Fleet Electrification: Challenges and Opportunities Faced by Utilities and Fleet Operators

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Acronyms

BEV	Battery Electric Vehicles
DC	Direct Current
DOE	Department of Energy
DOT	Department of Transportation
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FTA	Federal Transit Administration
GIS	Geographic Information System
ICE	Internal Combustion Engine
IIJA	Infrastructure, Investment and Jobs Act
IOU	Investor-owned utility
ISO	Independent system operator
MHDV	Medium- and Heavy-Duty Vehicles
NEVI	National Electric Vehicle Infrastructure Formula Program
PUC	Public Utility Commission
RTO	Regional transmission operator
SEO	State Energy Office
SEP	State Energy Program

Executive Summary

Over the last decade, electric vehicles have gone from a fringe technology to a mature, cost-competitive, and mainstream alternative to internal combustion engine vehicles. Most of the early gains have occurred in the sphere of light-duty personal vehicles. Medium and heavy-duty commercial electric fleets sit on the edge of entering the mainstream. A number of corporations and government entities have announced plans to electrify their medium and heavy-duty fleets. This transition will have large-scale impacts on an electric grid that is also dealing with the growing challenge of intermittent renewable energy. This report was produced in collaboration with the GridWise Alliance, a membership organization focused on championing the principles, policies, and investments needed to transform the electricity grid into a secure, and modern, foundation of a low carbon future.

This report seeks to answer the overarching question, "What actions and resources are required by utilities to support fleet operators that seek to electrify their fleets?" The focus is on medium and heavy-duty vehicles utilized in logistics, distribution, delivery, and public transit. The fledgling nature of fleet electrification means that many of the challenges, and best practices to counter these challenges, are yet to be identified. This report is composed of findings from interviews with utilities, regulators, fleet operators, and consulting firms who are all stakeholders in the fleet electrification process. Several persistent and overarching problems were identified by the interviewees: more data and information need to be shared between fleet operators and utilities, fleet operators need to engage utilities as early as possible, and the patchwork of state regulations and utilities serves as a barrier for many fleets and utilities—especially those that span multiple states.

Major findings include:

- **Predicting the impact of electrified fleets on local grid infrastructure is a challenge for utilities.** Fleets can have a significant impact on localized grid infrastructure. Best practices include using software to help predict the costs, specific infrastructure upgrades and timeline to service a fleet request. **The entities interviewed identified four areas that investments will need to be made to support fleet electrification**: (1) infrastructure to support increased electricity demand, (2) infrastructure to support resiliency, (3) clean energy generating technologies, and (4) human capital.

- **Fleet operators and utilities agree that early engagement with one another is critical and needs to improve.** Both parties can benefit from charging at off peak times, and two key methods of achieving that are smart chargers and carefully constructed rates. There is also potential for using distributed energy resources and vehicle-to-grid in the future to provide further resiliency to the grid, although these technologies may not be widely adopted by private entities today.

- **The patchwork of state regulations stands as a barrier to broad fleet electrification efforts.** This is particularly true for large fleet operators and utilities that operate in multiple states. Dealing with inconsistent regulations complicates these efforts. **Regulatory structure also significantly impacts the ease of electrification.** States with more forward-thinking regulatory patterns can make it easier for fleet operators to electrify, and make it easier for utilities to meet their needs as quickly and efficiently as possible. **States that allow most or all charging infrastructure to be rate based are more conducive to fleet electrification.**
- **In general, it is too early for fleet operators and utilities to understand the funding they can access in the Infrastructure Investment and Jobs Act.** Many utilities are assessing their qualifications for various parts of the bill. Much of the funding is distributed at the state level, which adds a layer of complexity. Since state offices have not started the disbursement of funds, it is hard for utilities to know their eligibility.
- **The more data fleet operators and utilities can share, the better.** Three factors dictate everything on the grid: load size, load location, and load time. The more a utility knows about the fleet they are servicing, the more likely they will be able to appropriately upgrade and site infrastructure for the demand. In many ways, a general estimate, delivered earlier, is more useful to a utility than highly specific demand estimates delivered later. This is due to the long time frame required to facilitate infrastructure upgrades. Even still, more granular information can be very helpful because although grid supply in demand is in flux, it follows predictable patterns. Carefully planned and timed usage of charging technologies based on this information can dramatically reduce the strain on the grid.

Major recommendations include:

- **Early engagement is essential.** Fleet operators need to reach out as early as possible in the process of bringing charging infrastructure online. Upgrades to grid infrastructure can take months to years to complete. The earlier a fleet can connect with a utility, the more time the utility has to determine what upgrades may be necessary.
- **Fleet operators must share as much information as possible.** The more information a fleet operator can provide about location, fleet size, procurement schedule, vehicle type, charger type, and charging schedule, the better a utility can service a fleet operator's needs. Since the timing of charging can affect what type of upgrades are needed, this data is essential. It allows utilities to build the correct amount of infrastructure or more effectively use existing infrastructure. This increases the pace of electrification and keeps costs down.
- **Utilities must make the process of fleet electrification easier and more transparent.** Utilities need to have fleet electrification specialists on staff, customize fleet service requests, and use fleet-friendly software. These three best practices help fleet operators understand the process and timeline of electrification. Many larger fleet operators have specialized employees on staff to help the fleet reach its electrification goals. Smaller and mid-sized

operators often do not have familiarity with utilities. Utility fleet specialists could help bridge the information gap between fleets and utilities. Software can give fleet operators a clear estimate of the costs and timeline surrounding an electrification request.

- **State legislatures and/or regulators should expand the tools available for utilities to recover fleet electrification costs.** Allowing utilities to rate base all infrastructure up to the charger encourages fleet electrification and can be accomplished in a rate-neutral way. Clearing certain regulatory hurdles to allow utilities to preemptively build capacity for electric fleets can increase the pace and efficiency of electrification while keeping long-term costs low.

I. Introduction

This report focuses on the steps that will need to be taken by utilities in the United States to accommodate the increased demand for electricity and related infrastructure by fleet operators as they transition from conventional fuel to electric fleet vehicles.

Several large fleet operators, including Walmart, Amazon, and DHL in the private sector, and the cities of New York, Los Angeles, and Seattle in the public sector, have stated goals related to fleet electrification, or have already begun electrifying their fleets. Because these fleets are transitioning from conventional fuels, this switch represents an entirely new – and sizable – source of demand for electricity that must be met by the nation's electric utilities.

Electric utilities operate in a highly regulated market, and are permitted to recoup investments only in accordance with the regulation of the state, or states, in which they operate. Given this regulatory environment, as well as the practical aspects of installing utility infrastructure, utilities may require lead times up to three years to accommodate customer requests which may not be consistent with the goals of fleet operators seeking to electrify their fleets, particularly if utilities are not involved early in the process. Further, the differing regulations across states may impact the ability of certain utilities to recoup investments associated with meeting the demands of fleet electrification in a way that is efficient and fair to all parties, including the utilities' broader customer bases. From the fleet operators' perspective, this regulatory patchwork means that companies that operate fleets across multiple states will need to consider the regulations of each state in which they operate, and the procedures of multiple utilities, both of which may impact the extent to which the fleet operator is expected to contribute to the utilities' costs to meet the fleet operators' requests.

As will be highlighted in the following report, the project focuses specifically on fleet electrification, as opposed to the electric vehicle market generally. This focus was chosen because of the outsized impact of fleets - many of which are comprised of medium and heavy-duty vehicles - on issues central to society writ large, including climate change and local air quality. Further, given the size of the vehicle fleets operated by many entities, the decision of even a single large entity to fully electrify their fleet has a significant impact both on these larger societal issues and on the electric demand utilities must serve.

Utilities have been in the business of meeting new electricity demands for their customers since their inception. Even so, as detailed in this report, meeting the demands of fleet electrification is an emerging issue that presents unique challenges that many utilities are just beginning to tackle. This report aims to paint a picture of how utilities are considering these issues, and how the regulatory landscape in which they operate impacts these decisions. Given the "laboratory" effect of the different environments in which utilities (and fleets) operate, the report seeks to highlight various approaches to fleet electrification from the perspective of utilities. The report also will offer insights applicable to fleet operators considering fleet electrification, geared toward ensuring fleet operators can reach their electrification goals as cost-effectively as possible.

The report is based on 18 semi-structured interviews, the majority of which (11) were with representatives from utility companies. All interviewees from the utility sector were employed by member organizations in the GridWise Alliance. Utilities were selected to provide variety in geographic location, ownership structure, and size. In addition to interviewees from the utility sector, interviews were conducted with two state energy commissions, one state public utility commission, two consulting firms active in the fleet electrification space, the World Resources Institute, which is spearheading a nationwide effort to promote school bus electrification, and Walmart, a nationwide retailer which operates the largest private truck fleet in North America, and has stated a goal of reaching zero fleet emissions by 2040.

The report is framed by an overarching research puzzle, with specific research questions that explore relevant sub-issues within the broader research puzzle, as outlined below.

Research Puzzle

What actions and resources are required by utilities to support fleet operators that seek to electrify their fleets?

Research Questions

1. To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
3. To what extent do current mechanisms allow utilities to rate base these investments?
4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
5. What broader lessons can be learned from the needs of private entities seeking to electrify their fleets that are applicable to other entities that may seek to electrify their fleets in the future?

II. Background and Literature Review

Section II will review existing literature relevant to this report and will provide background information necessary to understand concepts in the following sections. This section will detail the opportunity provided by fleet electrification to mitigate climate change and local air pollution and will describe the current state of technology available to fleet operators and the economics of deploying that technology versus conventional fuels. Additionally, this section will provide an overview of the electric grid system in the United States generally, and the state and federal regulatory environment that utilities operate within. Lastly, this section will highlight the provisions related to electric vehicles and electric vehicle charging stations in the Infrastructure Investment and Jobs Act, which provides a significant source of funding to support transportation electrification.

A. Climate Change and the Opportunity Provided by Fleet Electrification

Society's opportunity to hold global warming to 1.5ºC, while still technically feasible, is effectively gone. (IPCC, 2022). Global annual greenhouse gas emissions, instead of decreasing as would be required to limit warming, continue to increase. From 2010 to 2019, global greenhouse gas emissions averaged about 56 $GtCO_2$-eq, more than 9 $GtCO_2$-eq higher than average emissions from 2000-to 2009.[1] This increase represents the highest increase in average emissions from one decade to the next on record.

While global warming over 1.5ºC will have severe consequences, particularly for the countries most vulnerable to climate change, the worst impacts of climate change can still be avoided if greenhouse gas emissions are reduced quickly. To have a two-thirds chance of limiting global warming to below 2ºC, annual global greenhouse gas emissions will need to be reduced by a rate of 0-.7 $GtCO_2$-eq per year from 2020 to 2030, and 1.4-2 $GtCO_2$-eq from 2030-2050 (IPCC, 2022).

However, finding ways to achieve emissions reductions at the scale necessary has proven to be a vexing problem. In the United States, the transportation sector accounts for more greenhouse gas emissions than any other sector, at 29 percent, and 35 percent of all carbon dioxide emissions. (U.S. Environmental Protection Agency, 2022; Nadel, 2021). Although the vast majority of vehicles on the road in absolute terms are privately-owned light-duty passenger vehicles, fleet trucks and buses have an outsized impact on emissions. In the United States, freight trucks and buses account for less than 5 percent of all vehicles on the road, yet they account for over 10 percent of all vehicle miles driven, 26 percent of all conventional fuel use, and 29 percent of all carbon dioxide emitted from vehicles. (Nadel, 2021). In total, medium and heavy-duty vehicles emit over 456 million tons of carbon dioxide annually. (Congressional Research Service, 2022). Taking into account the current energy generation mix, converting all medium and heavy-duty fleet vehicles to zero-emission vehicles in the United States would reduce greenhouse gas emissions by 224 million metric tons annually by 2040, or nearly 4.3 percent of all domestic greenhouse gas emissions (Environmental Defense Fund, 2021; U.S. Environmental Protection Agency GHG Inventory).[2]

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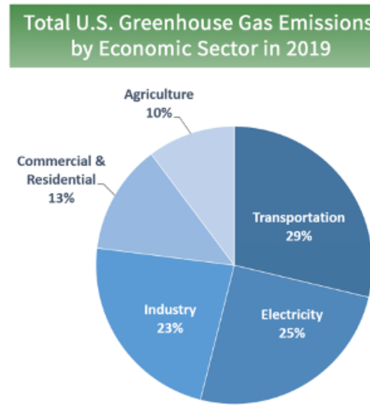
[1] Gt-CO_2eq is an abbreviation for gigatons of carbon dioxide equivalent, which measures greenhouse gas emissions of carbon dioxide and other greenhouse gasses by their equivalent relative to the warming capacity of CO_2.

[2] This figure takes into account sequestration from the land sector, thus reducing the denominator of the ratio; excluding land use sequestration yields a figure of 3.4 percent.

Figure 1: Total U.S. GHG Emissions by Economic Sector in 2019



Source: EPA, 2022

These figures, coupled with the rapidly improving business case for EV fleet vehicles (discussed in Section IV B) and the potential for rapid uptake of EV fleets by well-resourced business entities, suggest that fleet electrification represents a prime opportunity to reduce domestic greenhouse gas emissions on the time-scale required to limit global warming below 2ºC. (National Grid, 2021).

Local Air Pollution

In addition to the outsized impact of fleet vehicles on the global atmosphere, fleet vehicles also contribute significantly to the problem of local air pollution. Medium and heavy-duty fleet vehicles emit over 32 percent of all nitrogen oxides ("NO_x") from the transportation sector, which contribute to the formation of ground-level ozone and other local air quality impacts (Lowell, 2021). NO_x and particulate matter ("PM") emissions from medium and heavy-duty vehicle emissions are estimated to cause 2.7 million cases of lost or restricted work days annually, 4,290 hospital visits, and 4,550 premature deaths every year. In total, the costs of these impacts are estimated to exceed $53 billion annually. (Lowell, 2021).

The concentration of local air pollution also presents troubling environmental justice concerns. Populations that live closest to major roads and highways, ports, depots, distribution centers, and other locations with significant fleet vehicle traffic bear the greatest environmental harm from these pollutants. For example, in Oakland, California, Interstate-880, which allows truck traffic, was estimated to have air pollution levels more than double that of Interstate-580, a comparable highway in the same city that prohibits truck traffic. (Environmental Defense Fund, March, 2021). On average in the United States, Asian and Black Americans face exposure to PM at rates 56 and 44 percent higher than white populations, respectively. (Environmental Defense Fund, 2021).

Further, individuals who ride on buses – disproportionately people of lower-income, people of color, and school children – are at significantly increased risk of exposure to these pollutants through tailpipe emissions. (Environmental Defense Fund, March, 2021).

Thus, fleet electrification offers the potential to significantly improve two of society's most pressing problems – climate change and local air pollution, particularly given the readiness of the current technology and the strong economic case for fleet electrification, discussed in more detail in the next section.

B. Information on Electrification of the Transportation Sector

This section will examine the current state of the business case for fleet electrification, including the current state of applicable technology, the upfront costs to fleet operators of going electric, and a comparison of electric fleet costs versus conventional fuels.

Current State of Applicable Technology

Charging Levels & Vehicle Class

There are a variety of weight classes of battery-electric medium-and-heavy duty vehicles (MHDV) in the market. Each weight class has different charging needs based on the vehicle and battery size, usage schedule, and application of the vehicle. The two charging methods that are available are Level 2 chargers, which charge within 9-15 hours (depending on battery capacity), and Direct Current (DC) fast chargers, which can charge most vehicles within 1-2 hours (Parks, 2021).

