THE ELECTRIC SCHOOL BUS TRANSITION:

Accelerating Equitable Deployment Through Understanding Grid Impacts and Policy Solutions

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LIST OF ACRONYMS

AC	Alternating Current
ACT	Advanced Clean Trucks
CARB	California Air Resources Board
CSBP	Clean School Bus Program
CSNA	Climate Solutions Now Act
DC	Direct Current
DCFC	Direct Current Fast Charge
EPA	Environmental Protection Agency
ESB	Electric School Bus
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GHG	Greenhouse Gas
HC	Hosting Capacity
ICE	Internal Combustion Engine
NO_x	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter smaller than 2.5 μm
PUC	Public Utility Commission
TCO	Total Cost of Ownership
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything
VOC	Volatile Organic Compound
WRI	World Resources Institute

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EXECUTIVE SUMMARY

The electrification of the U.S. school bus fleet of nearly half a million vehicles provides utility companies and other stakeholders with the opportunity to achieve a variety of health, environmental, energy, resilience, and economic development goals. Students from underserved communities face a disproportionate share of air pollution and other harms associated with emissions from the largely diesel-powered school bus fleet. If pursued with an equity-centered approach, the electrification transition can serve to help address current and historic inequities.

Accelerating the equitable deployment of electric school buses (ESBs) presents a number of challenges, including the need to manage grid-related impacts and to establish new utility sector policy solutions. This white paper aims to analyze the potential impact of widespread school bus electrification on the electricity grid, demonstrate the unique opportunities presented to utility companies, and serve as a guide for public utility commissions (PUCs), policymakers, and school bus operators to reduce common barriers to adoption and ensure an equitable transition to ESBs. The report will explore the current state of school bus electrification, the anticipated growth in demand for ESBs, and the importance of incorporating equity as a key value. It will highlight the critical role that utility companies can play, and are already supporting, for an equitable and efficient transition and it will provide a detailed guide that maps the roles that a utility company could play throughout the school bus electrification journey. This report will provide a novel assessment of the grid and load impacts from ESBs at scale on the power system to help inform the transition. Finally, the report addresses policy enablers for school bus electrification and offers recommendations on how utility companies can employ innovative and accessible services to support the equitable electrification of school bus fleets.

The bipartisan Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA) have created a once-in-a-generation financial opportunity to electrify school buses across the nation and deliver a unique set of benefits to students, communities, and school bus operators. The Environmental Protection Agency's (EPA's) Clean School Bus Program (CSBP) prioritizes high-need school districts and low-income areas as well as Tribal school districts. The EPA aims to meet recommendations from the Justice40 Initiative to ensure that at least 40% of the benefits from the CSBP fund disadvantaged communities. Additional funding is available through a growing number of state programs as well. More information on state-level funding is available from the World Resource Institute's (WRI) website. School bus operators, a term used to include school districts and school bus contractors, have already begun to take advantage of these opportunities. Federal funding alone, however, is not enough to fully electrify all school bus fleets across the United States due to the complex set of infrastructure, operational, and financial issues needed to implement projects at scale; additional support and complementary programs to achieve this important vision and advance equity will be required. All stakeholders, including customers, communities, school bus operators, policymakers, and the utility industry, have important roles and must come together to take advantage of this opportunity and accelerate the equitable transition to ESBs.

The electrification of a school bus fleet necessitates the collaborative efforts of a diverse and dedicated team, bringing together various stakeholders, community members, and expertise to ensure a project's success. This white paper targets key members of the ESB ecosystem and is intended to be used as a resource for communities, utility companies, public utility commissions, policymakers, and school bus operators, considering, or in the process of, transitioning to ESBs. Developing and fostering these collaborative efforts between the various stakeholders creates the potential for innovative solutions designed to deliver the full spectrum of intended benefits from school bus electrification. The benefits of school bus electrification include four significant elements that incorporate cross-cutting equity considerations: environmental justice and public health benefits, environmental benefits, economic benefits, and grid flexibility benefits.

EQUITY IN TRANSITION

The transition to electric school buses can play an important and meaningful role in addressing many of the inequities faced by underserved communities and has the potential to deliver value to these communities. Throughout the electrification transition, it is imperative that underserved communities are prioritized to experience the health and societal benefits of ESBs. These communities are often disproportionately exposed to poor air quality, face greater burdens from climate change, and are frequently worst situated to manage these burdens. Focusing on equity early and consistently through every stage of ESB development and deployment increases the likelihood of ESB programs being maximally responsive to the community's needs. It also strengthens risk management by gathering a wider array of perspectives, including those from communities most impacted, which provides identification of potential and unrecognized conflicts. Clean Energy Works prepared an equity framework tailored for this paper that utility companies can work to implement along with community partners and other important stakeholders. This framework, presented in **Appendix B**, characterizes equity into four dimensions. These dimensions contour the ESB development and implementation life cycle from initial program conception through execution and evaluation: procedural, recognition, distributive, and reparative equity. Utility companies that follow this framework are more likely to build their role as valued partners in empowering communities and avoid perpetuating inequities in their ESB programs.

