take place where the vehicles are typically parked when not in service, such as in

a warehouse parking lot or at a bus depot. Long-haul trucks could also charge at a warehouse, but for longer routes—such as those made by sleeper cabs—the trucks will ideally use chargers en route, such as at rest stops. This presents multiple challenges for the grid infrastructure, especially given that multiple chargers will likely be operating simultaneously.

Installing several chargers at a depot, truck stop, or filling station involves many players to obtain permits, undertake construction, and work with the utility to ensure that adequate power is available when and where needed. The North American Council for Freight Efficiency (NACFE) (2019) and CalETC (2020b) have each outlined recommended processes. Combining these two sources results in the following general process:

1. Engage utility
2. Choose vehicles
3. Determine charging needs
4. Assess incentives and financing
5. Design site plan
6. Apply for permits, modifying plans if needed
7. Procure charging components
8. Deploy charging infrastructure

The utility is engaged first so that it can begin to think about power needs well before the power is needed, and also because utility input may affect subsequent stages. CalETC (2020b) estimates that the overall process can take 9–18 months for typical projects, and 24 months or more for large, complex projects. Although some large companies may undertake such efforts themselves, many will need guidance from a firm specializing in this process. To provide just one example, Siemens has a growing business building truck chargers and managing their installation (Fehrenbacher 2019).

MEDIUM- AND HEAVY-DUTY VEHICLE POWER-NEED FORECASTS

California

An October 2021 Guidehouse report forecasting vehicle and load growth for medium- and heavy-duty vehicles in California (Guidehouse 2021) offers a glimpse at the magnitude of the effort required to serve medium- and heavy-duty truck fleets. (Because this is the only state-specific estimate as of this writing, we treat California separately from other states.) The Guidehouse report estimates that power needs were modest in 2021 but will grow more than fivefold by 2030 and approximately 17-fold by 2040. This estimate does not include the impact of the recent California ACF rule. As figure 7 shows, the initial power demand will be focused on trucks that serve warehouses but after 2025, most of the growth will be for fleets, including heavy-duty fleets in the 2030s. As the figure also shows, much of the initial power will be used

in level 2 chargers (approximately 240 volts) but after 2025, most of the growth will be in DC fast chargers.

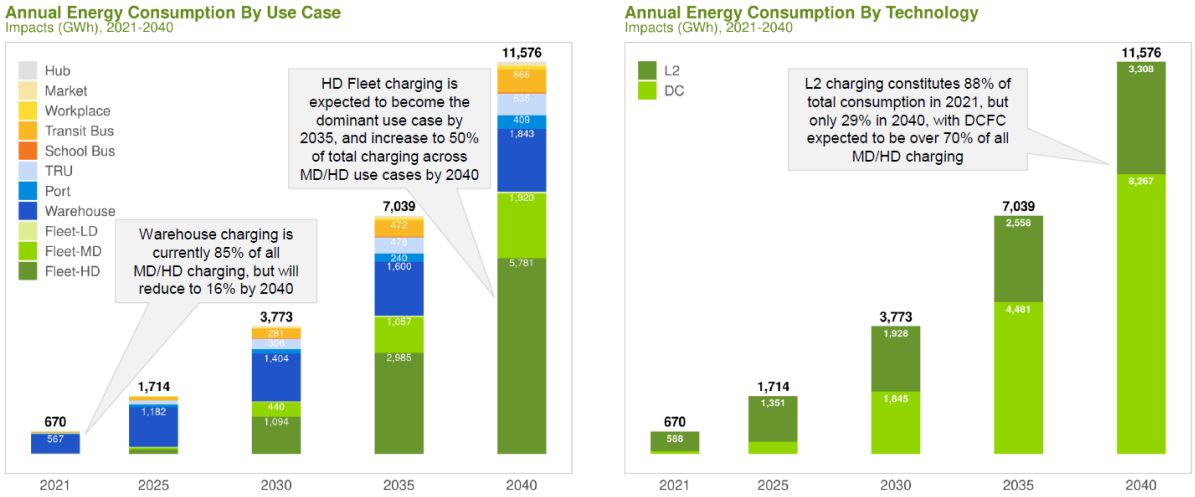

Figure 7. California forecast of energy needed for medium- and heavy-duty vehicles. Source: Guidehouse 2021.[3]

The Guidehouse report also examined the load shape of this power demand; it estimates that current truck power demand is relatively even throughout the day, but over time much of the load will shift to evenings and night as fleets plug in at the end of the workday (see figure 8). Although power availability is generally good overnight, EV trucks and buses will contribute to evening peaks unless this charging load can be shifted to later in the night.

[3] This figure was prepared by Guidehouse, Inc. for the sole use and benefit of, and pursuant to a client relationship exclusively with, CalETC and the California Municipal Utilities Association, which included preparation of the report we cite. Guidehouse is not responsible for our use of, or reliance upon, the figure.