MHDV like school buses, some delivery fleets, and utility trucks that have long periods of downtime between cycles can benefit from Level 2 charging. Vehicles with less idle time such as long-haul tractor-trailers and delivery fleets in constant usage would most likely require Level 3 DC fast charging.

Model Availability

Several manufacturers plan to deploy medium-and heavy-duty EVs in the coming years. According to CALSTART's Zero-Emission Technology Inventory (2021), the North American market will have 54 different manufacturers offering more than 100 models by 2022. According to the Department of Energy (2021) database of alternative fuel vehicles, most battery-electric vehicles' ("BEVs") driving ranges are between 75 to 240 miles. These ranges are sufficient for fleets that travel shorter distances like school buses, and delivery vehicles, but may not suffice for tractor-trailers that travel longer distances. The vehicle range allowed by current technology, however, is improving. Electric truck models with longer ranges of 500 miles are scheduled to enter the market within the next year (Nadel, 2021). Vehicles with ranges above 500 miles will most likely be capable of completing longer haul trips.

Economics of Fleet Electrification

Upfront Cost

Battery-powered light and medium-and-heavy duty vehicle classes currently cost more upfront than their internal combustion engine counterparts. However, the cost of batteries, which is the highest component of the vehicle cost, is declining. According to the California Air Resources Board (2021), the cost of batteries has dropped 90 percent since 2010 and is projected to continue to decrease.

When looking at electric trucks, the upfront cost is also substantially higher than diesel or gasoline trucks. For example, an electric tractor-trailer truck may cost about $75,000 more than a diesel tractor (Nadel, 2021). An electric transit bus costs about $750,000, compared to a diesel bus which costs around $315,000 (Nadel, 2021). Although upfront costs are much higher for BEV, there is expected long-term savings on fuel and maintenance costs.

As referenced in Table 1 below, operating costs for electric trucks are substantially lower than operating costs for diesel trucks. For example, a Class 8 long-haul diesel truck that travels 110,000 miles annually spends about $37,900 on fuel annually, whereas a Class 8 long-haul electric truck that travels the same distance annually spends about $17,783 on annual energy costs (Nadel, 2021). Savings from reduced operating costs for vehicles that travel tens of thousands of miles can pay off the electric truck's higher upfront cost in as little as three years (Nadel, 2021). Despite the long-term savings, the high upfront price tag of electric MHDVs could be a barrier to many entities seeking to electrify their fleets.

Cost of ownership

Operating costs, the per mile costs of a vehicle, are lower for battery-powered vehicles compared to conventional fuel. Maintenance costs for BEV are generally lower than their diesel counterparts due to their simpler design and fewer moving parts. BEV are expected to have 25 percent lower vehicle maintenance costs compared to gasoline and diesel vehicles (California Air Resources Board, 2021). However, MHDV are early in their deployment, therefore there is not sufficient long-term data or field experience to draw a higher level of certainty. The limited data that is available suggests that after factoring out early failures that are common with new technologies, electric MHDVs have lower maintenance costs than diesel vehicles (Nadel, 2021).

Midlife costs are the cost of replacing major components of the vehicle due to deterioration. Internal combustion-powered vehicles require a midlife rebuild near the end of their engines' life, whereas BEVs require a battery replacement which can be costly. As mentioned above, long-term performance for electric MHDVs and their battery performance is limited; however, most BEV manufacturers offer warranties of eight or more years and up to 300,000 miles (Nadel, 2021). This warranty suggests the battery life of a MHDV may be around eight years and is typically covered by the manufacturer's warranty.

Charging Cost vs. Conventional Fuel

The cost of charging battery electric vehicles for MHDV varies depending on the rate, what level charger the vehicle is using, fixed fees, and demand costs. For MHDV fleets, most charging is assumed to be completed at their depots overnight using a Level 2 charger. DC fast charging (Level 3) is typically completed en route, is more expensive, and greatly varies based on the utility's rate or charging structure.

A study conducted by AMPLY Power (2021), an electric vehicle charging company specializing in fleet operating trucks, found that *managed charging* drastically reduces fuel costs compared to conventional fuel. Managed charging, also known as smart charging, allows a utility or third-party to remotely control electric vehicle charging in response to the needs of the grid (Myers, 2017). For example, if there is a higher demand for electricity during a specific period of time a utility can slow the charging speed for electric vehicle charging. On the other hand, if the demand for electricity is lower, the utility can speed up the charging speed.

In the AMPLY Power study, AMPLY Power developed the Dollar per Gallon-equivalent (DPGe) to compare the cost of one gallon-equivalent of electric fuel and one gallon of gasoline or diesel (AMPLY Power, 2021). DPGe expresses the dollars needed to drive a BEV the same distance compared to an internal combustion vehicle (AMPLY Power, 2021). This study looked at charging costs in 25 major U.S. cities and found on average with managed charging, electric fuel is 43 percent cheaper than gasoline for medium-duty vehicles and 37 percent cheaper than diesel for heavy-duty fleets (AMPLY Power, 2021). Fleets that implement managed charging can expect substantial savings on fuel costs.

Table 1: Comparison of annual energy costs for diesel and electric trucks

	Approx. upfront cost (US$)	Annual miles	Fuel economy (mpg or mi/kWh)	Total fuel or electricity consumption (gal or kWh)	Annual energy costs (US$)	Payback (years)
Class 2b–3 diesel	50,000	23,725	12.5	1,898	5,755	3.7
Class 2b–3 electric	67,000		2.0	11,863	1,151	
Class 4–5 diesel	55,000	36,500	9.3	3,946	11,964	3.3
Class 4–5 electric	85,500		1.3	28,077	2,723	
Class 6–7 diesel	85,000	Data Not Available	7.0	5,214	15,810	3.5
Class 6–7 electric	125,000		0.8	45,625	4,426	
Class 7–8 tractor diesel	130,000	51,100	8.8	5,807	17,606	7.5
Class 7–8 tractor electric	200,000		0.6	85,167	8,261	
Class 8 tractor (long-haul) diesel	130,000	110,000	8.8	12,500	37,900	5.5
Class 8 tractor (long-haul) electric	240,000		0.6	183,333	17,783	

Source: Nadel, 2021

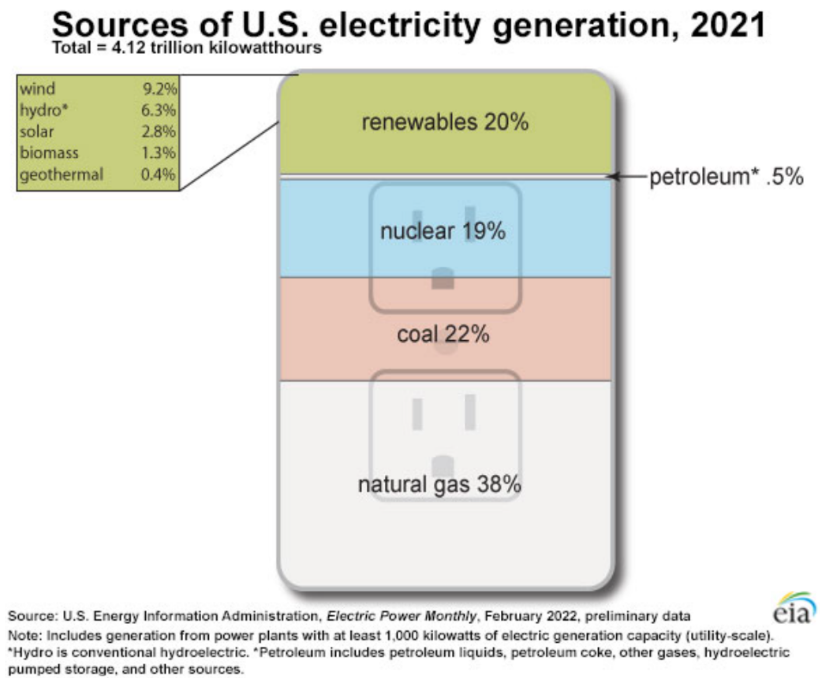
C. U.S. Electric Grid

While electric vehicles are one component of the electrification of the transportation sector, it is also important to understand the role that the electric grid plays in supplying the electricity to charging stations. The delivery of electricity to customers relies on three different assets: generation, transmission, and distribution.

Sources of Electricity and Electricity Infrastructure

In the United States, electricity is generated from a variety of different sources. According to the U.S. Energy Information Agency (n.d.), as illustrated in Figure 2, electricity in the U.S. is generated mainly from natural gas followed by coal, renewables, nuclear, and petroleum.

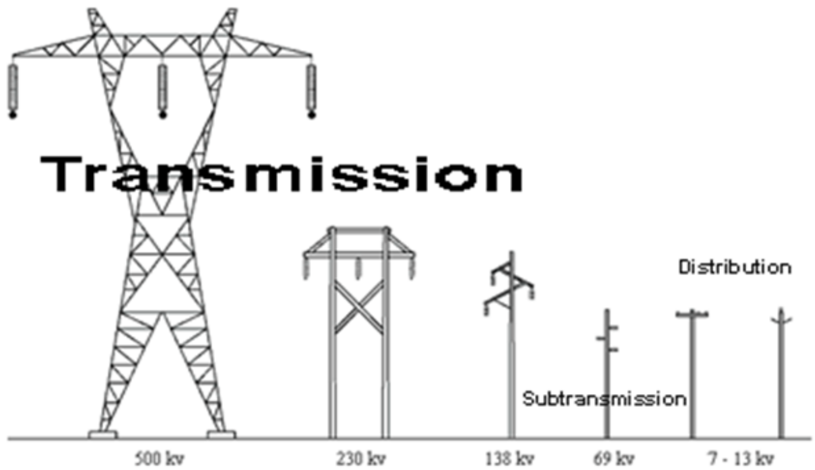
Figure 2: Sources of US Electricity Generation



Source: U.S. Energy Information Administration, n.d.

Once electricity is generated from these sources, it needs to travel to consumers through transmission and distribution assets which include substations, transformers, sensors, poles, and wires. Transmission substations use transformers to step up the voltage of the electricity generated prior to it traveling along transmission lines. By increasing the voltage of the electricity along transmission lines, utilities can reduce the amount of energy lost along the wires. After transmission, the voltage of the electricity is then reduced through step-down transmission at the distribution levels so that the electricity can be safely used by consumers. The transformers that step-up and step-down the voltage are located in substations. As shown in Figure 3, wires and the towers and poles make up the physical infrastructure of the transportation of electricity along the grid (U.S. Department of Energy, 2014).

Figure 3: Types of Transmission Lines



Source: Occupational Safety and Health Administration, n.d.

Transmission towers are larger than that of distribution poles since they support lines that transport electricity at much higher voltages and over much larger areas.

Efforts are underway to modernize the U.S. electric grid. Technologies are being added to the grid to promote greater efficiency and reliability of the system. Two such technologies include energy storage and smart meters. Energy storage technology can help better integrate intermittent sources of energy, such as renewables like wind and solar, into the electric system by storing the excess energy generated and discharging the electricity back onto the grid when additional supply is needed. Energy can be stored through pumped hydroelectric, batteries, compressed air, flywheels, and thermal energy storage (U.S. Environmental Protection Agency, *Electricity Storage*, n.d.). Energy storage technologies have been found to enhance the efficiency and operation of the grid by providing "application-specific energy services across different components of the grid" (Zame et al., 2017). Smart meters, meanwhile, can allow for two-way communication between consumers and utility providers. Smart meters allow the consumer to better understand electricity usage including when energy is used and its associated costs (SmartGrid, 2019). It can also allow the utilities to immediately know if there has been a disruption of service, which can improve restoration efforts. In addition, smart grid technologies can help utilities reduce their energy losses by managing voltage levels.

Interconnection

To ensure the reliability of the electricity grid broadly, the grids of local utilities are interconnected with each other making up three interconnections in the United States. The contiguous United States is made up of three interconnections: the Eastern Interconnection, the Western Interconnection, and the Electric Reliability Council of Texas. The three interconnections act almost entirely independently of each other, sharing very little power among them. Each interconnection plays an important role in grid reliability by creating additional routes of power to flow within its boundaries and allowing generators of electricity to supply multiple load centers (U.S. Energy Information Administration, 2016).

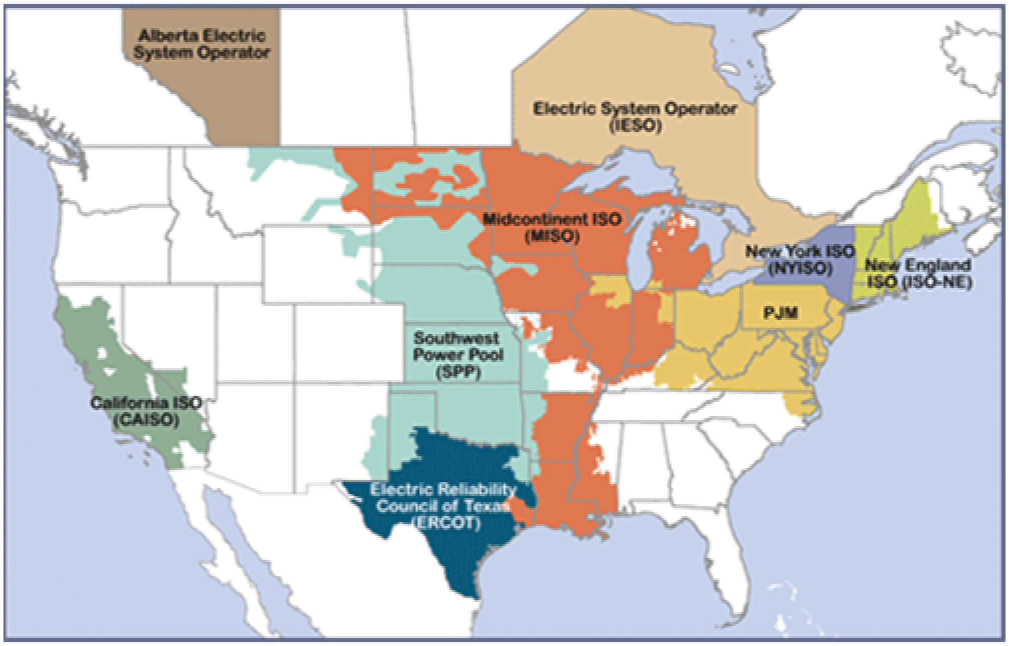
Regulated vs. Deregulated Electricity Markets

In addition to the multiple interconnections, the United States electricity market is composed of regulated and deregulated markets. The electricity market of the United States has historically been made up of monopolistic, vertically integrated utilities that act as both the grid operator and owner of all assets of the electricity system: generation, transmission, and distribution. Beginning in the early 20th century, utilities entered into a regulatory compact with state and local governments and were given a monopoly to provide electricity in a given region and in return, these utilities would be regulated by these governments and be entitled to charge rates sufficient to deliver an agreed-upon rate of return (Rose, 2004).

However, in the 1990s, states began to deregulate their electricity markets, which would unbundle ownership of the generation assets and the transmission and distribution assets in an attempt to promote greater competition. This was a result of several actions taken by the federal government beginning in 1978. In 1978, the Public Utility Regulatory Policies Act (“PURPA”) was enacted as part of the National Energy Act, which allowed power generators not owned by utilities, to enter the electricity market and sell their power to electric utilities (American Public Power Association, 2020). To further deregulate the electricity market, the Energy Policy Act of 1992 was enacted which granted these independent power producers equal access to the utilities’ transmission system (Slocum, 2008).