UNDERSTANDING GRID IMPACTS

This white paper discusses a new analysis prepared by the Electric Power Research Institute (EPRI) to analyze the charging profiles and infrastructure impacts of ESBs on the electric distribution system. The complete analysis can be found in **Appendix A** in the form of a memorandum. The analysis models the technical and economic drivers of ESB charging equipment operations to determine various ESB load shapes and evaluates the impacts of those loads at various feeder locations. The analysis was designed to provide a clearer perspective on the operational aspects of ESBs and the resulting potential need for infrastructure investments in support of school bus electrification. Important highlights include:

- **The ability for distribution feeders to accommodate ESBs will vary from feeder to feeder.** Depending on the specific characteristics of the feeder (e.g., existing load, topology, line rating, the presence of distributed energy resources), the ability for the available capacity to host large ESB deployments, along with potential corresponding grid investments required, will vary. School bus operators will benefit from understanding potential grid and feeder implications.
- **There is seasonal and daily variability in the hosting capacity**. School bus operations have unique load profiles that provide opportunities for cost savings through the ability to capitalize on off-peak capacity availability, but there may be site-specific and use case-specific constraints that should be thoroughly considered. Nonetheless, it is important to recognize the opportunity for the industry to help inform future policy and regulations.
- **Grid impacts of ESBs will vary depending on the flexibility of operators' schedules and what percent of non-route time can be spent charging.** Although most ESBs typically sit idle in the evening and overnight following their daily route schedules, other operational constraints may impact the times and durations available for charging. ESBs that can be plugged in for more of their non-route time, or dwell time, may be charged with less expensive, lower power equipment that could potentially trigger fewer grid upgrades and lower demand charges.
- **Available hosting capacity will inform the process and timeline for school bus operators navigating electrification.** For operators with depots located along distribution feeders with relatively greater hosting capacity, near-term electrification will be simpler because current grid capacity will support at least the initial phase of depot electrification. For operators with depots along feeders with relatively lesser hosting capacity, electrification could be more complex and entail more time and costs as it will depend on the utility company's timeline for adding capacity or the utility company's or operator's identification of additional solutions (e.g., mobile energy storage). Operators should work with their utility company's timeline to understand the available hosting capacity and achieve their electrification goals in the most cost-efficient manner across various depots.

THE ROLE OF UTILITY COMPANIES

Despite increased levels of adoption of ESBs, the transition is still in the early stages, with just over one percent of the school buses committed to be electrified in the United States (WRI, 2023). Utility companies can play a critical role in supporting an equitable and efficient transition. Utility companies may play traditional and non-traditional roles to support school bus operators in developing, implementing, and deploying ESBs. Important utility roles include:

- **Essential strategic partner in electrification planning, connecting ESB fleets to the broader power grid.** Utility companies promote long-term planning by understanding the grid impact of the services and potential site infrastructure upgrades associated with fleet electrification. Utility companies can help the school bus operator understand the process for requesting new utility service, the associated timeframes and costs of the required infrastructure, ways to optimize consumption, and engage community and equity partners in this process.

- **Source of knowledge and experience from prior deployments to enable operators to navigate electrification.** Utility companies that have already supported ESB deployments have knowledge that can inform operators throughout planning and installation. Sharing insights from these experiences can help districts avoid potential pitfalls and optimize their fleet electrification plan.
- **Provider of incentive programs and an innovator of design rates.** Utility companies can develop incentive program offerings that address common barriers to adoption for school bus operators and complement government funding programs. These programs could range from offering incentives on ESB purchases and electric vehicle supply equipment (EVSE) to minimize the upfront capital cost to designing rates intended to minimize the total cost of ownership to technical assistance programs to educate bus operators. These programs will offer school districts practical means to meet their electrification targets.

POTENTIAL POLICY ENABLERS

Beyond the available federal and state funding, supporting policies and regulatory programs will be needed to complement this funding and help reduce barriers to adoption and accelerate ESB deployment. This white paper highlights several examples of various policy levers and regulatory programs in existence or that could potentially reduce barriers and accelerate adoption:

- **To help operators navigate the complex end-to-end process of electrification, utility companies, in cooperation with regulators, can develop programs tailored to reduce barriers to adoption and accelerate the transition to ESBs.** Well-designed, utility-sponsored programs can work in tandem with government funding programs and serve to address barriers and accelerate equitable adoption of ESBs. Through utility-sponsored programs offering a wide range of solutions, utility companies can help operators navigate the complex end-to-end process of electrifying their fleet. Those utility-sponsored programs can include rebates and incentives for ESBs, support for infrastructure and equipment, and customer-facing tools and resources.
- **To reduce operators' total operational costs and manage utility grid impacts, policymakers could consider developing innovative rate design.** To support ESB adoption, and affordable management and operations, policymakers could collaborate with PUCs and utility companies to develop programs and incentives and innovative rate designs that support equitable electrification. These programs and incentive structures would help accelerate the widespread implementation of ESBs and access to benefits with a focus on underserved communities. Rate design can be an effective tool for policymakers to incentivize charging behaviors and minimize system impacts. Given the unique operating characteristics of ESBs, rates can be designed to take advantage of periods of lower system demand and provide benefits to operators and utility companies.
- **To meet future demand, policymakers should consider a more proactive approach to grid planning in support of school bus electrification.** Compared to the current, reactive approach

to system investment under the traditional regulatory paradigm, policymakers should consider allowing utility companies to proactively invest in the system to facilitate and prepare for school bus electrification. When utility companies collaborate closely with school bus operators on the operators' long-term electrification plans, traditional concerns about the risk of stranded utility investments can be mitigated, enabling time and cost savings for fleet operators, utility companies, and customers through efficient construction and deployment of necessary infrastructure.