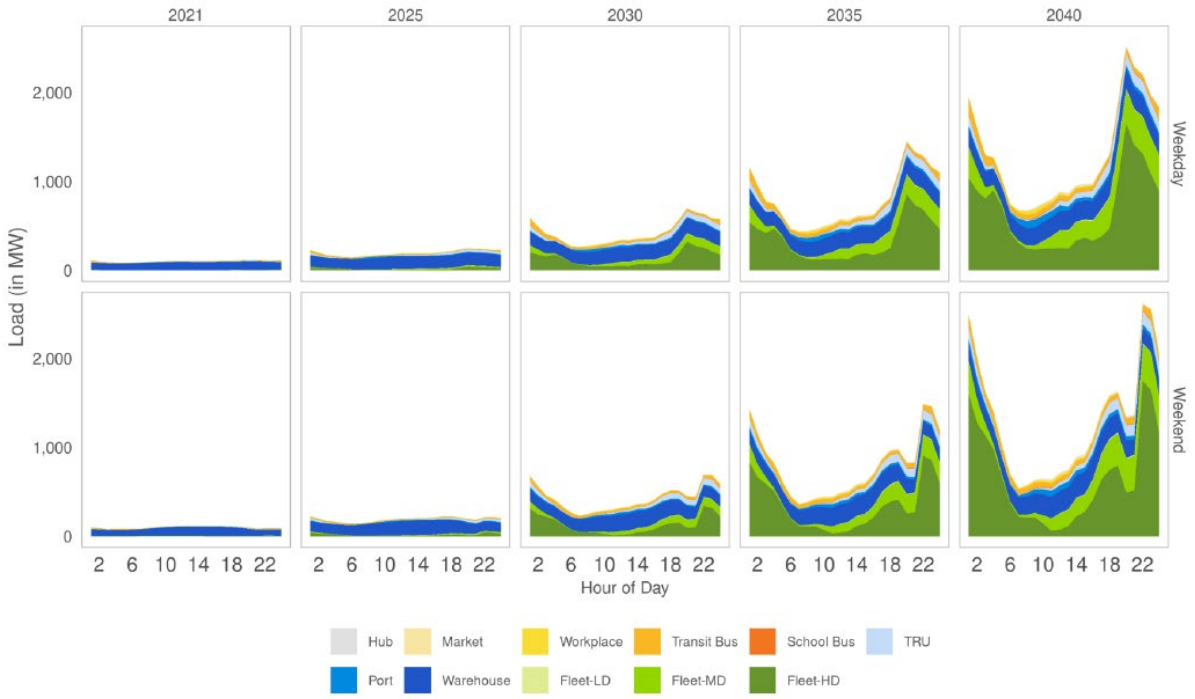

Figure 8. California forecast of power needs for medium- and heavy-duty vehicles. Source: Guidehouse 2021.[4]

Elsewhere in the United States

Some truck charging will be needed in many if not most locations, but charging will be particularly needed in areas with high demand for truck services (e.g., cities) and along major trucking routes. ICCT recently conducted a county-level analysis to identify locations with high needs for electricity to charge medium- and heavy-duty trucks. Figure 9 summarizes the results. Key areas with substantial electric loads from trucks include the California to Texas corridor, Florida, the West Coast, and the Northeast, as well as key nodes such as Chicago and Salt Lake City.

[4] See footnote 3.