Following these actions, the Federal Energy Regulatory Commission (“FERC”) issued Order Nos. 888 and 889 in 1996, which provided the regulatory framework necessary to promote competition in the wholesale electricity market. These orders gave rise to Independent Systems Operators (“ISO”) as a means to satisfy the requirements of the orders requiring public utilities that own, control, and operate transmission systems to provide non-discriminatory access to transmission (Federal Energy Regulatory Commission, 2015). In 1999, FERC issued Order 2000, which encouraged the voluntary formation of Regional Transmission Operators (“RTO”) to further build upon the ISO concept (Federal Energy Regulatory Commission, 2015). These orders sought to increase competition in the electricity market. While ISOs and RTOs perform the same roles as the grid operators in deregulated electricity markets, RTOs differ in that they must meet specific characteristics and functions and require approval from FERC (Federal Energy Regulatory Commission, n.d.). The graphic below illustrates the areas of the country that have moved to deregulate the electricity markets.

Figure 4: Map of Deregulated Energy Sectors



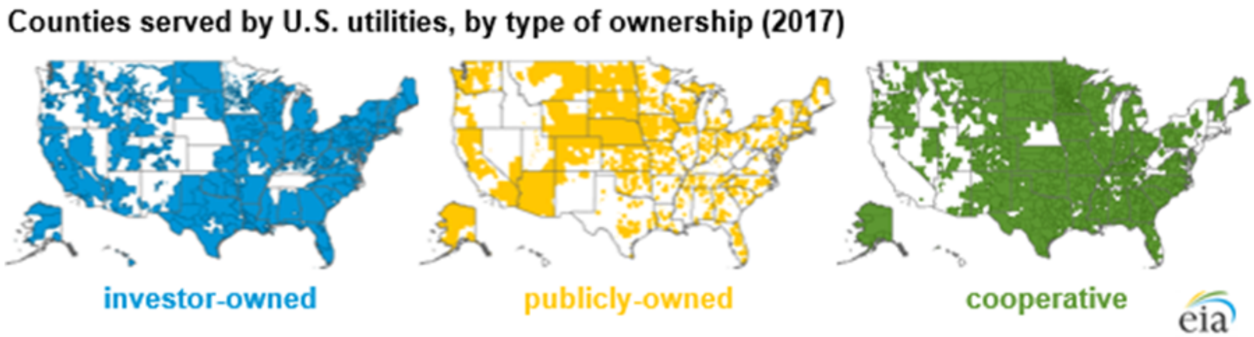
Source: FERC, n.d.

Utility Ownership Structure

Furthermore, the United States is comprised of several types of utility ownership structures. In 2017, there were nearly 3,000 electric utilities operating in the United States. These utilities consist of investor-owned utilities, electric cooperatives, and publicly owned utilities.

- Investor-owned utilities ("IOU") are for-profit and issue stock owned by their stakeholders.
- Electric cooperatives are not-for-profit, member-owned utilities. While this type of utility is located in 47 states, they are most prominent in the Midwest and Southeast.
- Publicly owned utilities are owned and operated by either federal, state, or municipal entities or public utility districts.

Figure 5: Counties Served by U.S. utilities, by type of ownership as of 2017



Source: U.S. Energy Information Administration, 2019

Despite only 168 total IOUs in the United States, compared to 812 electric cooperatives and 1,958 publicly owned utilities, IOUs serve 2.5 times the number of customers of the two other types of utilities combined, or three-quarters of the U.S. population (U.S. Energy Information Administration, 2019). Furthermore, in 2020, IOUs generated 1,350,672 GWh of electricity versus 210,355 GWh generated by electric cooperatives and 579,744 GWh of electricity produced by publicly-owned utilities. This means that IOUs generated 1.7 times as much electricity compared to electric cooperatives and publicly owned utilities combined. In addition to electricity generated from utilities, the U.S. imported 47,234 GWh of electricity from Canada and Mexico, and non-utilities, such as independent power producers, generated 1,868,313 GWh of electricity (Edison Electric Institute, n.d.).

Regulatory Scheme

System of Federalism

The regulatory environment of utility companies is a classic example of Federalism, typical of governance in the United States. As a general matter, aspects of economic activity that qualify as interstate commerce are subject to federal jurisdiction, whereas purely intrastate economic activity is not (U.S. Constitution). Thus, economic activity in the utility sector characterized by interstate commerce, such as interstate electricity transmission and wholesale energy markets, is subject to federal jurisdiction. All other aspects of regulation that do not touch upon interstate commerce, such as retail rates, retail distribution service, and siting, are generally subject to state jurisdiction. As a result, the Texas Interconnection grid, which serves only the state of Texas, is not subject to federal jurisdiction.

Aspects of utility regulation under federal jurisdiction typically fall under the authority of FERC. FERC promulgates regulations regarding the transmission of electricity interstate, and transactions in wholesale energy markets.

Public Utility Commissions

Aspects of utility regulation that fall under state jurisdiction are regulated by state entities generally known as public utility commissions, although these entities may have different names depending on the jurisdiction (EPA, 2010). Approximately three-quarters of public utility commissions are appointed by the relevant state governor; however, in about a quarter of states, commissioners are elected. (EPA, 2010). Generally, public utility commissions exist to ensure that utilities provide reasonable, adequate, and efficient service to utility customers, who historically were not protected by the benefit of competition given that utilities have historically operated as regulated monopolies. (Lazar, 2019).[3]

Ratemaking

A prominent aspect of public utility commission regulation is "ratemaking," or how a public utility commission allows utilities under its jurisdiction to recoup costs associated with its activities and earn a return on its investments. (EPA, 2010). Because electricity customers historically (and often still) have had one option for electricity service, rate design serves the critical role of protecting customers in the rates they pay for an essential service. (EPA, 2010; Lazar, 2019).

Utilities, as regulated monopolies, cannot charge any price for electricity service. Rather, they set rates in accordance with the regulations of the public utility commission and generally must justify their rates to the public utility commission in a "rate case," which provides oversight of the process. (EPA, 2010). Utility investments that are permitted by the public utility commission to be passed on to customers are said to be "rate based," because they are accounted for in the rates charged to the utility's entire customer base.

The traditional and most prominent ratemaking model allows utilities to earn a predetermined rate of return on approved capital expenditures, and to recover operating expenses but earn no return on them.[4] Typically, utilities must show that capital expenditures are "used and useful," (*i.e.*, are currently being used to provide service to customers) and are "prudent investments" (*i.e.,* capital expenditures were not wasteful). (EPA, 2010).

Rate Design

The concept of "rate design" pertains to the structure of the electricity charges customers pay for electricity service. A typical rate design includes a relatively small flat fee for fixed charges associated with the provision of electricity service, and a volumetric component per unit of kilowatt hours ("kWh") used by the customer. Utilities typically have different rate structures based on whether the customer is residential, commercial, or industrial, and may make

[3] However, as noted in the preceding section, in the 1990's measures were taken which introduced more competition for electricity generation.
[4] This formula is typically denoted as $R = E + (V - D)r$, where R = revenue requirement, E = operating expenses, V = value of the utility's tangible/intangible property, D = depreciation, and r = the approved rate of return.

distinctions among those groups as appropriate if approved by the public utility commission (Lazar, 2015).

Utilities often incorporate "tiered" pricing structures, which escalate as monthly volume increases. For commercial and industrial customers, rate design typically incorporates a "demand charge," which is based on how high the customer's usage peaked in a given month, regardless of usage throughout the rest of the month. Utilities may also incorporate "time-of-use" rates, which charge higher rates per kWh during peak usage periods, and less during off-peak periods. (Lazar, 2015).

Because ratemaking establishes the incentive structure for utilities, and rate design establishes the incentive structure for customers, there are significant public policy implications for both, particularly given the impact of these incentive structures on the issue of greenhouse gas emissions and local air quality. (EPA, 2010).

Recent federal legislation provides significant funding for transportation electrification, which may impact how utilities are able to cover the costs of EV infrastructure in their jurisdictions. This legislation is detailed in the following section.

D. The Infrastructure Investment and Jobs Act (IIJA)

The IIJA (H.R. 3684), passed on a bipartisan basis in 2021, provided for $1.2 trillion in overall spending to be allocated over five years. Particularly of interest is that the bill provided for a total of $7.5 billion specifically for EV charging infrastructure. Of that $7.5 billion, the IIJA allocated $5 billion to the NEVI program, which provides funding to build new EV charging stations. The bill also allocated an additional $2.5 billion to the Charging Fueling Infrastructure Program, a competitive grant program geared in part toward the deployment of EV charging infrastructure. Of particular relevance to fleet operators, H.R. 3684 only provides for funding for charging infrastructure designed for commercial fleet operators if those charging stations are open to more than one commercial entity. The states will have the most input over where the money goes, as the $5 billion from the NEVI will be managed on a state-by-state basis and the funding will go directly to the states where it will be disbursed by state DOTs, whereas the Charging Fueling Infrastructure Program will be run out of a new office run jointly by the DOE and the DOT. An upside of the funding scheme from the bill is the fact that the federal government will pick up 80 percent of a project's tab while the remaining 20 percent will be picked up by the private sector or by local governments (Ferris, 2022).

The entities eligible for the $2.5 billion in grants under the IIJA can be states and localities, tribes, territories, metropolitan planning organizations, port authorities, and groups of the aforementioned entities. To qualify for the grants, eligible entities must contract with private entities for acquisition, installation, construction, maintenance, and operation of publicly accessible EV charging infrastructure. Said infrastructure must also be located along designated "alternative fuel corridors", where it is accessible to all EV drivers. Those receiving the grant may also use part of it to provide the private entity with operating assistance for up to five years after the charging infrastructure is installed. Also, the eligible entity and the private entity may enter into a contracting arrangement or even a cost-sharing arrangement (Garner, Greenfield, Fan, 2022).

Another $500 million in funding will be provided directly to SEOs through the SEP. This will be disbursed over a period of five years with no match required. Each SEO will receive and manage all SEP funding. This funding will be used on programs to help reduce carbon emissions in the transportation sector by 2050 and accelerate the use of alternative transportation fuels for, and the electrification of, state government vehicles, fleet vehicles, taxis, and ridesharing services, mass transit, school buses, ferries, and privately-owned passenger and medium- and heavy-duty vehicles (U.S. Department of Energy, 2021).

The IIJA directs $274 billion to the DOT (Uddin, 2021). Within the DOT, investments will be allocated to five main areas: agency programs and operations, grants calculated by formula, competitive grants, loans, and the Highway Trust Fund. EV infrastructure is eligible for $30.7 billion including $7.7 billion for the deployment of EVs and related infrastructure, $12.7 billion for the deployment of all types of clean vehicles and fueling infrastructure, including EV charging stations, and $10.3 billion for grid and battery-related investments. The bill includes a $72 billion Surface Transportation Block Grant Program that was reauthorized under The Surface Transportation Reauthorization Act of 2021 that funds EV charging stations and vehicle to grid integration.

Outside of the $7.5 billion set for EV charging infrastructure, there are other funding schemes within the IIJA that are also of interest, which includes the Consideration of Measures to Promote Greater Electrification of the Transportation Sector. The bill encourages state public utility commissions to "promote greater electrification of the transportation sector," by attempting the following (Garner, Greenfield, Fan, 2022):

- Promoting affordable and equitable EV charging options for residential, commercial, and public charging infrastructure.
- Improving customer experience.
- Accelerating third-party investment for light, MHDV EVs.
- Recovery of marginal costs of electricity delivery to EVs and associated charging infrastructure.

Table 2 below lays out the various EV charging infrastructure incentive programs present in the IIJA:

Table 2: IIJA EV Charging Infrastructure Incentive Programs

Infrastructure Investment and Jobs Act					
Programs	Grants for Charging and Fueling Infrastructure	National Electric Vehicle Formula Program (NEVI)	Advanced Energy Manufacturing and Recycling Grant Program	Consideration of Measures to Promote Greater Electrification of the Transportation Sector	Grants for Energy Efficiency Improvements and Renewable Energy Improvements at Public School Facilities.
Funding	$2.5 billion	$5 billion	$750 million	TBD (State)	$500 million

Source: The National Law Review, 2022

The IIJA also puts funding towards bus electrification programs, most notably, the Clean School Bus Program and the Low- and No-Emissions Transit Bus Program. The Clean School Bus Program makes $5 billion available over the next five years to replace existing gasoline-powered school bus fleets with electrified buses. The money for this particular program is split with $2.5 billion going towards purchases of zero-emissions or electric school buses and the other $2.5 billion also going towards electric buses, but also those that run on other fuels such as compressed natural gas, propane, and biofuels. The EPA will award the funds to states, localities, tribal governments, and other entities that provide school bussing services to public school systems. This includes contractors who sell qualifying buses, EVSE, and other charging infrastructure as well as related non-profits.

The Low- and No-Emissions Transit Bus Program sets aside $5.6 billion for purchasing or leasing of zero- and low-emission transit buses. This includes money for the acquisition, construction, and leasing of supporting facilities. This funding will be provided through the FTA in the form of grants to states, localities, and tribal governments. The deadline for applications for the funding available in 2022 is May 31, 2022.

The infrastructure law also supports clean energy supply chains by providing the DOE with $140 million to create a rare-earth element extraction and separation facility and refinery. In addition, it gives agencies direction to evaluate and adhere to permitting timelines for critical mineral projects, namely the production of lithium-ion batteries for EVs. This is designed to make the production of lithium-ion batteries cheaper and more efficient.

During the public comments process, there was a large amount of interest in the $7.5 billion from the IIJA which cuts across many different sectors of American economic life (Ferris, 2022). During the rulemaking process, the DOE and DOT received comments from more than 500 different entities, including large companies like Amazon, state departments of transportation, utilities from across the country and interest groups representing a wide array of American industries and social causes.

In their comments, these entities highlighted several categories of priorities to target funding. The categories include rural areas, urban low-income areas, maintenance of the new charging infrastructure, and freight vehicles such as trucks. The commenters also highlighted the various challenges that the funding in the bill poses. For example, commenters highlighted challenges with installing chargers in rural and low-income areas, where the economics may be insufficient to justify EV charging in the private sector. Additionally, it should also be noted that the spending rules contain a wrinkle when it comes to heavy-duty vehicles. In the spirit of targeting funds toward public resources, funding is only available to heavy-duty charging stations that are shared by more than one company (Ferris, 2022). Finally, there is a requirement that each highway charging station must have at least four chargers that can deliver 150 KW of power.

With the literature review section of this report complete, the report now turns to primary data collected to answer the report's research puzzle, detailed below.

III. Primary Data Collection

This section will briefly discuss the reasoning underlying the report's focus on an interview format, before turning to the specific insights that those interviews revealed.

Why interviews?

Although the literature review yielded significant insight, the review was not sufficient to fully answer the research puzzle and questions that this report sought to answer. Therefore, interviews were selected as the most effective method of getting in-depth information from a variety of relevant entities. This format allowed for leveraging the GridWise network through its membership, which let the team engage with high-level employees at each entity who were directly involved in fleet electrification. Further, given how rapidly the dynamics of fleet electrification are moving, this method allowed the report to incorporate information detailing how utilities and other entities are considering fleet electrification *today*, which a focus on literature review would not have allowed. Ultimately, this method produced a high response rate, and significant insights were achieved from the conversations with the interviewees beyond what would have been achievable from reviewing strictly existing literature.

Why semi-structured interviews?

The semi-structured interview style was specifically chosen because it allowed a greater degree of flexibility in the conversations with the interviewees. The flexible structure of semi-structured interviews meant that a reproducible script could be used, increasing efficiency and comparability, while at the same time allowing the interviewer to delve deeper into topics that they found to be particularly pertinent to the overall project, and allowing interviewees some flexibility to add information they deemed relevant. Also, due to the qualitative nature of the data being collected, our team felt that the semi-structured interview style was an effective way to extract the necessary information to faithfully address our research questions.