- **To enhance the full value proposition of ESBs, utility companies should consider equitable compensation mechanisms for vehicle-to-grid (V2G) utilization.** In determining the appropriate levels of compensation, utility companies should consider the type, location, time of day, and magnitude of benefit provided by the exported power. By providing a fair compensation mechanism for this exported power, utility companies can create a more equitable rate structure and help to lower overall costs for ESB operators.

School bus fleet electrification represents an unprecedented opportunity for environmental, public health, economic, and grid flexibility gains to address longstanding social equity issues. Navigating this complex and multi-faceted transition in collaboration with diverse stakeholders will be instrumental to the success of this opportunity. Utility companies have a critical role in facilitating this transition by offering strategic partnerships, incentive programs, sharing insights from prior deployments, and leveraging their expertise for efficient grid connections. Using existing and emerging policy tools effectively can catalyze ESB adoption while advancing an equitable transition. Stakeholders are responsible for working together to address barriers and to leverage funding and policy mechanisms to maximize the benefits of school bus electrification for students and communities across the country.

CHAPTER I

BACKGROUND

The growing concern about climate change and air pollution's impact on public health has prompted various stakeholders to consider sustainable alternatives to traditional modes of transportation. One such area of focus is the electrification of school buses. There are 480,000 school buses in the United States, and as of the end of 2022, 3,043 electric school buses (ESBs) were awarded, ordered, delivered, or deployed in the U.S. (Chard et al., 2023). ESB adoption presents numerous opportunities and benefits, such as environmental, total cost of ownership (TCO) savings, improved student and driver health, educational benefits, and economic development opportunities in the green job sector. The Environmental Protection Agency (EPA), at the direction of Congress, is encouraging school bus operators, a term used to include school districts and school bus contractors, to adopt ESBs with the introduction of the Clean School Bus Program (CSBP), which will provide $5 billion of funding to replace existing school buses with zero- and low-emission buses. Under the 2022 rebate round of the CSBP, the EPA awarded funding for an estimated 2,400 additional ESBs, nearly doubling the previous national total (Lewis, 2022).

The current unprecedented funding wave for ESBs has already started to bridge the financial gap between internal combustion engine (ICE) school bus fleets and electric ones. The U.S. has taken many steps toward increased adoption of ESBs, but several supplementary opportunities exist. Despite the increased level of funding for ESBs and the magnitude of adoption, federal funding alone is not enough. This transition can often be complex and present challenges, particularly in underserved communities that stand to benefit the most from this transition. The utility industry is uniquely positioned to address the unique barriers and challenges to ESB adoption and advance an equitable distribution of the benefits of ESBs. These barriers include upfront capital costs, education around ESBs, electric vehicle supply equipment (EVSE) technology and the associated infrastructure planning, navigating the new service connection process, and resources to support small pilot programs and the transition to large-scale deployments.

Recent initiatives and policies such as the CSBP have been instrumental in advancing the electrification of school buses, a critical step toward reducing greenhouse gas (GHG) emissions and improving air quality in communities that need it most. However, further exploration of the crucial role utility companies can play in aiding and expediting ESB adoption presents significant opportunities for innovation. Utility companies can help unlock new, effective strategies to electrify school bus fleets, which will promote a more sustainable future for the transportation sector. By working with school bus operators and communities, utility companies can provide tailored solutions for required infrastructure, incentives to purchase buses and bus batteries, demand management programs, and grid resilience solutions.

In recent years, initiatives and policies at the state and federal levels have sought to alleviate the most notable barrier to school bus electrification: the upfront cost of an ESB, which can be more than twice that of an ICE bus. The purchase price of ESBs vary based on type, make, model, and geographic location, with a range of $230,000 to more than $400,000 (Williams, 2022; Office of General Services, 2022). However, other significant barriers exist, such as upfront investments for charging infrastructure and grid upgrades, comprehension of new technology, and working through operational challenges. Utility companies have a unique opportunity to help operators overcome these barriers and accelerate this market transformation.

The electrification of a school bus fleet necessitates the collaborative efforts of a diverse and dedicated team, bringing together various stakeholders and expertise to ensure a project's success. This team could be comprised of a variety of individuals from the school bus operator, the bus dealer, the charging infrastructure company, city planners, first responders, and the local utility company. The collaboration between these stakeholders not only streamlines the implementation process but also addresses all aspects of the project. Partnering with a utility company as early as possible in the process will help the operator understand the framework of an ESB transition and develop a long-term strategic vision for school bus electrification as they transition from a pilot program to a large scale ESB implementation. Local utility companies can play a crucial role in offering advisory services, ensuring access to the energy needed to charge the fleet, while facilitating any additional necessary energy infrastructure for operating the ESB fleet. This includes meters, transformer, and capacity upgrades, as well as providing a customer electricity rate that helps with managing overall electricity costs. Utility companies can also benefit from this adoption from a grid flexibility perspective and are rising to meet these barriers and challenges.

New improvements in local air quality monitoring and planning initiatives for community resilience can help equitably deploy finite clean transportation resources, like ESBs, where their impact will produce the most benefit. Principles of environmental justice promote an inclusive process to develop and prioritize initiatives. In turn, the needs and benefits of different communities aid these processes.

CHAPTER II

BENEFITS OF SCHOOL BUS ELECTRIFICATION

The benefits of electrifying school buses cover four significant elements that include cross-cutting equity considerations: environmental justice and public health benefits, environmental benefits, economic benefits, and grid resource benefits. All four of these deliver important benefits to communities deploying ESBs. In this context, utility companies hold an increasingly central role in facilitating this transition to address climate change and shape ESB policies to foster school bus electrification and support a cleaner, more resilient electrical grid. The need to scale quickly is further necessitated by government mandates to electrify the sector and an abundance of available funding, positioning utility companies as crucial players in promoting both school bus electrification and the modernization of the electrical grid.