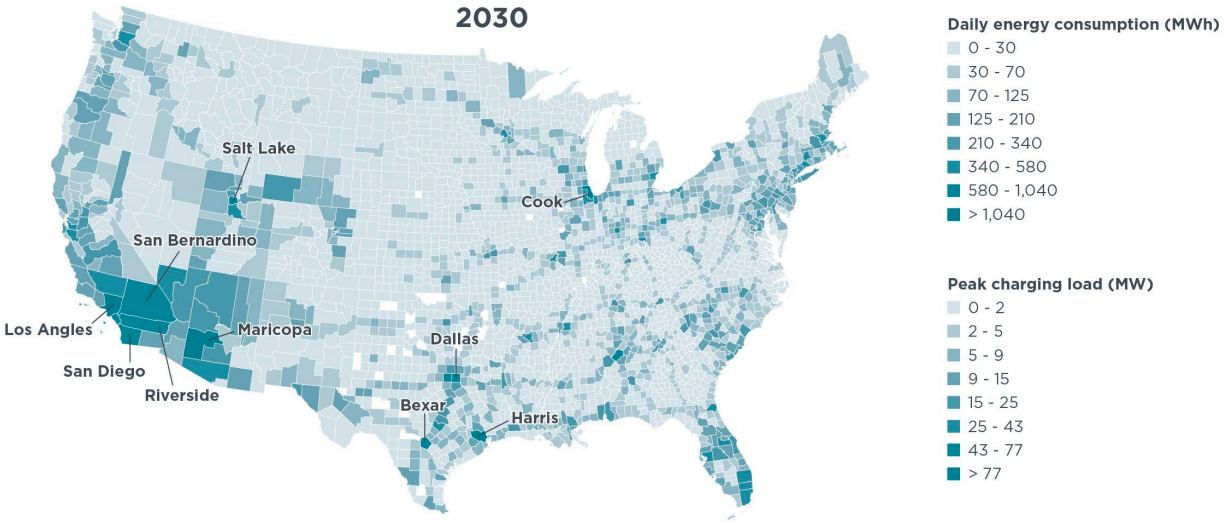

Figure 9. Projected county-level electric truck energy consumption in 2030. The 10 counties with the highest consumption are labeled. Source: Ragon et al. 2023.

Case Studies

In the following sections, we first discuss several states with statewide proceedings and multiple utilities (California, New York, Massachusetts, and Illinois). We then discuss two individual utilities (Portland General Electric and Xcel Energy).

CALIFORNIA: LEADING THE WAY

In the United States, California utilities have been leading the way on this issue. State agencies and a state-wide effort, CalSTART, have been funding demonstration projects and vehicle and charger purchases for several years.[5] As noted earlier, CARB has mandated that starting in 2035–2042 (depending on vehicle type) manufacturers can sell only zero-emission medium- and heavy-duty vehicles. Not counting the latest 2023 regulation, by 2035, more than 300,000 trucks will be zero-emission vehicles (Guidehouse 2021). California utilities operate programs that work with fleet owners to install the necessary infrastructure for electric vehicle fleets, as we now describe.

Southern California Edison[6]

Southern California Edison (SCE) is an investor-owned utility that serves much of the Los Angeles basin and points north, south, and east. It operates the Charge Ready Transport (CRT) program for medium- and heavy-duty fleets. Typically, when customers request new or

[5] CalSTART has since expanded its activities to include work in some other states and nationally.

[6] Personal communications with Justin Bardin, senior manager, eMobility Program, SCE (January 2022) and with James Hanggi (July 2023).

upgraded service from the utility, fees are associated with the new upgrade. Through CRT, the utility generally pays these costs for qualifying participants, and in some cases it will pay up to half the cost of chargers; the customer is responsible for the other half and for charger installation costs (managed charging is encouraged). The program presently consists of four sub-programs:[7]

1. *Turn-Key Installation Program*. For multifamily properties in designated disadvantaged communities, SCE will leverage program funds to design, install, operate, and maintain the EV charging stations at no additional cost to program participants. Participants must pay for the electricity.
2. *Charging Infrastructure and Rebate Program*. This program funds the utility and customer costs of the distribution infrastructure upgrades and provides rebates for the purchase and installation of qualifying charging equipment.
3. *New Construction Rebate Program*. This rebate-only program for multifamily buildings helps to offset the costs associated with the purchase and installation of EV charging equipment at properties that must comply with CALGreen code requirements.
4. *Small Site Rebate Program*. This program serves multifamily, public sector, and commercial property owners and managers choosing to install four or fewer EV charging station ports. It offers a rebate for any participant who designs, purchases, and installs the customer side of the meter infrastructure work.

Sites procuring at least two electric vehicles are eligible for these programs, but more vehicles are often needed for the economics to make sense for the utility. One way to do this is to develop and implement a phased plan, with some components sized for future planned growth and other components added as needed. SCE notes that most fleets it works with are so far choosing to electrify only a modest portion of their fleet (e.g., 10%). CRT has 132 commitments (signed contracts) so far. Utility "make-ready" upgrades have been completed for 50 sites to support 1,039 medium- and heavy-duty EVs. An additional 65 customer applications are now being evaluated. The 197 contracts and pending applications could serve more than 4,000 electric trucks and buses. CRT has a five-year goal of 870 sites, with an average of 10 chargers per site. The utility notes that one charger can usually serve several vehicles and that cycling of charging, some storage, and other load management techniques can potentially reduce capacity needs depending on a customer's level of resiliency risk. It has also found that some customers initially think they will need high-power draw chargers but upon examination find that lower power levels (e.g., <50 kW) will serve the need. SCE is targeting more than one vehicle per charger, if suitable for a customer's

[7] Further details can be found at www.sce.com/evbusiness/chargeready.

operations, and is striving for at least 40% of the sites to be in low- and moderate-income communities (J. Hanggi, senior communications advisor, SCE, pers. comm., July 2023).