Research Question Design

Before the interviews were conducted for the data collection phase, five overarching research questions were identified, on which subsequent interview questions were based. Through the questions, the goal was to be able to cover the five major topics that were identified as being the most important to cover for this project. Table 3 below includes the topics covered by our research questions and the proposed purpose:

Table 3: Research Question Topics and Purposes

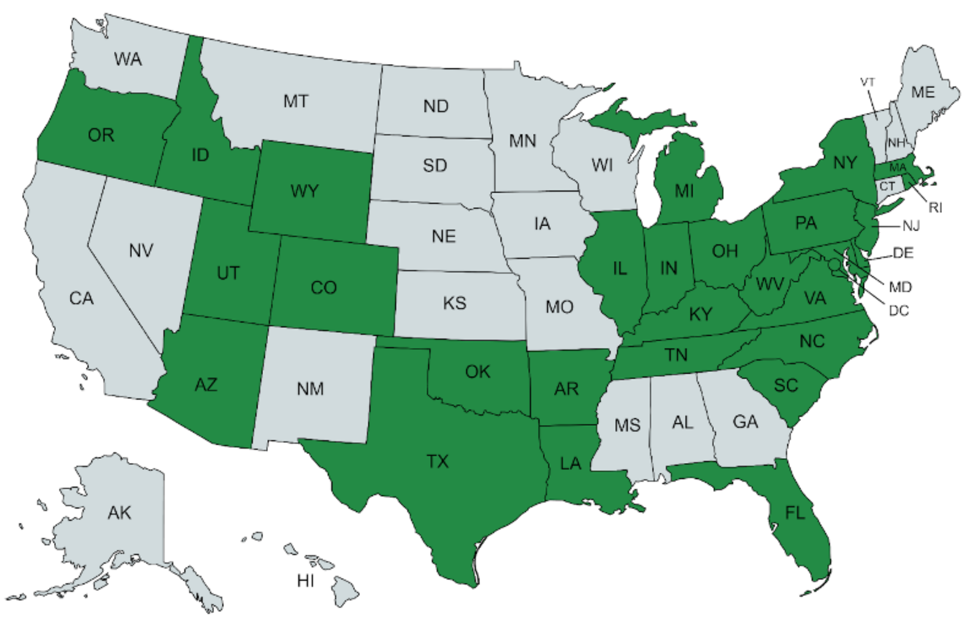
General Research Question Topic	Purpose
Question 1: Status Quo	Answering the question; Where are we now?
Question 2: Level of investment required in the future	Answering how much investment is required to support future fleet electrification
Question 3: How the investments be paid for	Answering if the utility has considered how they will recoup costs to support fleet electrification and how the regulatory regime in their service area impacts these decisions
Question 4: Policy implications	Answering if the entity has considered or attempted to access any of the new funding schemes from the recently passed IIJA.
Question 5: Broader lessons	Identifying any broader lessons that can be learned as entities on both the supply and demand side start to navigate further fleet electrification needs.

The questions were then relayed to GridWise who provided comments and recommendations. Once these comments from GridWise were incorporated, the team moved on to the data-gathering phase.

Interviewee Selection Process

After designing and finalizing our research questions, the team then worked with the representatives from GridWise to determine an initial list of entities to reach out to in order to conduct a series of semi-structured interviews. The team from GridWise reached out to their members, and ultimately interviews with 18 entities were arranged. Although all utilities interviewed were GridWise member organizations, the selection process focused on providing a wide variety of industry perspectives, including from the three different types of utilities - investor-owned, publicly owned, and cooperatives - as well as variety in geographic location and entity size. In addition to electric utilities, the team interviewed two consulting companies with extensive experience in fleet electrification from multiple perspectives, a global research organization, three government entities and a nationwide fleet operator. A list of the interviewed entities can be found below. Additional information on each entity and the interviews of each entity, including interview questions, can be found in the appendix.

Figure 6: Map of the States in which the Utilities Interviewed Provide Service



- *Utilities*
  - American Electric Power ("AEP")
  - Arizona Public Service Co. ("APS")
  - Dominion Energy ("Dominion")
  - Duke Energy

- Exelon Corporation ("Exelon")
- National Grid
- New York Power Authority ("NYPA")
- Platte River Power Authority ("Platte River")
- Portland General Electric ("PGE")
- Rappahannock Electric Cooperative ("REC")
- United Power

- *Consulting Companies*
  - DNV
  - Guidehouse Consulting ("Guidehouse")
- *Global Research Organization*
  - World Resources Institute ("WRI")
- *Government Entities*
  - California Energy Commission ("CEC")
  - Colorado Energy Office ("CEO")
  - Oregon Public Utility Commission ("OPUC")
- *Fleet Operator*
  - Walmart

Interview Structure

The semi-structured interviews were conducted remotely through Zoom, a video conferencing technology, between March and April, 2022. Each interview lasted from 40 minutes to an hour and was attended by two-to-three representatives from the capstone team and at least one representative from the entity. On the part of the capstone team, one member conducted the interview while the other team members took notes. All of the meetings were recorded to further aid notetaking efforts. The capstone team received the entity's permission to record before the start of the interview. Each interviewee was also given a copy of the interview questions beforehand to elicit a more effective response. In general, the interviewer followed the script and asked the questions that were given to the interviewee beforehand. At the end of the interview, there were also some questions related to sharing further research as well as some time allocated to allow the interviewee to broach any subject that they deemed valuable which was not initially covered by our interview questions. During drafting of the report, each entity was given an opportunity to review references to the entity to ensure accuracy.

IV. Findings

Section Overview

This section summarizes the results and findings of the semi-structured interviews that were conducted over the course of the project. The findings are broken down by the five major research questions. The five questions are further broken down into sub-questions, as they were asked in the interviews. The findings are presented in the order that they were asked to interviewees in the interviews. These findings are primarily focused on highlighting two things: finding consensus among stakeholders to identify major issues and solutions, and identifying ways that certain stakeholders have implemented creative or industry-leading solutions.

A. Results for Question I: To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes to operating practices and grid infrastructure (Where are we now)?

The first primary research question, and the interview questions within it, were meant to determine the status quo, or how prepared utilities are to accommodate fleet electrification currently. These questions investigated utilities' current hosting capacity, what type of predictive modeling utilities have done to forecast demand from fleet electrification, and what type of data and information they felt they needed from fleet operators and vice versa.[5] Interviewees shared and identified strengths and weaknesses in the information sharing process, as well as existing techniques and programs that have been successful thus far.

On the whole, utilities expressed that they have given significant thought to vehicle electrification and that planning thus far has only been conducted on a macro-scale. Given the significant demand a fleet can put on a specific substation, it can be very difficult to predict fleet demand on the micro-scale without detailed information from a fleet operator. Nearly everyone interviewed agreed that early engagement between utility and data sharing was extremely beneficial to both parties.

Does the utility know how much excess capacity it has based on the geographic location that could be used to accommodate fleet electrification now?

Demand on the electric grid is defined by three simple factors: size of the load, location of the load, and timing of the load. Every utility interviewed, regardless of structure, indicated that they have a good sense of where they had excess capacity on the grid *today*. All utilities agreed that

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[5] Hosting capacity is the amount of electric demand that can be added to a distribution system before control changes or system upgrades are required to safely and reliably integrate additional electric demand. *Hosting capacity does not represent a hard limit on the amount of additional demand that can be added to the distribution system*.

excess capacity is just a “snapshot” that could change in an instant, and so there was a temporal element that needed to be considered in addition to location.

The representatives from AEP succinctly pointed out that fleet electrification is just one source of new demand out of many possible sources, all of which the utility must consider. AEP referenced the potential for economic growth to have a similar effect on local grid demand for electric vehicles. For example, AEP noted that they often have adequate capacity to serve expected growth in an area until a major new commercial or industrial customer is sited in the area, necessitating a review as to how to meet that new capacity, as well as ongoing growth on that portion of the grid. Similarly, the CEC noted that its most recent 2021 energy forecast anticipates that growth in transportation electrification will constitute 50 percent of new demand on the grid through 2035, and of that, about 20 percent will be freight, meaning that even if fleets could be modeled accurately on the substation level, there are many other factors at play for understanding what type of load a substation will be able to handle at a given moment.

The interviews revealed that static capacity maps were commonly cited across utilities as a way they quantify excess supply. A few of the entities that were interviewed were in the process of producing tools that are trying to paint a more precise picture. United Power, a rural electric cooperative in Colorado, noted that smart meters have given it a much timelier and more precise picture of how the utility’s grid functions. The CEC developed a tool dubbed the “EDGE” tool to help model major transmission lines across utilities. The EDGE tool is software that helps analyze the grid inputs and outputs that can be anticipated from fleets, as well as other factors that will be added in the next decade like distributed energy resources. These factors are subdivided by census tract and larger areas known as Traffic Analysis Zones. This modern tool helps provide a degree of granular forecasting that older, less dynamic methods lack.[6]

Perhaps the most sophisticated tool was one developed by AEP. The tool uses GIS to provide a first cut analysis and give a good picture to fleet operators of available demand by location that can help increase speed of adoption and reduce cost. It helps circumvent the typical utility application process that can take months, and delay electric fleet uptake. This tool is not yet ready for public consumption. A representative of AEP addressed the issue of adequate grid capacity to support fleet operators transitioning to EVs, by saying, “We have an obligation to serve the customer, and we will provide electricity wherever and whenever they want it—but typically they are very interested in how fast can they get it and how much is it going to cost them?” This tool should help AEP address those two concerns.

Have you attempted to quantify the increased demand from future fleet electrification?

The majority of interviewed utilities have conducted some manner of overarching analysis into the types of large-scale demand increases fleet electrification will have on the grid. Eight out of eleven utilities interviewed had undertaken, or were in the process of undertaking such a project. Most of these studies were conducted for internal planning and analysis. On the whole, they

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[6] EVSE Deployment and Grid Evaluation (EDGE) Toolhttps://efiling.energy.ca.gov › getdocument

hoped to identify overall demand changes in the utility's service territory and what types of infrastructure upgrades might be needed on substations and feeder lines serving electric fleet depots. The studies ranged widely in scope and sophistication, but a general prediction of increased demand and identifying theoretical upgrades required to accommodate a fleet request were achieved by many of the studies. As highlighted in the previous section, predicting demand on the substation level is challenging. CEC noted that a large fleet can require significant local upgrades on distribution infrastructure, with a single customer potentially needing many times its existing load, but that overall grid demand increases from transportation electrification will continue to grow at a regular pace. Full adoption of large-scale commercial fleets has not reached maturity, so many of the predictions must use Artificial Intelligence and assumptions borrowed from how ICE fleets operate and what is known about vehicle charging habits thus far.

A team from National Grid produced a sophisticated study in 2021 on the grid impacts of fleet electrification. Predicting the impact on a given substation or feeder line in 10-20 years is challenging, but the study shows a forward-looking prediction of the necessary upgrades that a utility might need to make in a world with widespread fleet electrification. In particular, the study noted that within National Grid's service area, fleets will increase demand to the point that significant upgrades will be required at the feeder and substation levels. In some cases, these impacts could be felt even in the immediate to medium term due to fleet clustering and the increase in demand associated with a large commercial fleet. In particular, the study recommended that the piecemeal approach taken by utilities for other service requests is ill-suited for fleet electrification. Looking at future vehicle demand and upgrading infrastructure preemptively and strategically can decrease the overall cost of electrification significantly (National Grid & Hitachi, 2021).

The SEOs interviewed also expressed that they tried to do their own quantification of how EVs were going to impact fleets. Unlike utilities, state officials were not focused on local grid impacts, but instead on how new demand from EVs would affect the grid as a whole. While fleets and utilities generally have an interest in how electrification will affect them, state officials can provide a broader overarching picture of what kind of demand can be expected from fleets in the future. These bigger picture predictions can be made with a greater degree of precision than the local effects of electrification. The CEO helped produce an in-depth report modeling different electrification scenarios and their impacts. One key finding is that only 5 percent of the vehicles in the state are MHDV, yet they consume 25 percent of the state's transportation energy (Xcel Energy, 2019), a finding supported by the report's literature review. This further underlines the significance of the local impacts that a large collection of electric heavy-duty vehicles can have on the grid. CEC has produced even more detailed modeling, looking at future stress on distribution lines caused by MHDV, as well as by other sources, using their "EDGE" tool.

What data do utilities need from fleet operators?

The need for more information was a ubiquitous theme among all groups interviewed—utilities, fleet operators, regulators, and consultants. All 18 interviewees alluded to the fact that more data and early engagement would ease the burden of every stakeholder in the fleet electrification process. From a utility standpoint, this data manifests itself in two forms. The first is precise information about fleet size, procurement schedules, fleet vehicle types, fleet/charging schedules, and charger types. Supply and demand on the grid are constantly in flux but do follow predictable patterns based on time of year, time of day, and weather, among other factors. This means the type of information described above helps utilities produce a much more precise picture of what type of upgrades and rates are required to service a fleet operator's needs. It also helps the utility provide more efficient service on the grid. If a fleet charges at off-peak times, it can help reduce the overall stress on the system, and as an outgrowth of that, the utility can reduce the number of behind-the-meter grid upgrades required to service the fleet.

The second data type is less related to the *type* of information provided by fleets, and more related to the *timing* of providing that information. In many ways, this is more important than granular details about fleet operations. If a fleet can give even a general estimate of demand and location early in the process, it allows the utility to have a more comprehensive picture of upcoming demand increases, and potentially combine multiple service requests into one larger infrastructure upgrade. This helps reduce the cost and time for upgrades, for all parties. All utility interviewees stressed the importance of early engagement. Interviewees noted that grid upgrades can take a long time, and fleet operators at times had unrealistic expectations of project timelines. If a substation upgrade is required, this could take up to three years to accommodate. Further, sourcing EV charging-specific infrastructure presents its own challenges, exacerbated by the supply chain issues currently plaguing many sectors. Currently, it is estimated that it could take 24 months or more to deliver a large charging port (Black & Veatch, 2020). Utility interviewees highlighted the importance of being a prospective fleet operator's "first call," which allows utilities the time they need to deliver service to a site.

Utilities nearly uniformly expressed that they would like more information from fleets. A representative at the CEO, when asked if utilities were receiving enough information from fleets responded that they were not. A sample fleet electrification study conducted by the Edison Electric Institute sheds light on the type of information that utilities are looking for fleets to provide. Such details include: location, location priority level, vehicle types, charging schedules, charger types, and a vehicle procurement timeline (Edison Electric Institute, 2019). Representatives from multiple utilities stated that some entities seemed concerned about sharing their information for competitive reasons. In that vein, PGE noted that public entities they had dealt with were more transparent about data sharing than private entities.

What data do fleet operators need from utilities to better understand hosting capacity? Is this data available to fleet operators? How can the divide be bridged?

Although some utilities have been developing tools to better understand hosting capacity based on geographic location, some interviews suggested that excess hosting capacity does not drive the business decisions of operators deciding where to site their charging depots. Walmart, for example, stated that this element did not factor into their facility siting decisions. The CEO also noted that, in their experience, the location of fleet operations was already established, and unlikely to change based on hosting capacity. In general, many utilities noted that larger and more sophisticated fleet operators have been good about engaging utilities early. WRI, which is engaging with EPA on the Clean School Bus Program, has noted that a big role they are playing is “translating” the needs of schools, which are generally not well-versed in utility procedures, to the utilities.