ENVIRONMENTAL JUSTICE AND PUBLIC HEALTH BENEFITS OF SCHOOL BUS ELECTRIFICATION

Diesel exhaust is internationally recognized as a cancer-causing agent (Miller et al., 2018). Diesel vehicles also produce large quantities of $PM_{2.5}$, a type of particulate matter that is 2.5 µm or smaller. In 2019 alone, $PM_{2.5}$ was responsible for 4.14 million deaths (The Lancet, 2020), which represents more than 7 percent of total global deaths. An increase of just 5 µg/m^3 of $PM_{2.5}$ per year was associated with a 13 percent increased risk of coronary events. For reference, New York City's $PM_{2.5}$ average was 9.9 µg/m^3 in 2022, but seasonal and hourly variations can frequently cause fluctuations higher than 60 µg/m^3. Higher $PM_{2.5}$ concentrations are associated with heart and lung disease hospitalizations, and asthma emergency room visits (CARB, 2023). Alarmingly, almost 95 percent of American school buses, which transport 55 percent of America's pupils (National Center for Education Statistics, 2007), run on diesel (De La Garza, 2021). On average, 60 percent of low-income students ride the bus daily compared to only 45 percent of non-low-income students (Bureau of Transportation Statistics, 2021). Moreover, Black students and children with disabilities rely on diesel school buses more than others (U.S. Department of Transportation Federal Highway Administration, 2017; Wheeler et al. 2009). Full school bus electrification will eliminate school bus tailpipe emissions and alleviate air quality issues for low-income, Black, and disabled students more than for their counterparts.

Residents of urban cores constitute 80 percent of the population of the United States. These epicenters of personal and logistical transportation bear a disproportional brunt of air pollution as they are subject to dense concentrations of transportation emissions. The operation of trucks, buses, and cargo ships inherent to cities permeates the air with a high concentration of diesel exhaust. Students in urban areas are particularly susceptible to the effects of this pervasive pollution. They are statistically more likely to face exposure to diesel exhaust overall than their peers in less populated areas. Diesel exhaust, a type of particulate matter (PM), is laden with lethal pollutants like nitrogen oxides (NO_x) and volatile organic compounds (VOCs). These pollutants deteriorate air quality and are instrumental in precipitating cardiovascular events, increasing lung cancer rates (OEHHA, 2001), and are notorious triggers for childhood asthma. Conversely, children in rural areas also face amplified exposure to diesel emissions from school buses, specifically due to extended routes and lengthy bus ride durations.

Underserved communities in urban areas suffer a more severe impact of air pollution, notably in regions proximate to school bus yards. These areas are known for persistent vehicle idling and pre-heating the cabins, both of which spew harmful emissions into the nearby air and greater atmosphere. Transitioning from traditional ICE school buses to ESBs presents an opportunity to mitigate the exposure of all communities to carcinogens, but most importantly those underserved communities suffering from more severe air pollution. If executed equitably, the electrification of school buses could be a pivotal milestone in rectifying a longstanding issue of American environmental justice and public health, thereby extending the benefits of cleaner transportation to all, irrespective of their socio-economic status.

ENVIRONMENTAL BENEFITS OF SCHOOL BUS ELECTRIFICATION

Anthropogenic GHGs, such as CO_2, are the primary cause of climate change. The transportation sector currently accounts for 27 percent of the United States' GHG emissions (EPA, 2023a). Replacing all the United States' diesel school buses with ESBs would avoid approximately 9 million metric tons of GHGs per year, the equivalent of removing two million cars (Casale and Horrox, 2022) from the road (EPA, 2023b). Widespread school bus electrification will have real, global implications for climate change.

Averaged across the United States, ESBs emit between one quarter and one third the amount of GHGs per mile driven compared to their diesel or gasoline counterparts (Argonne National Laboratory, 2020). ICE buses emit CO_2 as a byproduct of the internal combustion process; ESBs do not have tailpipe emissions and their GHG emissions originate from the source of electricity production. Electricity production sources, and therefore non-tailpipe CO_2 emissions from ESBs, will vary by state. Encouragingly, the carbon intensity of U.S. electricity generation has been steadily declining since 2007 (EIA, 2022), and the combination of new federal investment, state policies, and the recently announced EPA plan to reduce CO_2 emissions from power plants (EPA, 2023c) will accelerate grid decarbonization and decrease ESBs' indirect CO_2 emissions. Replacing ICE buses with zero-emission vehicles through federal and state mandates and through utility-company-supported programs will significantly reduce the U.S. transportation sector's GHG emissions. Moreover, such efforts will support equitable outcomes as Black Americans are projected to face greatest risks of climate change of all American demographic groups (EPA, 2021).

ECONOMIC BENEFITS OF SCHOOL BUS ELECTRIFICATION

Although the upfront cost of EVSE, infrastructure installation upgrades, and the ESBs may be higher compared to the cost of traditional diesel buses, ESBs can offer long-term savings in terms of reduced fuel and maintenance costs for school bus operators. ESBs' fuel, in the form of electricity, costs 40 to 75 percent less per trip than their diesel counterparts (Maine Department of Education, 2022), while maintenance costs are 40 percent less. The Clean School Bus Program and other incentive programs, vehicle-to-grid (V2G) technology, and innovative rate design are three components that can further bolster the economic case and minimize an ESB's TCO (Electric School Bus Initiative, 2022). Innovative rate design (Whited et al., 2020) and demand-side management (driivz, 2022) programs can incentivize off-peak charging, minimize grid impacts, and reduce operational costs, ultimately making the business case for ESBs more compelling. The charging strategy that a school bus operator chooses will impact the ESB's TCO. **Chapter 4** and **Appendix A** further discuss how different charging scenarios affect an ESB's operational costs.