As part of the CRT program, SCE asks customers about their electric vehicle plans for the next 10 years and incorporates this information in a database. California transit agencies are now doing the planning to meet a CARB Innovative Clean Transportation regulation that mandates 100% zero-emission buses by 2040 (generally electric or fuel cell); utilities are talking with the agencies and their consultants as part of this process. When SCE gets requests for charger connections outside the CRT program, it also asks about future plans and logs this information. These plans in turn are inputs considered in distribution system planning.

So far, the utility is generally finding that grid capacity is adequate in the short term to serve charging needs, but that upgrade needs will likely grow in the medium term (e.g., 7–10 years out) as fleets steadily electrify. For now, it can generally manage grid needs with good planning (e.g., school buses can typically be charged overnight and do not need fast chargers), load management techniques, and some battery storage to address peak needs. However, in areas around the ports of Los Angeles and Long Beach, where many fleets are located, electric trucks and buses are already being factored into grid upgrade plans. Conversion to electric vehicles is expected to help improve the known air quality problems around the ports. SCE anticipates phased grid upgrades in quite a few additional areas as it approaches 2030.

Pacific Gas & Electric (PG&E)

PG&E serves the San Francisco area as well as large parts of northern and central California. The utility's fleet program began in 2019 and is similar to SCE's program. The PG&E program helps pay for make-ready investments on both the utility and customer side of the meter and requires customers to procure a minimum of two medium-/heavy-duty electric vehicles. It has a slightly different procedure—the Rule 29 process—for any nonresidential EV charging that does not qualify for the fleet program. The Rule 29 process covers only utility make-ready investments. Although participation in the PG&E programs slowed during the COVID pandemic as businesses focused on pandemic-related disruptions, participation picked up again in 2022 as businesses recovered and more EV models became available. Future acceleration is expected, driven in part by California's ACF rule. A recent evaluation of PG&E's fleet program reports 158 contracts, 3,050 planned vehicle purchases, and 46 sites constructed, of which 42 were completed and energized as of December 31, 2022 (Cadmus and Energetics 2023).

PG&E has found that about half of the projects involve fewer than 10 vehicles, and only five projects so far have involved more than 50 vehicles. Its findings also show that most customers struggle with engaging engineers and contractors; as a result, projects can often take several years. More technical assistance could be helpful. The projects also vary a lot in cost, and for projects with high costs on the customer side of the meter, the incentives cover only a small portion of the overall cost. Customized incentives, as opposed to fixed

incentives, may be worth considering (K. Pech, program manager EV Fleets program, PG&E, pers. comm., July 2023).

PG&E is also undertaking extensive work to understand and incorporate fleet loads into its forecast. It purchased detailed data on fleets to understand current vehicles and also uses census tract data compiled by CARB and a statewide EV forecast compiled by the California Energy Commission. PG&E surveys fleet owners and is participating in a statewide planning assessment on freight movement in six key freight corridors. The utility incorporates all of this information into a geospatial forecasting tool that in turn informs its annual distribution plan and grid needs assessment. This annual effort focuses out to needs in the next 10–12 years, and it will file its next plan in September 2023. PG&E anticipates that fleet needs will drive some needed upgrades in the plan. For example, it has already received several requests for at least 10 MW of new service. Typically, this will be provided in phases as actual needs and feasible construction schedules align (N. Morelli, strategic analyst – decarbonization strategies, PG&E, pers. comm., July 2023).

The California Public Utilities Commission now has a docket open on preparing the electric grid for widespread electrification. That docket includes the Kevala (2023) study discussed earlier, which estimated a need for grid investments of $50 billion by 2035.

NEW YORK STATE

In New York State, utilities are now running full-scale light-duty make-ready programs and pilot medium- and heavy-duty programs. A New York Public Service Commission (NYPSC) proceeding is also examining barriers to medium- and heavy-duty vehicle infrastructure, including full-scale programs, and incorporating these vehicles into grid planning. The state has a clean school bus mandate that requires all new school bus purchases to be zero emission starting in 2027 and all school buses in operation to be zero emission by 2035 (NYSERDA 2023a). The state has also adopted the California ACT clean vehicle standards for medium- and heavy-duty vehicles. In addition, the Metropolitan Transit Authority, which operates subways and buses in New York City, has committed to using only zero-emission buses by 2040 (MTA 2022).

Here, we briefly profile pilot programs from the state's two largest utilities—Consolidated Edison (Con Ed), serving New York City and suburbs to the north, and National Grid, serving much of the area from Buffalo to Albany.