Walmart, which could certainly be classified as a large, sophisticated fleet operator, noted that they have needed to be proactive, particularly given that Walmart must engage with 954 utilities to achieve its fleet electrification goal. Walmart stated that it would like to see data approaches and methods standardized.

B. Results for Question 2: What levels of financial investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?

Does the utility have a way of knowing what hosting capacity fleet operators will need in the future?

In determining what future investments will be required to accommodate the greater demand for electricity associated with fleet electrification, interviewees were asked whether utilities know what hosting capacity fleet operators will need in the future. Overall, it was generally agreed that hosting capacity is less relevant for fleet electrification compared to other areas of electrification. Additionally, several of the utilities reported that they are still in the process of developing these maps for applications other than just for fleet electrification.

The representative from Walmart said that the hosting capacity of various geographic locations does not factor into their decision-making and planning of facility locations as the core business needs will ultimately drive where this infrastructure will be located. This was further supported by the representatives of the CEO, who stated that hosting capacity for fleet electrification may be irrelevant since the siting of depots is a fairly inflexible process, particularly if for small fleet operators based in only one or two locations.

According to the representatives of the CEO, having future hosting capacity accessible becomes relevant for the installation of public charging stations since they have more flexibility in siting than for fleet charging stations at depots. However, the representative from Walmart said that it is unlikely that Walmart’s fleets will utilize these public-facing chargers. More than 90 percent of the fueling of Walmart’s fleets occurs at the distribution centers and at this time they do not see any need to change this with the move towards electrification. The representative added that charging their fleets at the distribution centers occurs during planned downtimes, such as when their trucks are being loaded or unloaded. If they were to charge their fleets at third-party locations, such as public charging stations, this would cut into drive time and thus be suboptimal to their business.

What grid investment will be required to accommodate increased fleet electrification?

In addition to evaluating future hosting capacity, the interviewees were asked to identify what specific investments would be needed to be made by utilities to support the fleet electrification. The representatives from the CEO said that electrifying fleets will require new and upgraded generating, transmission, and distribution assets. The representative from DNV categorized these investments as significant, specifically in the hundreds of billions of dollars. Investments will be needed both to upgrade the existing aging electric infrastructure and to construct new infrastructure. Additionally, they stated that there is an emphasis to invest in rural areas. Specific challenges that rural areas face include a lagging infrastructure and likely less experience in permitting and siting of EV charging stations compared to urban population centers (U.S. Department of Transportation, n.d.). While the scale of the investments required to support fleet electrification was identified, many of the utilities agreed that the investments will vary depending on the project.

The entities interviewed identified four areas in which investments will need to be made to support fleet electrification: (1) infrastructure to support increased electricity demand, (2) infrastructure to support resiliency, (3) clean energy generating technologies, and (4) human capital.

Types of infrastructure that will need to be either upgraded or installed to support greater fleet electrification include circuit level and transmission level transformers, substations, high voltage lines, and transmission towers and poles, behind-the-meter technologies, and switches. This infrastructure is required to accommodate the greater capacity of electricity required to charge the electrified fleets.

Respondents also highlighted the importance of addressing resiliency. The representatives from Exelon and Dominion, for example, responded that with broad electrification trends, there is a need to strengthen the resilience of the electric grid. The electric grid needs to be resilient so that fleet charging is not disrupted due to weather events or cyberattacks. Such investments in resilience include hardening of the system, greater automation, and “self-healing” technologies. The Dominion representative also noted the important role of two-way communication technologies so that when there is damage to the grid, the problem can be identified and fixed as soon as possible.

As noted by Exelon, and as found in existing literature, many of the early adopters of fleet electrification are doing so for sustainability purposes. As such, there is a greater need for fleet electrification to be paired with the deployment of clean energy technologies.

Lastly, in addition to the necessary investments in physical infrastructure, interviewees acknowledged the importance of investing in human capital. The representative from Guidehouse emphasized that investments in stakeholder engagement and participation should not be overlooked as fleet operators move to electrify their fleets.

What does early engagement between a fleet operator and utility look like in practice? What steps can be taken to ensure maximum benefit and efficiency to all parties?

The majority of interviewees agreed that early engagement is important. Six of the utilities explicitly stated that the engagement process between the fleet operators and the utilities needs to improve.

Such improvements identified include establishing a dedicated team within the utility on electric vehicles of fleet electrification, according to the NYPA representative. AEP responded that in working with transit operators specifically, many utilities can provide operators assistance on applications for grant opportunities to support fleet electrification. This assistance typically comes in the form of advice on charger set ups, and depending on local regulatory considerations, may include rebates for chargers and/or make-ready work to lower their overall cost. The utilities can also help determine which available rate best fits the fleet operators' needs.These actions would create greater collaboration between the utility and fleet operator and each party is better able to understand what grid upgrades will be needed to support the addition of electric fleet vehicles and the upfront costs to fleet operators.

According to the utilities, early engagement between the utilities and fleet operators can better resolve issues that may arise as fleets seek to electrify. For example, the Dominion representative shared that with early engagement, the fleet operators can better understand the length of time it takes to complete the upgrades to the grid. This can, therefore, allow fleet operators to better plan their purchases of electric vehicles so that the infrastructure to support these vehicles is in place by the time these electric vehicles are ready to be deployed. Engaging with utilities early will allow fleet operators to understand these timelines and plan accordingly. The representative from Exelon stated that it may take anywhere from 18 to 36 months to install a new substation, for example. This timeline was confirmed by Walmart, which stated that currently, their longest timeline for a service upgrade is 36 months. The National Grid representative added that greater industry collaboration can help the utility determine grid impacts more comprehensively so that the utility can plan for the increased demand of all fleet electrifiers in an efficient manner.

In addition to early engagement, ensuring that the right people are involved in the conversation between the utilities and fleet operators was raised as an important issue by the fleet operator. The Walmart representative recommended that when utilities and customers are engaging in conversations, the utilities' project managers and distribution teams are involved. The Walmart representative noted that the project managers and distribution teams can provide the most accurate timeline for service upgrades or new construction services.

The two state energy offices indicated that state governments can play a role in the engagement between utilities and fleet operators. The representatives from the CEO highlighted a program in their state, the ReCharge Colorado Program, which provides coaching services on electric vehicle adoption throughout the state for consumers, local governments, workplaces, and multifamily housing development on electric vehicle deployment, which can include fleet electrification. The CEC representatives responded that if they see an area where they can predict a high level of demand with confidence, they can allow utilities to build or upgrade the basic (*e.g.*, substation or transmission lines) infrastructure in anticipation of this increased demand.

Has the utility considered methods for reducing peak demand associated with increased fleet vehicle charging? What rate changes for fleet operators have you explored to increase grid optimization?

Respondents identified two ways in which peak demand associated with increased fleet electrification can be mitigated: rate design and smart charging and energy storage technologies.

The representatives of Exelon, PGE, United Power, AEP, Dominion, CEO, CEC, and DNV identified rate design as a way to reduce the peak demand associated with increased electricity demand from fleet electrification. The AEP representative responded that while residential customers' rate design typically includes both energy and capacity costs in a flat-rate, commercial customers typically have rate designs where those costs of service are separated into those two components. Echoing this idea, the CEO representatives stated that for fleet operators, rate design should provide a sufficient signal to incentivize efficient charging patterns. CEO noted that Xcel Energy, one of the two IOUs operating in Colorado, has a Critical Peak Pricing component as part of its Electrical Vehicle Service ("S-EV"), which encourages customers to reduce their electricity use during critical peak times when retail electricity prices can increase by 10-fold. Customers on the S-EV rate will be charged lower rates when they charge EVs during off-peak hours.

Smart charging and grid technologies were also highlighted as a means to both reduce peak demand and lower costs for fleet operators. Several of the interviewed entities – NYPA, PGE, United Power, Dominion, CEC, and DNV – responded that these technologies can optimize the grid by reducing peak demand and flexible load management. In addition to smart charging technologies, the representatives from Exelon and CEC stated that onsite storage can reduce peak demand. The former board chair of Platte River proposed that in the future, a holistic approach to the grid is the best solution to the questions of peak demand, with vehicle-to-grid or vehicle-to-building technology selling or providing power back to the grid when demand peaks. These technologies are not close to maturity yet – as will be noted in the following subsection – but have the potential to dramatically alter the grid as it moves toward full electrification.

What incentives have you looked at for fleet operators that contribute grid services like frequency regulation[7]? Vehicle-to-grid infrastructure? Battery storage?

Overall, a majority of the utilities interviewed stated that electrified fleets are not currently seeking to provide grid services, primarily because of the lack of commercial penetration of these technologies and the lack of data to utilize fleets for grid services. Additionally, one utility – APS – said that there is no program currently established in Arizona that would incentivize fleet operators to provide these grid services. Furthermore, the representative from Exelon stated that the early adopters of fleet electrification are unlikely to provide grid services because many of these early adopters are doing so for sustainability purposes, not to provide grid services.

This is supported by the findings from the interview with Walmart. The representative from Walmart stated that they have not considered providing grid services from their electrified fleet and that it is not likely to be a part of their business model in the future. Specifically, the representative stated that Walmart is purchasing these electric vehicles for transportation, and therefore, providing grid services would interfere with and reduce the efficiency of the intended purposes of these fleet vehicles.

While the results from the interviews illustrate that private fleet operators and fleets in continuous services, such as public transit, may not consider grid services in their business models, electrified school buses can potentially provide many of these grid services, particularly for battery storage. APS stated that they are currently looking at school buses for storage opportunities. Dominion added that school buses sit idle during times of peak electric demand, and therefore, can discharge electricity back to the grid when needed. However, NYPA conducted a pilot program on school bus electrification and found that the costs associated with the hardware upgrades to the grid outweighed the benefits they provided to the grid.

C. To what extent do current mechanisms allow utilities to rate base investments associated with fleet electrification?

This research question was designed to explore what tools utilities have currently to recoup investments made to facilitate fleet electrification, and what regulatory improvements could be made that would allow utilities to more effectively facilitate fleet electrification in a way that is cost-effective and fair for all stakeholders.

Has the utility considered how it plans to recoup investments needed to accommodate the increased demand from fleet electrification?

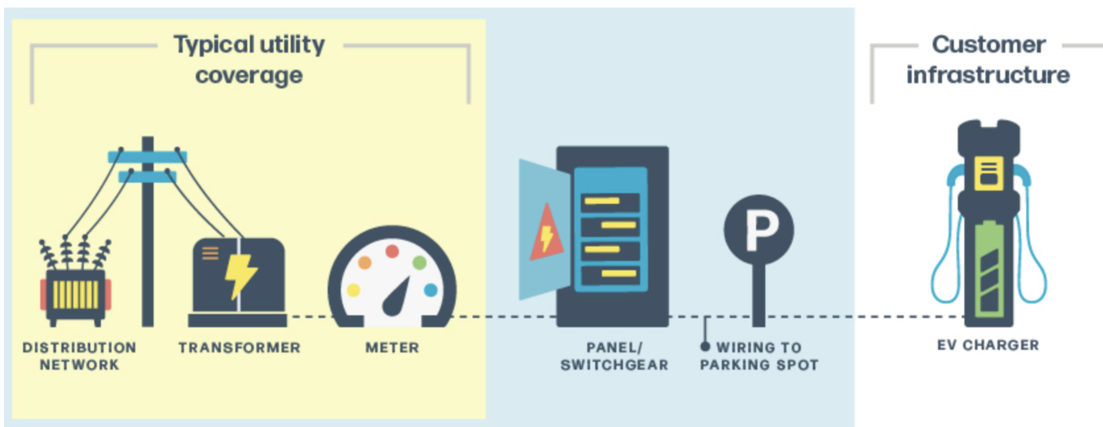
Generally, different states allow utilities in their jurisdiction varying degrees of latitude to rate base different infrastructure costs associated with fleet electrification. Responses to this question reflected the variance in state regulatory schemes, depending on the location of the utilities' service area. The most permissive states in this area, such as Oregon, allow utilities to rate base

[7] Frequency regulation services ensure the balance of supply and demand of electricity on the grid and the electric grid maintains a stable frequency of 60 Hertz. (PJM, n.d.)

all such costs, including the EV chargers. Other states, as detailed below, offer utilities in their jurisdiction less freedom to rate base these costs.

Entities with wider vantage points, including consulting firms, Walmart, WRI, and utilities with larger footprints that spanned multiple jurisdictions, were able to comment on these distinctions more broadly. For example, a representative from the consulting firm of Guidehouse noted "the Goldilocks approach," that he had seen across various utilities as they wrestled with the issue of accounting for the costs of fleet electrification. Under this conception, some utilities seek to rate base all costs of fleet electrification, some seek to rate base some but not all costs on the customer's side (illustrated by the blue-shaded section of Figure 7, below), and others seek to rate base just the costs of infrastructure on the utility's side of the meter (illustrated by the yellow-shaded section).

Figure 7: Potential Infrastructure for Rate Basing



Source: PGE, 2022

Representatives from Duke Energy, which has a large service area spanning six states, noted that every regulating entity in their jurisdiction views the issue of rate basing fleet electrification investments differently, which makes determining how to account for fleet electrification costs a challenge to navigate.

This sentiment was echoed by representatives from AEP. AEP noted that, due to the large footprint of AEP's service area, it had to consider the different regulatory schemes of each state. AEP stated that, in general, any infrastructure built out to a customer site can be rate based provided that it is used and useful. However, AEP noted that there is currently an ongoing debate across jurisdictions in its service area regarding rate basing the chargers themselves, and AEP's ability to do so depends on which state the infrastructure is sited in.

As noted above, in Oregon (the home of PGE), there is no such debate. PGE noted that Oregon utilities have the authority, based on legislation passed by the Oregon State Legislature in 2016, to rate base infrastructure related to transportation electrification. This authority allows PGE to offer robust “make-ready” incentives to entities through its Fleet Partner Program.[8] These incentives can cover the vast majority, or even the entirety, of a fleet operator’s upfront costs of building out a charging depot, and the cost of these incentives can be rate based by the utility. Critically, given that these incentives arguably accrue to the benefit of a single entity, PGE stated that because of the added volume of electricity sold as a result of these incentivized projects, PGE does not expect that these projects will increase rates for its broader customer base, and may even put downward pressure on rates. OPUC confirmed that, due to the Oregon state legislation, OPUC has broad discretion to approve Oregon IOU rate basing of fleet electrification projects, including associated guidance on project engineering and related matters. OPUC stated that its discretion to approve recovery of these costs exceeds the “prudence” standard, because it is in furtherance of the public purpose of promoting transportation electrification, as articulated by the Oregon State Legislature.

Other utilities fall more toward the middle of the “Goldilocks” spectrum. National Grid is able to offer “make-ready” incentives for potential fleet electrifiers that include some costs of equipment on the customer-side of the meter, such as trenching and cabling (*i.e.*, the blue area of Figure 6) but not including EV chargers.

APS noted that although the Arizona Corporation Commission recently approved a state-wide electrification plan which requires investor-owned utilities to pursue transportation electrification programs, there is not currently a “make-ready” mechanism that allows APS to help fleet electrifiers reduce upfront costs.

REC noted that, as a cooperative, it has a different rate-basing structure than investor-owned utilities in Virginia, which allows it some more flexibility in terms of how it recovers its costs. While EV penetration is still low within its service territory, REC noted that this regulatory flexibility, in another context, allowed it to adopt smart meters within its territory approximately twenty years ago, well ahead of most other utilities. REC noted that this flexibility could be an advantage as EV adoption continues to increase in the REC service territory.