GRID RESOURCE BENEFITS OF SCHOOL BUS ELECTRIFICATION

ESBs can offer a unique set of benefits when deployed as grid resources. These benefits can range from providing improved grid flexibility through delivering power back onto the grid during periods of high system demand to improved resilience during outages or critical emergencies. These benefits can be further enhanced when ESBs are able to charge during periods of lower energy prices and discharge power when power prices are higher.

V2G is a technological subset of Vehicle-to-everything (V2X) technology. V2X is an emerging technology that has been piloted and commercially deployed with select ESB fleets around the United States. V2X utilizes electricity's bidirectional power flow to allow ESBs to take electricity from the grid when needed for charging and export electricity from their onboard batteries. For V2G, that electricity is exported back to the grid. For utility companies, V2G utilization can lower infrastructure investments, decrease required grid upgrades, and increase grid flexibility and grid resilience. For operators, V2G utilization has the potential to decrease the TCO of ESBs by lowering monthly electricity bills.

To utilize V2G technology, ESB operators must use V2G-capable EVSE and ESBs and they must work with their local utility company. Utility companies play an influential role in providing operators with the resources and ability to use V2G technologies. V2G can also increase the complexity of electrification projects. Because buses and EVSE with V2G are distributed generators, they must go through a generation interconnection review process. V2G ESB chargers will not be allowed to be connected in charging mode until their generation interconnection request is approved. Additionally, many utility companies do not yet have well-defined rate structures designed for ESB-scale V2G implementation.

To increase grid flexibility, utility companies can request fleets with active V2G to supply additional electricity to the grid at crucial times to balance generation and demand. By allowing other electricity customers to use electricity drawn from the ESBs' batteries, as opposed to power from a fossil fuel-fired generation plant, V2G reduces costs for utility companies by allowing them to avoid additional, expensive peak-demand generation. While widespread increases of energy demand across the country may require corresponding grid upgrades, V2G technology might serve to better manage and mitigate the scale of those upgrades while having the potential to improve the overall economic case for ESBs. Proper utilization of vehicle-to-building (V2B) technologies, another technological subset of V2X, can supply buildings and other facilities with backup power during power outages to contribute to grid resilience. Where V2G dispenses energy into the grid, V2B dispenses energy to a building or facility during a power outage or to lower demand charges for that facility. In the case of a power outage, a fleet of ESBs could function as a grid resource at schools, hospitals, community centers, and low-income housing projects, or within a larger microgrid to provide emergency backup power. Operators planning to implement V2X should understand the operational and technical requirements and comply with the local utility company requirements. A strong partnership with the local utility company can also help operators identify locations where V2X benefits will provide the most value and where ESB batteries can potentially provide outage support, helping to serve critical loads and providing additional benefits to nearby communities.

CHAPTER III

EQUITY IN ELECTRIC SCHOOL BUS ELECTRIFICATION

Equity intersects with ESBs in a variety of ways, as systemic inequities are present in many aspects of the transition. Not all students have the same access to a clean air commute, and several historically marginalized groups rely on diesel school buses more than others. In many cities, the burdens of air pollution are more likely borne by communities in high traffic corridors, communities near school bus depots, and students who spend more time on diesel buses. Underserved communities that face financial barriers will benefit from federal and state funding for ESBs. At scale, ESBs create an opportunity to directly benefit the communities they serve in the form of portable resilience hubs to distribute energy at critical times. The transition to ESBs will create shifts in the workforce, which will necessitate economic development opportunities for these communities in the green economy.

School bus electrification provides an opportunity to create a system that significantly improves and transforms the quality of life for all people. The burdens and benefits of the American energy system are not distributed equitably. Underserved communities endure higher health and environmental burdens associated with energy production while spending higher proportions of household income to access the energy necessary to maintain their health and well-being. Prioritizing equity early and consistently through every stage of ESB development and deployment increases the likelihood of the program being maximally responsive to each community's needs (Moses and Brown, 2022).

In **Appendix B**, we present a framework prepared by Clean Energy Works that defines equity among four key dimensions and offers recommendations for implementation. Below are the definitions of those four key dimensions and an example for each from the Equity Framework:

Procedural equity—addresses ways to foster meaningful participation in planning and decision-making for communities that will be most impacted by school bus electrification. An example would be to establish multiple methods to receive community input for the electrification of school buses in their community ensuring the engagement is delivered in a culturally sensitive manner at a culturally relevant place, and during a culturally relevant time.

Recognition equity—demonstrates that utility companies comprehensively understand the historical developments underlying contemporary disparities in access to energy and transportation options. An example would be to conduct research on a zip code or census tract level to determine if there are disparities between communities to be addressed (rates of disconnection, grid failures, line and infrastructure upgrades, etc.) when electrifying the school bus fleet.

Distributive equity—focuses on outcomes and whether communities equally share the benefits and burdens of electrification. An example would be to conduct research to maximize investments based on equity considerations for ESBs (e.g., route selection, siting, and leveraging charging infrastructure and grid upgrades).