National Grid offers free fleet studies. In New York State, the fleet assessment services program is available to all customers and includes a site feasibility study and rate analyses. The state also has a medium- and heavy-duty vehicle pilot program to support make-ready infrastructure, though the program has eligibility guidelines on who it can fund (e.g., only participants in a state-funded vehicle rebate program) and what it can fund (only investments on the utility side of the meter). These guidelines have led to more than 90 studies, of which more than 80 are for school districts getting ready for the 2027 requirement that new school bus purchases be zero emissions. However, not many of these

studies have yet led to investments. This is because of the substantial investments needed on the customer side of the meter and the requirement to receive state vehicle rebates before a make-ready project can be approved. The NYPSC is now considering changes to the program to allow rebates on the customer side of the meter and on projects that do not participate in the state rebate program (R. Wheeler, Clean Transportation – Fleet Electrification program, National Grid, pers. comm., July 2023).

Con Ed has had a robust light-duty vehicle make-ready program with thousands of installations. For fleets, it offers fleet advisory services including site selection support, an EV cost calculation tool that includes information on rate options, and conversations about how the process works to install chargers and associated infrastructure. Con Ed also provides information and, in some cases, assistance for customers applying for state and New York City vehicle incentives and for EPA school bus grants. It has a pilot medium- and heavy-duty make-ready program that funds improvements on the utility side of the meter. Without any customer-side funding, uptake has been slow, with only one program participant so far (B. Reichborn-Kjennerud, director, E-Mobility, Con Ed, pers. comm., June 2023). Con Ed also undertook a pilot vehicle-to-grid (VTG) school bus pilot that found that VTG can work, but that it currently requires skilled staff to address technical issues and may shorten battery life (Con Edison 2022).

Both Con Ed and National Grid are actively considering how fleet vehicles will affect grid needs on the distribution and transmission systems. Con Ed has identified a nearly two-mile stretch of road along which more than 20 vehicle fleets are based. In a preliminary analysis, it estimates that by 2036, 56 MW of capacity will be needed to serve this load. The utility had been planning to update that area's substation in 2032 but based on its study of the area, it is now estimating that the upgrade will need to be completed by 2029 (Con Edison 2023). More broadly, Con Ed is conducting a more detailed bottom-up study of its entire service area, studying where vehicles park and may charge, in order to identify future "hot spots" for charging that can trigger grid upgrade needs at all levels in the system, from primary feeders up through transmission. This will be used to identify near-term "no-regrets" grid investment proposals as well as options for the longer term. Con Ed prepares 20-year distribution plans that are updated annually (B. Reichborn-Kjennerud, director, E-Mobility, Con Ed, pers. comm., June 2023).

National Grid is now working with a consultant to gather and analyze information on current fleets in its service area. It is also talking to many of these customers about their electrification plans and is advising customers on where capacity for substantial charger loads is available. They are also partnering with many school districts to apply for the funding under the EPA Clean School Bus program. The utility has identified clusters of fleets outside Buffalo and Syracuse that each may need 10's of MW of capacity (R. Wheeler, Clean Transportation – Fleet Electrification program, National Grid, pers. comm., July 2023).

The NYPSC medium-/heavy-duty vehicle docket is looking at both programs and the need to plan more proactively for transportation grid needs, rather than the current practice of just-in-time planning. New York state utilities filed joint comments making two major

suggestions: (1) that "compelling incentives" be offered through a full-scale make-ready program to accelerate the current limited market progress; and (2) that a proactive grid planning process be put in place "so utilities are ready to serve customer electrification loads in advance of requests for customer capacity" (Joint Utilities 2023).

Three recent studies on New York State are also worth mentioning, one by Synapse Resource Economics and the other two by National Grid and various partners. The Synapse (Metz et al. 2023) study found that utility investments in truck infrastructure can ultimately benefit all electric ratepayers as the income from electricity sales for trucks more than offsets the cost of investing in this infrastructure. The first National Grid study, conducted with Hitachi ABB, looked at the grid impacts of electric fleets on 19 distribution feeders that all served a substantial number of fleets. The study found that of the 19 feeders, 13 would eventually need to be upgraded when nearby fleets fully electrify. The study noted that on some feeders, upgrades will be needed before full electrification, especially when electrification of light-duty vehicles and space heating loads are considered. However, it also found that different charging strategies can reduce the magnitude and duration of peak loads, and thus that charging management needs to be an important part of future efforts (National Grid and Hitachi Energy 2021). The second National Grid study was mentioned earlier and looked at highway truck stop charging needs in the utility's New York and Massachusetts service areas. As we noted earlier, the study found that by 2045 many of the 71 highway truck stop sites examined will require at least 5 MW of power, and a few might need as much as 40 MW (Katsh et al. 2022). National Grid believes that distribution upgrade costs can be significantly reduced if grid upgrades for an entire corridor are planned as a system rather than done piecemeal.

MASSACHUSETTS

Massachusetts is also undertaking initial programs and recently began a grid modernization process overseen by a new Grid Modernization Council.

The state's two largest utilities are Eversource (serving Boston, Cape Cod, Western Massachusetts, and some Boston suburbs) and National Grid (serving areas around Boston and Central Massachusetts).