In the same vein, representatives from the CEO noted that although investor-owned utilities cover the majority of Colorado customers, there are only two investor-owned utilities in Colorado, versus approximately forty-four Rural Electric Associations and Municipal Utilities. The CEO stated that these non-investor-owned utilities tend to be more nimble and risk tolerant, and offer the potential for partnerships with the CEO beyond what is generally available with investor-owned utilities.

WRI also highlighted the debate regarding the appropriateness of rate basing EV infrastructure, which it has a broad perspective on given the nationwide WRI Electric School Bus Initiative.

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[8] A “make-ready” incentive is a term used in the utility industry (tantamount to “turnkey”) which means the utility will cover the cost (in whole or in part) or “making a customer’s site ready” to receive electricity service.

Representatives from WRI noted that because the rate basing of EV infrastructure costs was at times criticized as a subsidy for a privileged group, WRI views demonstrating the broad social benefits from the rate basing of infrastructure for EV buses as critical to their initiative. WRI noted that, in general, East and West-coast utilities, and certain parts of the Midwest, have been quicker to allow utilities more flexibility in terms of rate-basing EV charging infrastructure. WRI noted further that different utility ownership structures can result in differing viewpoints on this issue.

A representative from Walmart noted that Walmart must interact with 954 utilities to facilitate its fleet electrification goals. Walmart stated that the make-ready initiative available in California is a favorable environment, particularly given its large distribution network in the state. The representative also noted that a challenge from Walmart's perspective is keeping up with the technical rate-making aspects of all utilities across the nation and that ultimately EV charging infrastructure should be placed in a distinct rate schedule, which takes into account its unique dynamics.

Do you feel that the current regulatory landscape allows the utility to plan for and recoup these costs in a way that makes sense for the utility and its customers? If not, what changes do you think need to be made?

Utility interviewees' suggestions to make the regulatory landscape more conducive to efficient and fair cost recovery for EV charging infrastructure was generally influenced by the current regulatory environment in which those utilities operated.

Representatives from AEP noted that, in general, more regulatory freedom in how it recovers costs from EV fleet infrastructure would be helpful, particularly the ability to offer rebates and other incentives to provide more freedom for fleet operators to cover the upfront cost of charging infrastructure. AEP noted that state regulatory environments that discourage utility participation in charging infrastructure impede the adoption of EVs.

The representative from Dominion noted that a significant amount of utility strategy on the national level will focus on emphasizing the importance of utility fleet programs.

A representative from National Grid stated that although the regulatory scheme is sufficient in the immediate term, wider adoption of EV vehicles will require some changes. In particular, the representative noted the need for utilities to be more proactive, and invest more in EV charging infrastructure ahead of time in order to accommodate increased load from fleet electrification in a manner that is efficient over the long term.

A representative from United Power stated that a mechanism that allowed for a "levelized cost of infrastructure" would allow utilities to spread the costs of EV charging infrastructure out over a longer time period, but that the ability to do so varies by state, and that United Power did not currently have the ability to do so.

D. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?

Has the utility considered how it can utilize funds from the Infrastructure Bill toward the costs of additional charging infrastructure?

The passage of the IIJA in 2021 was a major step forward in terms of increased funding for EV infrastructure. All of the utilities interviewed were starting to consider the new funding schemes and were in the process of determining their eligibility under the new law, as well as how they can help their customers access the new funding. However, based on the language of the bill, many interviewees recognized that the bill does not offer as many funding opportunities for MHDV fleet electrification as they had hoped. The bill's funding schemes are mostly focused on creating the infrastructure for EV charging corridors which would primarily benefit personal light-duty vehicles. However, there may still be an opportunity for utilities to gain the funding in a more indirect way. Non-municipal utilities can still gain access to the funding in the form of public-private partnerships. For example, a utility like National Grid cannot get direct access to the funds from the IIJA, but they can partner with a bus agency that received a grant to make back-end changes.

With $5 billion being allocated to the states to be put towards NEVI, utilities will need to cooperate with the state DOTs in their areas of operation to gain access to these funds. However, since the money given by the state must also go to projects that are public-facing, the types of projects that relate to MHDV fleet vehicles are still limited.

From the consulting side, the firms that were interviewed have also concluded that the only way the private sector can access any of the funds from either major funding scheme is indirectly through participating in public-private partnerships. With the specification that the grants have to be public-facing, the money is generally more accessible for personal EVs. However, interviews with consulting firms did suggest that companies with light-duty fleets may be able to make use of the public-facing EV chargers for mid-route charging.

The conversation with Walmart highlighted that since the IIJA is still so new, many large fleet operators are still trying to assess their eligibility and any benefits they can gain from the programs included in the bill. From Walmart's perspective, they do not accept any federal funding, and so the federal grants under the IIJA are not a factor.

Are there any key questions or challenges you foresee with accessing IIJA funding?

Most utilities interviewed identified some challenges with accessing funds under IIJA, particularly to support fleet operator charging. However, utilities highlighted the possibility of highway corridor funding to support longer-haul fleet routes. Supply chain issues also came up as a challenge which will be exacerbated by the increased funding for EV charging infrastructure. A major supply chain problem is the slow speed of procuring the components of a fast charger, which *currently* takes 80-100 weeks. The “Buy America” requirement also presents challenges as until recently there was only a single factory for fast chargers in the United States which fulfills this requirement. Many are now onshoring factories and pursuing “Buy America " compliance since the passage of the IIJA.

Representatives from AEP identified that there was an existing challenging market for infrastructure supply (such as transformers), and due to the IIJA funds, that would likely add to demand. For example, AEP noted that lead times to procure some classes of transformers were already up to double usual delivery times, and due to additional demand resulting from IIJA, there could be significantly more supply chain pressure.

The consulting firms noted that advising their clients on how to access the money must be done on a state-by-state basis. The firms will have to work with state and local governments to get access to the funding and to determine who is eligible and how the money can be accessed as each of the states has its own processes.

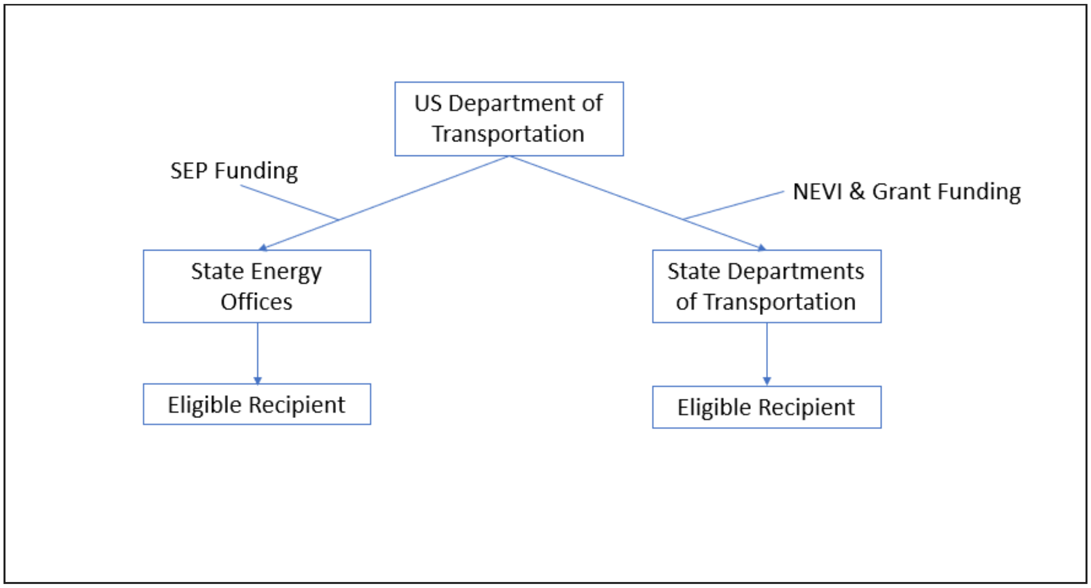
The Role of the State Government in Disbursing the Funding

While NEVI funding will be disbursed directly from state DOTs, the SEOs will be responsible for disbursing SEP funding, including the two interviewed pursuant to this report. Due to the nature of the IIJA funding schemes, utilities must work with the SEOs in their areas of operation for them to gain access to SEP funding. SEOs work closely with state DOTs to disburse the funds they received from the IIJA. In the case of Colorado, CEO has a partnership and several interagency agreements with the Colorado Department of Transportation (“CDOT”) in which CDOT provides the funding for CEO’s EV charging programs. The CEC also works closely with the California Department of Transportation (CalTrans) on the disbursement of the funds with both agencies jointly developing plans and scope of work. Perhaps the biggest challenge facing the state offices is that of timing, particularly in light of the supply chain issues highlighted above.

For their part, PUCs are not involved in the distribution of the funds from the IIJA. They will only become involved when a utility is involved in a project that could get funding. Their role in this situation is to help the project get funded and make sure the grant gets utilized.

Figure 8, below, illustrates the direction of IIJA EV infrastructure funding.

Figure 8: Direction of IIJA EV Infrastructure Funding



Regarding School Buses

One area where IIJA funding *can* play a major role is in helping to build out EV infrastructure around new electric school bus fleets. Utilities have been working with school districts in their areas of operation to electrify their bus fleets, and funding for school bus fleet electrification can come from IIJA programs. WRI, which is focusing on a nationwide effort to facilitate school bus electrification programs across the country, noted that it is working with EPA to gather and disseminate information to school districts who wish to apply for funding for this type of infrastructure. REC is also working on school bus electrification as an advisory member of the Beneficial Electrification League which supports the deployment of electric school buses. The REC representative noted that funds under the IIJA are particularly important, as electric school buses are expensive, costing around $350,000 - $400,000 each. School buses in rural areas will have different challenges when it comes to charging and maintenance than those in urban areas. Such challenges include insufficient access to parts for maintenance of the electrified bus fleet as well as the economic challenges in getting the electricity and charging infrastructure to the rural school districts that need it. Therefore, supporting electrification in rural areas will require significantly more grid upgrades to deliver power on the necessary scale.

E. What broader lessons can be learned for entities seeking to electrify their fleets?

The final research question aims to understand the best practices for any entity to transition their fleet to battery-electric MHDVs. Since the majority of fleet operators are early in the stage of electrification, it is beneficial to investigate broader lessons learned from utilities, fleet operators, and consulting firms involved in fleet electrification projects.

Utility's Perspective

Utilities play a critical role in the infrastructure planning and adoption of electric vehicles on both the residential and commercial levels. Every utility interviewed provided insight on steps fleet operators need to take to electrify their fleets.

Of the 11 utilities interviewed, 6 utilities communicated that early engagement between fleet operators and utilities is the most important component of electrification planning. PGE mentioned the need for fleet operators to understand their utility's specific processes and programs so they are knowledgeable about what is required for planning. According to PGE, it plans out broader infrastructure upgrades on a timescale of 5-10+ years, which means that the earlier the utility can connect with the fleet operator to assess their needs, the more informed this long-term planning can be.

Many utilities also highlighted the importance of having detailed data from fleet operators on vehicle quantity, vehicle size, fleet duty cycles, timeline of vehicle deployment, and specific charging needs. From an electrical load standpoint, Exelon cited that it can take 18-36 months to upgrade substations. Exelon explained that the earlier a fleet operator can connect with a utility to provide detailed data regarding the energy capacity they will need, the more time the utility can have to make necessary grid upgrades.

Three utilities emphasized the value of multi-stakeholder engagement between fleet operators and other entities. Several utilities mentioned connecting with electric vehicle charging companies, individuals familiar with charging technology, and fleet operators that have successfully converted to electric vehicles. A representative from REC recommended connecting with other entities that have electrified to get better insight on what is required to electrify and understand components of electrification that may be overlooked. REC provided the example of inadequate planning for the length of charging cords that may be an oversight but critical to a fleet's charging operation.

A representative from NYPA noted the importance of connecting with electric vehicle manufacturers, charger manufacturers, and the utility to get a realistic timeline of infrastructure upgrades like electrical switchgear and transformers. The NYPA representative also mentioned supply chain issues, noting that service requests are taking longer to accommodate and that this issue may get worse as a result of increased demand from the IIJA funding. For example, the NYPA spokesperson explained that an order for DC fast chargers can take a year to arrive. They also noted that the timeline of vehicle shipments may get worse as a result of the lack of raw materials for lithium-ion batteries. NYPA stated, however, that may change if the electric vehicle industry switches to different materials like iron-phosphate.

Consulting and Research Institute Perspective

The two consulting firms and research organizations interviewed, provided a unique perspective on their work with vehicle electrification.

DNV representatives highlighted the importance of understanding electric vehicle technology. According to a representative from the WRI, if there is not an individual with expertise in electric vehicles working with the fleet operator, the electrification process could be challenging. The WRI representative explained that most people do not have the level of comfort necessary to successfully electrify an entire fleet so experts in the technology are critical.

Supply chain issues were brought up as a major area of concern for vehicle orders, batteries, charging infrastructure, and other necessary materials. A representative from Guidehouse noted that fleet operators may have the charging infrastructure ready, but the vehicles may take months to years to be delivered due to supply chain issues. The Guidehouse representative recommended that federal leadership create goals around the commitment to manufacture electric vehicles and purchasing necessary raw materials to create certainty in the marketplace. Domestic manufacturing of batteries or using alternative raw materials to manufacture batteries could mitigate supply chain issues for fleets seeking to electrify.

Another component of electrification planning that was mentioned by interviewees is identifying critical vulnerabilities in the process. The representative from WRI recommends identifying all areas of electrification, besides the vehicle, that may be central to the process. The WRI representative conveyed examples like permits for charging stations, grant applications or rules that accompany grant awards, or other regulatory requirements. Another example provided by the WRI was forecasting data issues that may arise in rural areas that use managed charging to charge their fleet. WRI explained that if data connection issues occur in rural areas, the managed charging programs offered by utilities may not succeed.

Fleet Operator Perspective

Walmart, which seeks to reach zero emissions from its fleet by 2040, provided recommendations for other entities with electrification goals.

A representative from Walmart suggested fleet operators be upfront about getting service request timeline estimates from utilities and communicate those to internal stakeholders. According to the Walmart representative, the longest service upgrade timeline they have seen is 36 months. Walmart highlighted the importance of factoring in potential supply chain issues and how that may impact an entity's fleet electrification timeline.

As emphasized in many interviewee responses, planning early to get realistic timelines on grid infrastructure upgrades, charger installation, and electric vehicle orders will be essential in converting fleets to electric. Factoring in potential supply chain issues will also be critical in determining a realistic timeline for electric vehicle deployment and reaching a fleet operator's electrification goal.

V. Recommendations

A. Recommendation 1: Early engagement with utilities

Based on multiple utilities interviewed, it is highly recommended that fleet operators connect with utilities early during their electrification process. Every utility has different processes, grid capacity, and electric vehicle charging programs that need to be identified and understood at the first phase of planning.

As this paper highlights, grid upgrades will be necessary to accommodate fleet electrification and may take years to implement, depending on the upgrades required. One of the most common upgrades utilities will need is to update substations to ensure there is enough energy capacity to charge a nearby fleet. To determine which substations need to be upgraded to support fleet charging, the fleet operator must connect with the utility.

The second recommendation in this paper details the need for fleet operators to provide data to utilities so utilities can assist with electrification planning. If grid upgrades are needed in a particular area, fleet operators must request service timeline estimates from utilities and communicate those to internal stakeholders. Service requests may also take longer as a result of supply chain issues or market impacts from the COVID-19 pandemic, so the earlier fleet operators connect with their utility, the sooner they can submit service requests and provide those timelines to other relevant parties.