Reparative equity—explores how policies and programs can remedy historical and present-day harms, such as poor air quality, so that affected communities can thrive in the future. An example would be to provide resources and programs for training local school district staff and personnel on the transition to ESBs. Specific attention is required to training school staff for operating and maintaining the new charging infrastructure.

Successful implementation of these recommended measures will look different from community to community. But adhering to these principles can ensure that the potential can be realized for school bus electrification to reinforce equity along the four dimensions outlined above and thereby improve the prospects for a successful and self-sustaining ESB program.

CHAPTER IV

GRID IMPACT ANALYSIS

The Grid Impact Analysis section of this white paper is based on the technical work performed by the Electric Power Research Institute (EPRI) and is intended to give the reader a sense of the potential implications of school bus electrification on the electric distribution system at scale. The full memorandum from the technical work can be found in **Appendix A**, while the key observations and implications can be found at the end of the Grid Impact Analysis section. The goal of this technical work is twofold: to model the technical and economic drivers of ESB charging to determine load shapes, and to review a load hosting capacity analysis from representative feeders in the service territories of Exelon's operating subsidiaries. All assumptions and calculations used to prepare the Grid Impact Analysis section are discussed further in the memorandum.

Based on the dramatic percent increase in ESB purchases from 2020 to 2023, sustained federal funding through the EPA Clean School Bus Program, and an increasing number of gubernatorial and state mandates, it is imperative that utility companies and their regulators understand how school bus electrification will affect power demand and the potential need for supporting grid investments in their service areas over the next decade to manage the new, incremental demand. Understanding this increased demand will help utility companies determine how to better manage the grid and the scale of upgrades that be required.

While utility companies are familiar with load growth, the challenge with commercial and consumer electric vehicle (EV) transportation is that the magnitude of the new load is large, and it is still unclear at what times and locations EVs will charge. ESBs provide an opportunity for utility companies to serve these loads at minimal cost because of their highly predictable behavior and their relatively long dwell time. School buses generally follow the same schedule every day and dwell overnight at the same location for long durations. These two factors elucidate the power and energy needs that school bus depots demand.

Utility companies can use hosting capacity analysis data to help operators screen for feasibility and scope the size of their fleet electrification projects based on existing grid capacity. As utility companies continue planning to serve greater loads in the future from electrified buildings and transportation, they can educate customers including school bus operators on how these plans will impact the operators' facilities and inform viability and costs associated with depot electrification. Utility companies offering technical assistance resources to school bus operators will have a built-in channel for two-way communication regarding grid capacity and fleet electrification plans.

MODELING OF THE TECHNICAL AND ECONOMIC DRIVERS OF ESB CHARGING EQUIPMENT TO DETERMINE LOAD SHAPES

ESB charging economics are influenced by factors such as charging rates, rate and incentive structures, type of charging equipment, operational charging time constraints, and potential V2G compensation. Economical ESB charging is achieved at lower power levels, especially important for customers on rates including demand charges. Utility companies apply these charges, which are significant contributors to monthly utility bills and therefore an ESB's TCO, based on a customer's maximum power use in any given interval during the billing cycle. AC charging of ESBs can lower or even eliminate demand charges, delivering operational savings. However, these decisions must consider operational needs. Before purchasing EVSE, school bus operators should determine their ESBs' daily charging time and anticipated energy requirements under typical conditions.

Figures 1, 2, 3 plot three different charging scenarios and are purely illustrative. Across the three figures, the cost of the energy component of the bill (measured in $/kWh) is the same. However, faster charging requires more expensive EVSE, costlier site upgrades, and will result in higher demand charges. There are three different demand charge scenarios: representative typical demand charge (**Figure 1**), low demand charge (**Figure 2**), and high demand charge (**Figure 3**). The three figures show the relative cost of charging an ESB given different demand charges and EVSE types. Unitless, "per unit," plots are used with "AC Lowest Power" set as one unit for each case to avoid using electricity costs that might be quickly outdated. These factors result in the electricity cost per mile of ESB operation ranging from .72 to 3.70 per unit. ESB cabin heating and cooling loads are not considered in these scenarios. These factors also do not include additional costs for service with enhanced resilience. Charging requirements and technical feasibility considerations related to ESB cabin heating and resilience are discussed in **Appendix A**.

In the figures below, "lowest power" represents site level load management to minimize peak power draw. "Unmanaged" represents charging at the maximum power level of the installed charger. "Avoid peak" represents avoiding charging during a peak period in exchange for a reduced demand charge. "V2G" represents exporting to the power system during peak periods. In this example, V2G is valued proportionally to demand charges for illustrative purposes only.

Figure 1. Relative Charging Costs of an ESB with Various Charging Strategies (Representative Rate)