In Massachusetts, National Grid has approval to offer fleet studies to 100 public-sector customers; it has completed 78 of these studies and an additional 17 are underway. Several of these customers have already purchased EVs. So far, more than 75% of the studies have been for fleets located in low- and moderate-income communities. The health benefits to these communities have been a key selling point of the program to both regulators and customers. They have recently received approval to expand the program to serve more customers, bringing the total number of assessments for public fleets up to 275. This expanded program is set to expand in Fall 2023. National Grid also offers a comprehensive fleet infrastructure incentive program, which offers approximately $30 million of make-ready infrastructure incentives for fleets of all types (including grid-side and customer-side infrastructure). In addition to the make-ready infrastructure, the program will be launching

an off-peak rebate program, for 1,000 fleet vehicles to receive discounts for off-peak charging, and a demand charge rebate offering, which provides a demand charge holiday for the first year, and a discount for the following 9 years for any charging ports that have a load factor below 15%. All of these programs are currently accepting customers, and many fleets are already participating.

Eversource has operated make-ready programs in Massachusetts since 2018, focusing on public chargers. In 2023, it expanded the program to add some fleet services, including starting up a fleet advisory service, covering 100% of make-ready costs on the utility side of the meter, and covering average costs or actual costs (whichever are lower) on the customer side of the meter. In addition, Eversource offers rebates for chargers for public-sector fleets. Most of its activity is on light-duty vehicle fleets, but a small portion of the project budget has been set aside for medium- and heavy-duty fleets. A complementary program for private fleets is offered by the Massachusetts Clean Energy Center, an economic development agency dedicated to accelerating the growth of the clean energy sector across Massachusetts. Eversource also operates a simpler make-ready program in Connecticut (S. Tully, manager – electric mobility, Eversource, pers. comm., July 2023).

Eversource is an emerging leader in forecasting loads for fleet vehicles. It has established partnerships with large truck and original equipment manufacturers to gather GPS data on existing vehicle routes and refueling locations. It also compiles data on strategic accounts, which lets it estimate where electric charging loads will be. It then categorizes each load as forecasted (potential), uncertain, possible, probable, and certain. The latter two categories are projects that it includes in its 2–5-year planning forecasts and that it incorporated in its Electric Sector Modernization Plan, which was filed in early September 2023. This plan projects a 20% increase in electric demand over the next ten years and a more than doubling by 2050, driven by electrification of heating loads, electrification of vehicles, and normal load growth. Over the next five years this plan includes ten substation upgrades and five new substations to serve this load (Eversource 2023).

In Massachusetts, a 2022 law (House Bill 5060) established the Grid Modernization Advisory Council (GMAC) which will review and provide recommendations on electric-sector modernization plans filed by the Commonwealth's utilities. Utility filings in September 2023 will be reviewed by the GMAC, which will then make a recommendation to the Department of Public Utilities (the regulatory agency).

Two other studies are worth noting. First, Quanta and Scania are studying electrification in the Port of Boston. They estimate that substantial new electrification load could be added at the port. Second, the Electric Power Research Institute is conducting a study on the total cost of distribution upgrades in the state, assuming extensive electrification. As of this writing, neither of these studies have been published.

ILLINOIS AND COMMONWEALTH EDISON

In Illinois, the 2021 Clean Energy Jobs Act required the Illinois Commerce Commission (ICC; the state utility regulator) to oversee and the state's utilities to develop "beneficial electrification" plans, including plans to address fleets. The ICC hosted a series of workshops to provide input into these plans. Two of the workshops focused on fleets: one on fleets overall, and the second on public transit and school bus fleets. Material presented at the workshops emphasized how each fleet has unique needs and requirements and that a substantial portion of fleets are located in or near low- and moderate-income communities. Thus, fleet electrification can be an important step in reducing diesel emissions in these communities and thereby in improving community health. While some fleets are large, many are small. Workshop presentations discussed the need to educate fleet decision makers about electric vehicles; good initial markets for electric fleet vehicles, including drayage (hauling freight around ports, rail yards, and trucking terminals), delivery vehicles, and medium-duty trucks); and recommendations for utility efforts such as fleet planning services, total cost of ownership analyses, preliminary site assessments, early engagement on grid capacity issues, and planning, incentive, and various rate design issues.[8]

Based on this input, the state's utilities filed initial plans in July 2022 and more detailed compliance filings in May 2023. The ICC reviewed these plans and approved the modified plans in May 2023.

Commonwealth Edison (Com Ed) serves the greater Chicago area and is the largest utility in Illinois by load served, serving about 70% of the state's population. Com Ed was already exploring fleet electrification issues. It held a workshop on electric vehicles for fleet managers, conducted a few pilot analyses for fleets on total cost of ownership, and has been gathering information on its large customers' electric vehicle plans through regular discussions between these customers and Com Ed customer service representatives.