Walmart, Guidehouse, and DNV cited supply chain issues as a factor that is critical to consider in electrification planning. NYPA expressed concern regarding bottlenecks in the supply chain surrounding electric vehicle batteries and delivery of charging equipment. Based on these conversations, it is clear that supply chain issues will be imperative to factor into electrification timelines and ordering necessary equipment. Connecting with utilities early on will give fleet operators the time and information they need to complete other areas of the electrification process like ordering charging equipment and electric fleets. The earlier fleet operators can place orders, the more time they will have to factor in supply chain issues to other parts of the electrification process.

Many large fleet operators have ambitious electrification goals targeted within the next two decades. Connecting with the utility early on gives fleet operators a clearer understanding of the electrification process, what is required, and a realistic timeline of vehicle deployment. The earlier a fleet operator can connect with their utility, the more likely they will be to reach their fleet electrification goals.

B. Recommendation 2: Utilities Need More Data from Fleets

Change is a constant on the grid, and since the stress on the substation level can vary dramatically based on time and location, the more data a fleet can provide, the better. Three factors dictate everything on the grid: load size, load location, and load time. The less a utility knows about the fleet they are servicing, the more assumptions they are forced to make, which can lead to overbuilding or underbuilding for demand. Further, generating these assumptions takes time, and is less efficient than getting this information directly from fleet operators. This is a suboptimal outcome and negatively impacts what fleet operators are most concerned about: time and cost. Since the time of charging can affect what type of upgrades are needed, this data is also particularly essential.

At present, many fleets are reluctant to share data with utilities. Most utility interviewees stated that this was a problem they ran into, and noted fleets often want a lot from utilities, but are unwilling to give much in return. The fleet operators may be worried that sensitive data about fleet schedules, vehicles, and routes will harm their competitive edge if they are made public or discovered by a competitor. One utility even noted that large private companies had wanted the utility to sign nondisclosure agreements for access to basic information. This is a major barrier to improving the electrification process. While fleets may be reluctant to share their data with utilities, it ultimately helps their bottom line. As Recommendation 3 will further illuminate, a freer flow of information in both directions is critical to improving the nascent fleet electrification process. To make the fleet electrification process efficient for all parties, including utilities' larger rate base who in some cases will be footing a portion of the bill for a fleet electrifier, fleets must be more willing to share with utilities.

Several representatives from both utilities and consulting firms noted that often fleets and utilities are speaking "a different language." This communication barrier will get better with time, but there are actions that both parties can take to help improve these issues. Utilities can ensure that they provide tailored services to fleets to make it easier for them to understand the process, and more comfortable with sharing their data with the utility. Another improvement could come from legislation and regulation by protecting the sensitive data that fleet operators share with utilities, as well as third parties, making them more comfortable and willing to share sensitive information. More uniform industry standards may also help with data sharing, as the piecemeal approaches across utilities can be a challenge for fleet electrifiers. This problem mirrors many others uncovered by this report—the patchwork of state regulations, state funding, and different utility processes make the landscape around electrification difficult to navigate.

C. Recommendation 3: Fleet Electrifiers Need Information from Utilities

As discussed in the preceding recommendation, utilities view receiving information from aspiring fleet electrifiers as critical to accommodating fleet electrifiers' service requests. However, this flow of information must go both ways.

First and foremost, for fleet electrifiers to provide the necessary information for utilities to accommodate their requests, operators must *be aware* of the importance of engaging with utilities in the first place. Several utilities noted that potential fleet electrifiers were often unaware of the importance of including utilities in the planning stages of an EV charging infrastructure buildout, and at times had unrealistic expectations of the timeline for the necessary utility infrastructure implementation. Thus, outreach to fleet operators is a critical first step in establishing a flow of information to operators from utilities. Utilities are generally aware of the fleet operators operating within their service territory given their existing business relationship. While it is critical for fleet electrifiers to provide relevant information to utilities, the operators must be aware of this fact in order to act on it. Thus, utilities may benefit from proactively targeting fleet operators in their service area with preliminary information on fleet electrification, even if those entities have not yet approached the utility or stated an explicit fleet electrification goal.

As noted in Recommendation 2, it is also critical that utility representatives with an understanding of the technical aspects of EV infrastructure are involved at an early stage to provide information to fleet operators. The representatives interviewed from both Guidehouse and WRI noted that they act as facilitators between utilities and fleet operators and are effective in those roles because they are conversant in the language of both parties. Similarly, the representative from Walmart discussed a conversation with a utility which would have been more productive if representatives from the utility had a project engineering background. These examples suggest that there may be some room for improvement for utilities in hiring, training, or repositioning utility employees who have both the requisite technical skills and fluency in the language of fleet operators necessary to assist fleet electrifiers, such that operators can get the information they need from utilities to make informed business decisions.

Finally, conversations with both Walmart and the CEO suggested that a utility's excess hosting capacity at specific geographic locations does not factor into a fleet operator's decision to site EV charging infrastructure in a specific location. Based on those conversations, a fleet operator's operations are generally already established, and those decisions are made based on calculations central to the entity's core business. As such, providing hosting capacity information to fleet operators is likely a low priority, at least in the near term, but may become more important as customers evaluate infrastructure service needs and timelines. Later adopters of fleet electrification may be willing to be more flexible in siting charging infrastructure, particularly in jurisdictions where the regulatory environment requires the operator to contribute to the infrastructure costs associated with increasing hosting capacity at a specific location.

D. Recommendation 4: State Regulatory Bodies Should Expand Rate Basing Tools to Support Fleet Electrification

The results of this report highlight the differences in regulatory schemes that affect utilities' ability to rate base costs associated with supporting fleet electrification. While utility companies - particularly those with service areas spanning multiple jurisdictions - and large fleet operators have long been accustomed to navigating different regulatory environments across states, as one

IOU representative noted, states that limit a utility's ability to own and rate base charging infrastructure are impeding the adoption of electric fleet vehicles. This contention is supported by the example of PGE, in Oregon. PGE, which has legislative authority to rate base transportation electrification infra3structure, also has the most developed fleet charging program across all utilities interviewed pursuant to this project. While a variety of factors likely contribute to that dynamic, common sense suggests that PGE's ability to rate base EV fleet charging infrastructure (and thereby decrease the upfront costs to fleet operators of going electric) is a significant factor. It is also worth emphasizing that PGE does not expect the rate basing of fleet electrification infrastructure to increase rates for its customer base. Rather, the increased volume will allow these projects to be at worst rate-neutral, and may even decrease rates for PGE's customers.

This position is further supported by comments provided by Walmart. While no California utilities were interviewed for this report, a representative from Walmart stated that California has a favorable environment for early fleet electrification efforts due to the "make-ready" initiatives permitted in California to support fleet electrification. If this regulatory incentive to electrify fleets is influencing the decisions of an entity as well-resourced as Walmart, it would likely have an even larger influence on other entities for which the upfront costs of electrification are more burdensome.

Several utilities, as well as other entities, referenced the current debate across state regulatory commissions regarding utilities' ability to rate base fleet electrification infrastructure costs. **This debate should be resolved in favor of expanding the ability of utilities to rate base costs to support fleet electrification,** including charging infrastructure, in states that do not currently permit it. One benefit of the United States system of federalism is that it allows states to take cues from other states, and adopt policies that have been proven viable by other states. As evidenced by the experiences of PGE and Walmart, regulatory mechanisms such as those adopted in Oregon will encourage broader uptake of fleet electrification in a utility's service area, which will promote the important public policy goals of decreasing carbon emissions and local air quality impacts, and will not negatively impact the utility's broader customer base.

VI. Conclusion

In order to mitigate the worst impacts of climate change, greenhouse gas emissions will need to be reduced in all sectors of the economy. Since transportation is the largest contributor to CO2 emissions, electric vehicles are a vital tool in reducing emissions. In particular, the medium and heavy-duty trucks and buses involved in many fleet operations disproportionately emit significantly more CO2 than the light-duty vehicles which make up the majority of vehicles on the road. Converting trucks and buses to electric motors is a prime opportunity to reduce emissions and contribute to the global effort to address the climate crisis, and to address associated local air quality concerns.

While many large fleet operators are converting their fleets to electric, the recent passage of the IIJA provides funding and support for electrification across multiple sectors. The demand for electric vehicles and charging infrastructure will increase substantially in the next few years as will the demands placed on the electrical grid. This research highlights the importance of working with utilities and industry experts to determine the specific grid upgrades, infrastructure, charging programs, and rate changes that will be needed to support electrification on a larger scale.

Since many fleet operators are at the very early stages of electrification, this research can be helpful to advise both utilities and fleet operators on the level of collaboration necessary to electrify a fleet. More importantly, this paper provides specific recommendations for fleet operators on the importance of connecting with their utility early, engaging with multiple stakeholders during the process, and providing necessary data to utilities.

Like most new technologies, there is a great level of uncertainty regarding challenges that may occur in the future. It is unknown how batteries and renewables will further mature into increasingly affordable and effective technologies. It is also unclear how fleets will adjust the way they operate based on the strengths and weaknesses of EVs as compared to ICE vehicles. While this paper provides recommendations based on the utilities, fleet operators, and consulting organizations' electrification experience, more research is needed to address the grid impacts on other parts of the country and sectors of the economy.

As this paper explores, regulatory structures vary across regions and utility types. The varying regulatory structures can determine how much investment a utility puts into charging infrastructure which as a result can either encourage or discourage fleet electrification. Future research analyzing the impact of different regulatory structures on electric vehicle infrastructure in each service territory across the U.S. could contribute to a broader understanding of how regulatory changes could promote further fleet electrification.

Electrification of the transportation sector is essential for our climate and human health. Lessons learned today by early adopters will be critical in easing the transition for future adopters. As EV technology continues to improve, electric fleets have tremendous potential to outperform the ICE vehicles that are used predominantly in fleets today. These fleets will be more efficient, require less maintenance and result in significantly lower fuel prices. The future of fleets will not only put us on the path to zero emissions, it will also outperform existing technologies. For this transformation to be successful, utilities and fleet operators must be prepared for the challenges ahead.

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VIII. Appendices

Appendix 1: Entities Interviewed

American Electric Power is an investor-owned energy holding company. Its 7 utilities operate in 11 states – Ohio, Texas, West Virginia, Virginia, Tennessee, Indiana, Kentucky, Oklahoma, Michigan, Arkansas, Louisiana – and provide services to about 5.5 million customers. The team interviewed Adriane Jaynes, Electric Transportation Manager, and Daniel Francis, Director of Customer Solutions & Policy Insights, on March 30, 2022.

Arizona Public Service Co. is an investor-owned utility company providing services to 2.7 million customers in Arizona. The utility is the largest energy provider in the state. The Team interviewed Tony Perez, Senior Energy Innovation Analyst, on March 18, 2022.

Dominion Energy is an investor-owned utility providing services to about 7 million customers in 8 states – Idaho, North Carolina, Ohio, South Carolina, Utah, Virginia, West Virginia, and Wyoming. The team interviewed Kate Staples, Electrification Manager, on March 30, 2022.

Duke Energy is an investor-owned energy holding company. Its utilities provide services to 8.2 million customers in North Carolina, South Carolina, Florida, Indiana, Ohio, and Kentucky. The team interviewed Evan Shearer, Principal Integrated Planning Coordinator, and Jason Haines, Manager of Fleet Electrification, on March 15, 2022.

Exelon Corporation is an investor-owned energy holding company. Its utilities provide services to more than 10 million customers in Delaware, New Jersey, northern Illinois, central and western Maryland, southeastern Pennsylvania, and Washington D.C. The team interviewed Chris Budzynski, Director of Utility Policy, on March 3, 2022.

National Grid is an investor-owned utility providing service to more than 20 million people in New York, Massachusetts, and Rhode Island. The team interviewed Gideon Katsh, Principal Analyst in Clean Energy Development, on March 25, 2022.

New York Power Authority is a state-owned public power utility operating 16 generating facilities and more than 1,400 circuit-miles of transmission. The team interviewed John Markowitz, Director of E-Mobility Technology & Engineering, on March 10, 2022.

Platte River Power Authority is a community-owned electric cooperative, providing services to Estes Park, For Collins, Longmont, and Loveland, Colorado. The team interviewed Wade Troxell, former chair of the board of directors, on March 15, 2022.

Portland General Electric is an investor-owned utility providing service to 1.9 million customers in Portland and Salem, Oregon, and its surrounding area. The team interviewed Larry Bekkedahl, Senior Vice President of Advanced Energy Delivery, Luke Whittemore, Transportation

Electrification Engineer, and Andy Macklin, Director, Smart Cities & Grid Products, on March 8, 2022.

Rappahannock Electric Cooperative is a rural electric cooperative providing services to 22 counties in central Virginia. The utility has over 170,000 electric connections. The team interviewed Joyce Bodoh, Director of Energy Solutions and Clean Energy, on March 11, 2022.

United Power is a rural electric cooperative providing services west of Denver, Colorado, and northeast of Denver. The utility surpassed 100,000 meters served and 300,000 members in June 2021. The team interviewed Joel Danforth, Energy Programs & New Business Director, on March 23, 2022.

DNV is a consulting firm specializing in assurance and risk management as well as a leading classification society and advisor to the maritime industry. They also provide advisory services to the energy transition including renewables, oil and gas, and energy management. The team interviewed J.R. Killigrew, Head of EV Business Development North America at DNV, on March 14, 2022.

Guidehouse Consulting provides consulting services to public and private entities focusing on transformational change, business resilience, and technology-driven innovation. They have provided their services to utilities, fleet operators, and government entities to support fleet electrification. The team interviewed Derek Jones, Director of Mobility Solutions, on March 14, 2022.

World Resources Institute is a non-profit, global research organization providing support to private and public entities on issues related to food, forests, water, ocean, cities, energy, and climate. They have launched the Electric School Bus Initiative to support the transition towards electric school bus fleets. The team interviewed Gregg Kresge, Senior Manager of Utility Engagement and Transportation Electrification, and Stephanie Ly, Senior Manager of eMobility Strategy and Manufacturing Engagement, on March 21 and 29, 2022.

California Energy Commission is the state energy office for California. The team interviewed Quentin Gee, Supervisor of the Transportation Energy Forecasting Unit, and Mike Nicholas, Supervisor of the Infrastructure Modeling and Assessment Unit, on March 29, 2022.

Colorado Energy Office is the state energy office for Colorado. The team interviewed Christian Williss, Senior Director of Transportation Fuels and Technology, and Kelly Blynn, Transportation Climate Change Specialist, on March 30. 2022.

Oregon Public Utility Commission is the regulatory agency overseeing electric, gas, and telephone utilities. They are responsible for setting the rates and the rules for Oregon's investor-owned utilities, such as Portland General Electric. The team interviewed Eric Shierman, Analyst, on April 14, 2022.

Walmart is a national retailer in the United States targeting a 100 percent zero-emission fleet by 2040. The team interviewed Steve Chriss, Director of Energy Services, on March 29, 2022.

Appendix 2: Interview Questions

Utility Interview Script

*The enumerated research questions are not meant to be asked. Rather, they frame the bulleted interview questions beneath it.