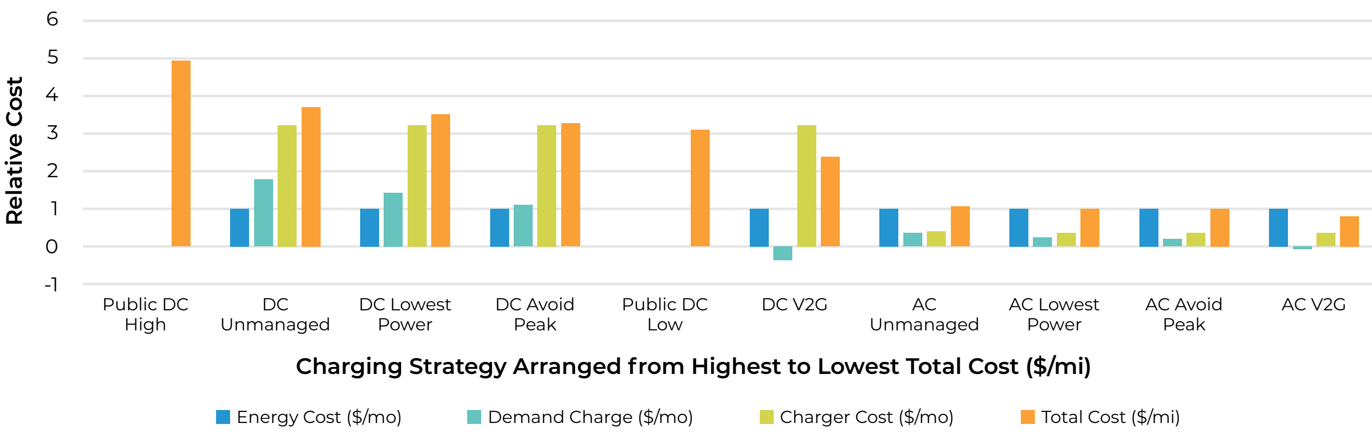


Figure 2. Relative Charging Costs of an ESB with Various Charging Strategies ($2/kW-month Demand Charges)

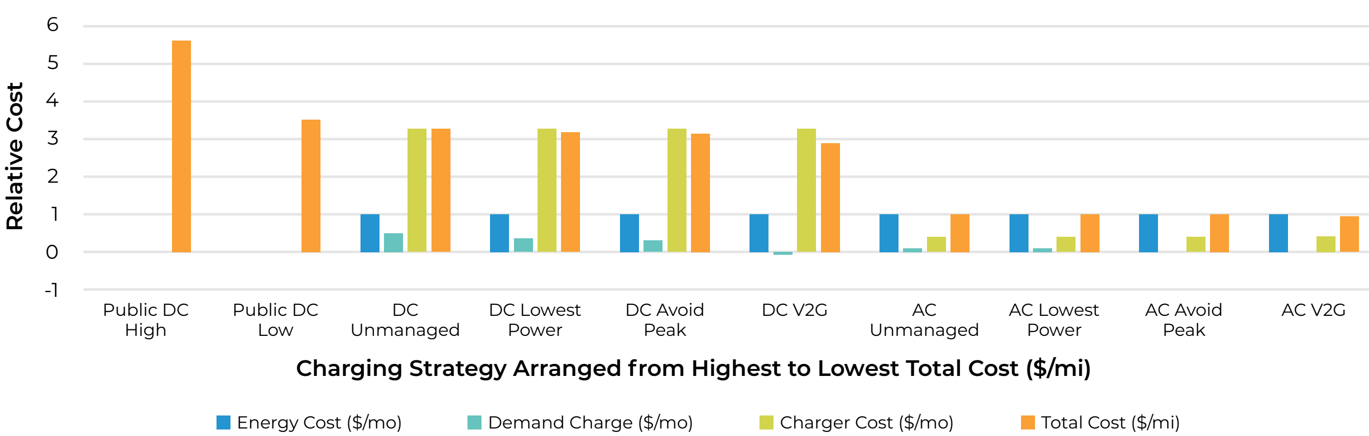
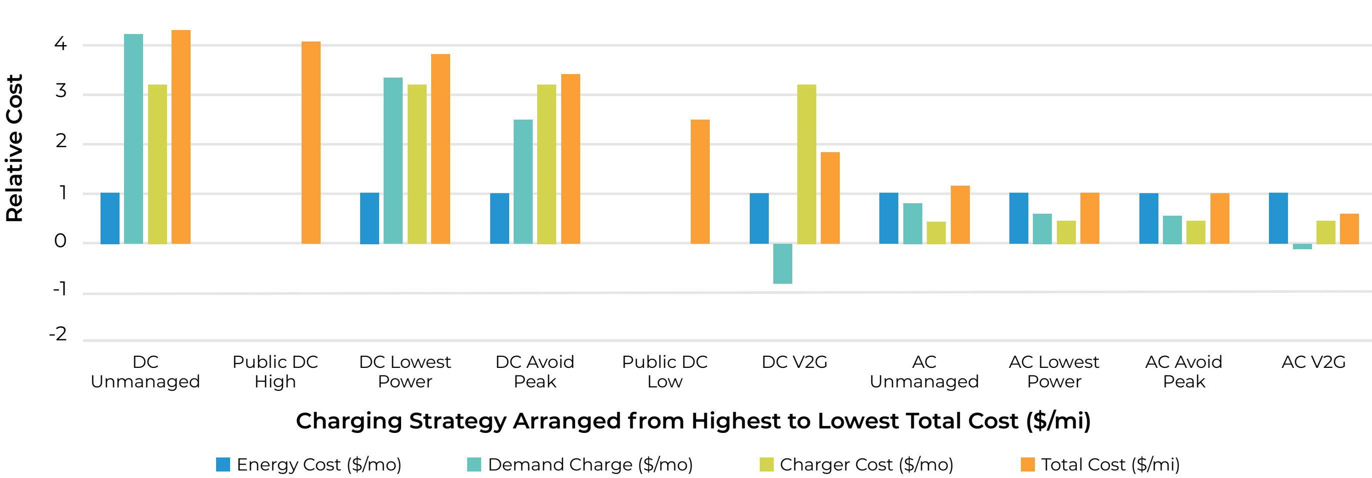


Figure 3. Relative Charging Costs of an ESB with Various Charging Strategies ($20/kW-month Demand Charges)