Com Ed's Beneficial Electrification plan (Com Ed 2023a, 2023b) focuses on community and public health benefits, including prioritizing investments for low-income customers and in environmental justice communities. The plan includes $24 million over three years for residential programs; $124 million over three years year for commercial, industrial, and public-sector programs (C&I plan); $18 million over three years for customer education and awareness programs; and $15 million for pilot programs. In terms of its funding, the C&I plan allocates (approximately) the following:

[8] Material from the workshops is available at www.icc.illinois.gov/informal-processes/beneficial-electrification-workshops-2021-2022.

- Three-quarters of funds to support vehicle purchase rebates, including rebates of $5,000–75,000 for fleet vehicles, $120,000–180,000 for school buses, and $80,000–120,000 for transit buses.
- About 15% of funds to support charging infrastructure rebates for businesses and public facilities in or serving environmental justice communities.
- More limited funds for rebates for electric building and industrial process technologies and to support infrastructure readiness for building and forklift electrification.

In conjunction with its plan, Com Ed will implement an optional rate class designed to help customers avoid high upfront costs for charger installation and to provide an alternative to the default demand-based rate structure.

Com Ed files grid investment plans periodically with the ICC. Its most recent multiyear plan is now pending before the state utility commission and includes specific proposed grid enhancements to enable customers to electrify their homes, businesses, and vehicles (Com Ed 2023c).

PORTLAND GENERAL ELECTRIC

Portland General Electric (PGE) serves Portland, Oregon, and its surrounding communities. PGE began a three-year Fleet Partner program in July 2021. Through customer inquiries and utility outreach, the program engages customers to consider purchasing EVs and associated infrastructure. Once a customer expresses interest, PGE will prepare a preliminary no-cost fleet study for a customer site. This free study includes electric vehicle feasibility assessment, charging analysis, fuel cost and clean fuel credit analysis, site assessment, and preliminary designs and cost estimates. Based on the plan, customers might commit to the build phase, in which PGE will provide turnkey final design and construction of make-ready infrastructure; a custom Make-Ready Incentive based on the forecasted energy use of the chargers (up to $750,000); and PGE ownership and maintenance of make-ready infrastructure for 10 years.[9] For projects above $15,000, customers make a deposit and must install at least one qualified Level 2 or DC fast charger within six months. Early experience showed that many customers were slow to advance from the feasibility study to the build phase. But projects picked up in late 2022 and, as of January 2023, the Fleet Partner Build funding has been fully reserved (PGE 2023b).

PGE has also been working to incorporate fleets into its grid planning. PGE's Clean Energy Plan and Integrated Resource Plan 2023 included high, medium, and low forecasts of transportation electrification loads and related demand response programs (PGE 2023a). And its 2022 Distribution System Plan highlights how it utilized a distributed energy resource

[9] This is a tariffed program, and variations are not permitted.

(DER) and transportation electrification (TE) forecasting and adoption tool for location-based planning that "combines detailed accounting of our customer base, technology performance features and costs, and public policy drivers in order to forecast DER and TE load and adoption at the customer site-level." The distribution plan notes that:

> [A]s of May 2022, we have 7.7 MW (nameplate) of connected charging load requests at various stages in our Fleet Partner program application process. These requests are cumulative across the service territory and stem from 27 distinct customers aiming to add over 650 electric vehicles (EVs) over the next five years. The load additions are spread across 33 different feeders and average 311 kW per site.

The plan includes a variety of future substation improvements and grid needs. So far, however, these projects were not isolated to identify any that were triggered specifically by new fleet loads, a situation that PGE is expecting to change in the future (PGE 2022).

XCEL ENERGY

Xcel Energy is a major U.S. regulated electric and natural gas delivery company that serves approximately 3.7 million electricity and 2.1 million natural gas customers across parts of eight Midwestern and Western states; it is the largest utility in Colorado and Minnesota. The company operates programs supporting fleet electrification in four states: Colorado, Minnesota, New Mexico, and Wisconsin.

Xcel Energy's fleet programs are similar in Colorado and Minnesota. The fleet programs include three main components: advisory services, infrastructure support (e.g., make-ready investments from the grid to the charger), and optimization resources (including rebates and opt-in rate designs). Rebates are for chargers (particularly for multifamily buildings) and potentially in the future for school buses. Advisory services are centered on the Fleet Electrification Advisory Program, which works with customers to complete a comprehensive assessment to help determine the best course of action for electrification, including charging site suitability and projected cost of the infrastructure. The Fleet EV Service Pilot in Minnesota is available to organizations in the public sector and nonprofit organizations. In Colorado, however, eligibility expands to the private sector. Xcel Energy also provides optional Level 2 charging solutions that they will install and maintain in addition to the infrastructure support; these investments are added to the rate base (T. Santori, senior EV product manager, Xcel Energy, pers. comm., August 2023). This last component has been controversial as it competes with other charging providers and faces other concerns (Walton 2023).