1. To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes (Where are we now)?
    - Does the utility know exactly how much excess capacity it has based on geographic location that could be used to accommodate fleet electrification now?
    - Have you attempted to quantify the increased demand from future fleet electrification?
    - What data do utilities need from fleet operators in order to do so?
    - What data do fleet operators need from utilities in order to better understand hosting capacity?
        - Is this data available to fleet operators?
    - Is there a way fleet operators can work with utilities to understand hosting capacity? Is there a common method across utilities that you are aware of that can help local fleets understand hosting capacity (e.g., solar industry hosting capacity maps)?
        - Would the utility be willing to participate in something to that effect?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
    - Does the utility have a way of knowing what hosting capacity fleet operators will need in the future?
    - Specifically, what grid investments will be required in order to accommodate increased fleet electrification?
    - What does early engagement between a fleet operator and utility look like in practice?
        - What steps can be taken to ensure maximum benefit and efficiency to all parties?
    - Has the utility considered methods for reducing the peak demand associated with increased fleet vehicle charging?
        - What rate changes for fleet operators have you explored in order to increase grid optimization?

                - Time-variable and real-time market-based rates for charging at times that increase grid utilization and the use of renewable energy?
        - What incentives have you looked at for fleet operators that contribute to grid services like frequency regulation?
            - Vehicle to grid infrastructure?
            - Battery storage?
3. To what extent do current mechanisms allow utilities to rate base these investments?
    - Has the utility considered how it plans to recoup investments needed to accommodate the increased demand from fleet electrification?
    - Do you feel that the current regulatory landscape allows the utility to plan for and recoup these costs in a way that makes sense for the utility and its customers?
        - If not, what changes do you think need to be made?
4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
    - Has the utility considered how it can utilize funds from the Infrastructure Bill toward the costs of additional charging infrastructure?
    - Are there any key questions or challenges you foresee with accessing IIJA funding?
5. What broader lessons can be learned from the needs of private entities seeking to electrify their fleets that are applicable to other entities with fleet electrification goals?
    - What concepts are applicable to all entities who might at some point electrify their fleets?
        - From the utility's perspective, what do you think fleet operators need to know that could help them plan for electrification?
        - What potential issues do you see for those entities?

6. Miscellaneous
    - Have you or a customer conducted a case study on fleet electrification and the impact that it will have on your utility?
        - If so, what did it cover?
        - Would you be able to share this case study with us?
    - Based on what we've talked about today, is there anything else that you think is important to know that we haven't had a chance to cover?

Consultant Interview Script

*The enumerated research questions are not meant to be asked. Rather, they frame the bulleted interview questions beneath it.

1. To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes (Where are we now)?
    - What data do utilities need from fleet operators in order to quantify increased demand as a result of future fleet electrification?
    - What data do fleet operators need from utilities in order to better understand hosting capacity?
        - Is this data available to fleet operators?
    - Is there a way fleet operators can work with utilities to understand hosting capacity? Is there a common method across utilities that you are aware of that can help local fleets understand hosting capacity (e.g., solar industry hosting capacity maps)?
        - Would a utility be willing to participate in something to that effect?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
    - Specifically, what grid investments will be required in order to accommodate increased fleet electrification?
    - What does early engagement between a fleet operator and utility look like in practice?
        - What steps can be taken to ensure maximum benefit and efficiency to all parties?
    - In your experience, have utilities considered methods for reducing the peak demand associated with increased fleet vehicle charging?
        - Are there incentives utilities can offer fleet operators that contribute to grid services like frequency regulation?
            - Vehicle to grid infrastructure?
            - Battery storage?
3. To what extent do current mechanisms allow utilities to rate base these investments?
    - Do you help utilities structure investments in infrastructure associated with fleet electrification in a way that ensures those investments can be rate-based?

4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
    - Are there any key questions or challenges you foresee with accessing IIJA funding for both the utilities and fleet operators that seek to electrify?
5. What broader lessons can be learned from the needs of private entities seeking to electrify their fleets that are applicable to other entities with fleet electrification goals?
    - What concepts are applicable to all entities who might at some point electrify their fleets?
6. Miscellaneous
    - Are there any specific reports or case studies on fleet electrification that you would recommend to us to review?
    - Based on what we've talked about today, is there anything else that you think is important to know that we haven't had a chance to cover?

State Energy Office Interview Script

*The enumerated research questions are not meant to be asked. Rather, they frame the bulleted interview questions beneath it.

1. To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes (Where are we now)?
    - Has the Colorado Energy Office done any type of forecasting regarding the increased demand of electricity from fleet electrification, and the ability of the grid to accommodate that increased demand?
    - Does the Colorado Energy Office have access to hosting capacity information for Colorado utilities?
    - To your knowledge, do Colorado utilities have the information they need from fleet operators to accurately plan for increased fleet electrification?
    - Do fleet operators have the information they need from utilities in order to plan for fleet electrification, to your knowledge?
    - Is there a way fleet operators can work with utilities to understand hosting capacity? Is there a common method across utilities that you are aware of that can help local fleets understand hosting capacity?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
    - Specifically, what type of grid investments will be required in order to accommodate increased fleet electrification?

    - Do you have a concept of the amount of total grid investment that will be required to meet this demand in Colorado?
    - Do you know what the current process looks like between a fleet operator considering electrification and the utility?
        - Do you think this process could be improved in any way?
        - Do you view facilitating this process in any way as within the purview of the Colorado Energy Office?
    - Under current regulations, what tools do utilities have for reducing the peak demand associated with increased fleet vehicle charging?
        - Do they have the ability to create a distinct rate schedule?
            - Time-variable and real-time market-based rates for charging at times that increase grid utilization and the use of renewable energy?
        - What tools do utilities have to incentivize fleet operators to contribute to grid services?
            - Frequency regulation?
            - Vehicle to grid infrastructure?
            - Battery storage?
        - Do you think current incentives are sufficient to prompt fleet electrifiers to participate?
3. To what extent do current mechanisms allow utilities to rate base these investments?
    - Under current regulations, are utilities able to rate base grid infrastructure upgrades needed to support fleet electrification?
        - What if those upgrades are required to support the electrification of a single entity?
    - Is the utility able to rate base “behind the meter” equipment/infrastructure (*e.g.*, the chargers themselves)?
    - Do you feel that the current regulatory landscape allows utilities to plan for and recoup these costs in a way that makes sense for the utility and its customers?
        - If not, what changes do you think need to be made?
4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
    - Is the Colorado Energy Office involved at all in the disbursement of funds under the IIJA?
        - If so, how?
5. Miscellaneous

- Has the Colorado Energy Office conducted any research or case studies on fleet electrification?
    - If so, what did it cover?
    - Would you be able to share this information with us?
- Based on what we've talked about today, is there anything else that you think is important to know that we haven't had a chance to cover?

Fleet Operator Script (Walmart)

*The enumerated research questions are not meant to be asked. Rather, they frame the bulleted interview questions beneath it.

1. To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes (Where are we now)?
    - Have you attempted to quantify the amount of additional electricity your fleet electrification goals will require?
        - What factors go into that analysis?
        - By geographic location?
    - What information do you need from utilities in order to do so?
        - Have you been able to get the information that you need?
            - Does this vary across utilities?
    - Are you aware of any tools that fleet operators can use to better understand current hosting capacity? Is there a common method across utilities that you are aware of that can help local fleets understand hosting capacity (e.g., solar industry hosting capacity maps)?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
    - Have you had discussions with utilities regarding your projected electricity demands from fleet electrification and the utilities' ability to meet those demands in various geographic locations?
        - Is there any information that you have regarding fleet electrification planning that you are reluctant to share with the utilities for competitive reasons?
            - If so, are there any steps utilities could take to help alleviate this concern?
    - At this point, does the hosting capacity of various geographic locations factor into your charging infrastructure planning at all?
        - Does it make sense for you to tailor the geographic location of distribution centers based on excess hosting capacity/utility infrastructure, or are those locations too established at this point?

- What does early engagement between a fleet operator and utility look like in practice?
    - What steps can be taken to ensure maximum benefit and efficiency to all parties?
- Have you had discussions with utilities geared toward reducing the peak demand associated with increased fleet vehicle charging?
- Have you had discussions regarding potential rate schedule changes? (e.g.,time-variable and real-time market-based rates for charging at times that increase grid utilization and/or the use of renewable energy?)
- Have you had discussions with utilities about the potential for fleet operators to contribute to grid services?
    - Frequency regulation?
    - Vehicle to grid infrastructure?
    - Battery storage?
        - Generally, these types of grid services require relinquishing some level of control over the charging process. Do you think it makes sense for you to do so?

3. To what extent do current mechanisms allow utilities to rate base these investments?
    - The ability of utilities to rate-base EV charging infrastructure varies considerably by jurisdiction. Are there any state regulatory schemes that you have found are particularly conducive to meeting your fleet electrification goals?
        - Any that seem particularly challenging?
    - All else being equal, would you prefer a regulatory environment that allowed the utility to rate-base *all* behind the meter charging infrastructure (assuming the utility owned and operated the infrastructure), or would you prefer to own and operate the infrastructure even at added cost?
    - In general, what changes would you like to see in the current regulatory landscape in this area?
4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
    - Have you considered how you might be able to utilize funds from the Infrastructure Bill toward the costs of additional charging infrastructure?
    - Are there any key questions or challenges you foresee with accessing IIJA funding?
5. What broader lessons can be learned from the needs of private entities seeking to electrify their fleets that are applicable to other entities with fleet electrification goals?

- Based on your experience in this space so far, are there any concepts that you have learned that could be applicable to all entities who might at some point electrify their fleets?
    - What potential issues do you see for those entities?

6. Miscellaneous
    - Have you conducted any case studies or pilot programs regarding fleet electrification?
        - If so, what did it cover?
        - Would you be able to share any of this information with us?
    - Based on what we've talked about today, is there anything else that you think is important to know that we haven't had a chance to cover?

Oregon Public Utility Commission Interview Script

*The enumerated research questions are not meant to be asked. Rather, they frame the bulleted interview questions beneath it.

1. To what extent can the fleet electrification goals of private entities seeking to electrify their fleets be accommodated by the grid without making any changes (Where are we now)?
    - Has the PUC done any type of forecasting regarding the increased demand of electricity from fleet electrification, and the ability of the grid to accommodate that increased demand in Oregon?
    - Does the PUC have access to hosting capacity information for Oregon utilities?
    - To your knowledge, do Oregon utilities have the information they need from fleet operators to accurately plan for increased fleet electrification?
    - Do fleet operators have the information they need from utilities in order to plan for fleet electrification, to your knowledge?
    - Is there a way fleet operators can work with utilities to understand hosting capacity? Is there a common method across utilities that you are aware of that can help local fleets understand hosting capacity?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
    - Do you have a concept of the amount of total grid investment that will be required to meet this demand in Oregon?
    - Specifically, what type of grid investments will be required in order to accommodate increased fleet electrification in Oregon?
    - Do you know what the current process looks like between a fleet operator considering electrification and the utility?
        - Do you think this process could be improved in any way?

        - Do you view facilitating this process in any way as within the purview of the PUC?
    - Under current regulations, what tools do utilities have for reducing the peak demand associated with increased fleet vehicle charging?
        - Do they have the ability to create a distinct rate schedule?
            - Time-variable and real-time market-based rates for charging at times that increase grid utilization and the use of renewable energy?
        - What tools do utilities have to incentivize fleet operators to contribute to grid services?
            - Frequency regulation?
            - Vehicle to grid infrastructure?
            - Battery storage?
        - Do you think current incentives are sufficient to prompt fleet electrifiers to participate?
3. To what extent do current mechanisms allow utilities to rate base these investments?
    - We spoke to Portland General Electric, who said that under Oregon law they have the authority to rate-base their costs associated with fleet electrification service, including the charging infrastructure. When did Oregon utilities get this authority?
        - To what extent does the PUC have oversight over utilities' decisions to rate base these costs?
        - From what you have seen so far, what has the effect of utilities' rate basing of these costs been on overall rates for Oregon customers?
        - In your view, has this accelerated the uptake of fleet electrification across the state?
        - Are there any concerns that this policy discourages private investment in the state?
    - In general, do you feel that the current regulatory landscape allows utilities to plan for and recoup their fleet electrification costs in a way that makes sense for the utility and its customers?
        - If not, what changes do you think need to be made?
4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
    - Is the PUC involved at all in the disbursement of funds under the IIJA?
        - If so, how?
5. Miscellaneous

- Has the PUC conducted any research or case studies on fleet electrification?
    - If so, what did it cover?
    - Would you be able to share this information with us?
- Based on what we've talked about today, is there anything else that you think is important to know that we haven't had a chance to cover?

WRI School Bus Initiative Script

*The enumerated research questions are not meant to be asked. Rather, they frame the bulleted interview questions beneath it.

1. To what extent can the fleet electrification goals of entities seeking to electrify their fleets be accommodated by the grid without making any changes (Where are we now)?
    - Have you attempted to quantify the amount of additional electricity the ESBI goal will require?
        - What factors go into that analysis?
        - By geographic location?
    - What information do you need from utilities in order to do so?
        - Have you been able to get the information that you need?
            - Does this vary across utilities?
    - Are you aware of any tools that fleet operators can use to better understand current hosting capacity? Is there a common method across utilities that you are aware of that can help local fleets understand hosting capacity (e.g., solar industry hosting capacity maps)?
2. What investment in grid infrastructure is required to support the fleet electrification goals of private entities seeking to electrify their fleets?
    - Have you had discussions with utilities regarding your projected electricity demands from school bus electrification and the utilities' ability to meet those demands in various geographic locations?
    - At this point, does the hosting capacity of various geographic locations factor into your charging infrastructure planning at all?
        - Does it make sense for you to tailor the geographic location of bus parking hubs based on excess hosting capacity/utility infrastructure, or are those locations too established at this point?
    - What does early engagement between WRI/school district and a utility look like in practice?
        - What steps can be taken to ensure maximum benefit and efficiency to all parties?

- Have you had discussions with utilities geared toward reducing the peak demand associated with increased bus fleet vehicle charging?
- Have you had discussions regarding potential rate schedule changes? (e.g.,time-variable and real-time market-based rates for charging at times that increase grid utilization and/or the use of renewable energy?)
- Have you had discussions with utilities about the potential for school bus fleets to contribute to grid services?
    - Frequency regulation?
    - Vehicle to grid infrastructure?
    - Battery storage?
        - Generally, these types of grid services require relinquishing some level of control over the charging process. Do you think it makes sense for you to do so?
        - Are the current incentives being discussed sufficient to justify providing these services?

3. To what extent do current mechanisms allow utilities to rate base these investments?
    - The ability of utilities to rate-base EV charging infrastructure varies considerably by jurisdiction. Are there any state regulatory schemes that you have found are particularly conducive to meeting your fleet electrification goals?
        - Any that seem particularly challenging?
    - All else being equal, would you prefer a regulatory environment that allowed the utility to rate-base *all* behind the meter charging infrastructure (assuming the utility owned and operated the infrastructure), or would you prefer to own and operate the infrastructure even at added cost?
    - In general, what changes would you like to see in the current regulatory landscape in this area?
4. How can State and Federal policy, including funds from the 2021 Infrastructure Investment and Jobs Act, be targeted to most effectively facilitate the fleet electrification goals of private entities seeking to electrify their fleets?
    - Have you considered how you might be able to utilize funds from the Infrastructure Bill toward the costs of additional charging infrastructure?
    - Are there any key questions or challenges you foresee with accessing IIJA funding?
5. What broader lessons can be learned from the needs of private entities seeking to electrify their fleets that are applicable to other entities with fleet electrification goals?
    - Based on your experience in this space so far, are there any concepts that you have learned that could be applicable to all entities who might at some point electrify their fleets?

    - What potential issues do you see for those entities?

6. Miscellaneous
    - Have you conducted any case studies or pilot programs regarding fleet electrification?
        - If so, what did it cover?
        - Would you be able to share any of this information with us?
    - Based on what we’ve talked about today, is there anything else that you think is important to know that we haven’t had a chance to cover?