In both Colorado and Minnesota, Xcel Energy has submitted three-year Transportation Electrification Plans to each state's utility regulatory commission. A 2024–2026 plan for Colorado is now pending and a new proposed plan for Minnesota will be submitted in fall 2023. For Colorado, the commercial part of the proposed plan (which will serve medium and heavy vehicles) anticipates about 3,300 program participants and has a proposed three-year budget of $109 million with the biggest portions going toward EV supply infrastructure ($28

million), staffing and program administration ($16 million), and grid upgrades ($50 million). This last provision is for "no regrets" investments in distribution grid reinforcement, where capacity is already limited, allowing Xcel to be proactive and serve expected loads. As with Eversource and PG&E (discussed above), this planning will involve spatial forecasts (Xcel Energy 2023).

Discussion

As these case studies show, when utilities and states are proactive in educating fleet owners on and assisting them with electric vehicles, substantial uptake can happen—as illustrated by the approximately 8,000 trucks and buses that SCE and PG&E are assisting with (aided by state policies and incentives). As this education and assistance occurs, attention must be paid to serving more than one vehicle per charger and to considering the power level needed. Customers should be encouraged to share their EV plans for future years so that utilities can log these data to assist with distribution planning.

As Con Ed and National Grid have found, fleets are often grouped together, and these local areas will often need distribution system upgrades by the time fleets fully electrify. Often, these fleet-intensive areas are in low- and moderate-income communities that will benefit from reduced diesel emissions as vehicles are electrified. Other growing electric loads, such as for light-duty vehicles and heat pumps, will contribute to the need for distribution system upgrades.

Utilities should work with fleet owners to understand their vehicle electrification plans so that the utilities can plan to have adequate power available when needed. As Eversource, Con Ed, and PG&E are doing, utilities can purchase, analyze, and map data on fleet operations so that they can better understand geospatial power needs. Since many fleet owners do not yet know their plans, utilities have to plan for uncertainty, but they can reduce this uncertainty by regularly talking with their fleet owners to stay abreast of the latest information and to spot nascent trends. Given this uncertain and evolving trends, distribution planning analyses will need to occur more frequently for circuits with many fleets. Several utilities that we profile prepare annual updates to their distribution plans. Utilities are also moving away from five-year distribution plans to longer-term efforts that plan further into the future, ranging from 10 to 20 years. Such efforts should consider major trucking corridors together, as there are interrelationships along these corridors and potential economies from systematic planning that can help avoid piecemeal upgrades (Katsh et al. 2022). As we noted earlier, for example, California is preparing a review of six major freight corridors.

Fleet vehicle power needs are poised for rapid growth. We talked with a representative of one utility in late 2021 and again in mid-2023. During the first call, the representative thought that extensive power needs would not arise until nearly 2030. When reminded of that statement 1.5 years later, the person said that they are now playing catch-up and wished they had ramped-up efforts to prepare two years earlier. Leading utilities in California, Colorado, Massachusetts, and New York are now engaging in proactive planning so that power system upgrades are in place when they are needed. Often, as in the Con Ed case, utilities understand

the needs for distribution system upgrades, but as fleet EV procurement efforts accelerate, the date by which such upgrades are needed moves up. Funding for these efforts will be needed, as illustrated by the $50 million budget for "no-regrets" power system investments in Xcel Colorado's proposed Transportation Electrification Plan.

Regulators should encourage utilities to expand distribution planning to consider fleet needs. Plans should look 10–20 years into the future and be updated every year or two. Utilities need to be transparent in their planning and work to educate regulators on recent trends and how these will both affect needed transmission investments and provide air quality benefits as dirty diesel trucks are eliminated from roads. In our view, regular and open discussions between regulators and utilities on these issues would be useful. Such discussions would help grid upgrades to proceed in an orderly way to help meet fleet needs and state decarbonization and environmental justice goals, while also minimizing long-term costs to consumers.

Conclusion

Based on these cases, it appears that fleet electrification is gaining momentum and can have a substantial impact on electric grids. While such grid impacts are typically modest at the moment, hot spots with rapidly growing needs are emerging and must be addressed soon. Broader needs are also likely to increase over time. Fleet owners, electric utilities, and utility regulators must start planning for these impacts now, so that grid improvements can be steadily made as electric fleets grow. Further, fleet and grid planning should happen in parallel, so that grid upgrades do not happen too soon or later than needed. Massachusetts and New York State have promising processes underway that show how to achieve this. Grid impacts can be managed and planned for, but the time to begin this planning is now. In locations where utilities are not planning for fleet loads, regulators should encourage them to begin this planning soon.

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