As depicted in **Figures 1**, **2**, and **3**, AC charging, regardless of demand charges, leads to the lowest total charging costs per kWh. In areas with demand charges, using managed charging to avoid peak demand charges is more economical. Higher charging power outputs translate to more expensive charging costs, even in areas without demand charges, due to the difference in EVSE and onsite infrastructure costs. In areas with high demand charges, the cost discrepancy is even higher. If a direct current fast charge (DCFC) strategy is only needed for limited scenarios, charging ESBs at nearby public or shared DC fast chargers may be the most cost-effective solution. However, many public DC charging sites today are not designed to accommodate large vehicles such as Type C or D ESBs, so due diligence is required. Some public DC charging sites that were not designed to serve school buses may still be able to accommodate them through non-standard parking arrangements during low utilization hours—such as in the middle of the day on a weekday—but this type of usage may make a reliance on public fast charging an untenable strategy.

The site level charging demand from ESBs depends on choices of charging equipment and charging strategies. Consider two operators, one that has 50 ESBs of which all can spend most of their non-route hours charging and a second who has 50 identical ESBs with identical routes but is only able to charge during the middle of the day between the morning and afternoon routes. The constrained operations of the second scenario require 6.7 times the grid capacity from the utility company compared to the operator with flexible operations. The operator with flexible operations could charge 50 ESBs and not exceed 300 kW of total load, whereas the operator with constrained operations would require 2,000 kW to charge those same 50 ESBs because it charges them at a high power over a short duration of time. This operational difference would trigger the need for distribution system upgrades on one of the studied feeders later in this section.

In a service territory with a $30/kW-month demand charge (examples can be found in many districts in California), a 50 ESB site using a low-power 300 kW charging profile will pay $9,000/month in demand charges, while the high-power 2,000 kW charging profile will pay $60,000/month in demand charges. It is important for operators to understand how local utility rates work so that they can make cost-effective charging infrastructure investments.

ESB fleet operational flexibility may be constrained by contracting, labor, or other constraints that make it challenging or impossible to spend a large portion of non-route time charging. A fleet with constrained operations that only has time to charge during a small portion of the non-route hours will require higher power charging than a fleet with flexible operations. The higher costs for DC charging equipment and demand charges shown in **Figures 1**, **2**, and **3** above, however, may represent sufficient financial impact to justify a closer look at how operational flexibility might be harnessed to expand charging windows and to minimize ESB charging costs. Hardware decisions and operational flexibility may also allow for opportunities to modify operations to reduce energy costs and minimize grid impacts. Broadly, these opportunities are managed charging and V2G export.

Managed charging utilizes networked EVSE to charge ESBs at a lower power level or to avoid charging during certain hours of the day or year. Managed charging may be done in exchange for the reduction of a demand charge, a lower rate, or some other cost reduction from the utility company. A site that does not plan to manage charging may not require communications equipment for EVSE, which may save a few hundred dollars per year per charger. However, a site with managed charging may also need to invest in EVSE with a higher charging capacity. An example ESB can fully charge using a shared 19.2 kW L2 charger during 14 hours of idle time per day. With managed charging, this ESB may be reduced to 10 hours of charging time per day to avoid charging during a 4-hour period to comply with the managed charging program. The example bus with only 10 hours of charge time per day may require a dedicated 19.2 kW charger instead of a shared 19.2 kW charger.

For operators, V2G assets may unlock access to compensation for providing generation capacity, transmission capacity, and distribution capacity, or may unlock access to other compensation mechanisms or market opportunities. These compensation opportunities are likely to change over time. V2G values used in the economic analysis in this document are illustrative. As with managed charging, participating in V2G requires different infrastructure investments and ensuring the buses and charging hardware are V2G-capable; this hardware may have higher costs. There may also be higher costs for a generation interconnection from the utility company. If V2G will be utilized on school days, the impacts on charging power requirements for V2G sites will be larger than those on sites with managed charging because the energy exported to the grid must be recovered in a shorter period than the total dwell time. Those ESBs may then require higher power chargers. More information on V2G can be found in **Appendix A**.

Although V2G calculations are included in **Figures 1**, **2**, and **3**, it is still an emerging practice. The authors modeled illustrative V2G compensation that is proportional to demand charges. The scale of ESB V2G projects across the U.S. is low. A full list of current V2G pilot programs was published by WRI and can be found in the Hyperlinked Websites section. Retail electricity rates and programs that compensate for V2G services are widely variable and not widely offered. For this analysis, it was assumed that V2G compensation would be proportional to demand charges for illustrative purposes. For the cases shown above, V2G providers avoided 40 percent of the demand charge and were compensated at 80 percent of the value of the demand charge. This is an illustrative value in the absence of V2G rate data and is not meant as a recommendation for the scale or structure of V2G compensation. Additional considerations for V2G sites are discussed below and in **Appendix A**.

To avoid excessive grid impact and to lower potentially high demand charges in cold climates where ESBs require more power, the operator may consider the use of fuel-fired heaters to warm the ESBs' cabins, where policy allows. Fuel-fired heaters eliminate the need for electricity to be used to heat the cabin, which in some environments may be a difference of thousands of dollars per month in electricity costs. Additionally, for operators with constrained operations, creating a microgrid with stationary batteries could reduce demand charges and increase load-serving capability without grid upgrades. More information about heating and microgrids can be found in **Appendix A**.

HOSTING CAPACITY ANALYSIS OF REPRESENTATIVE FEEDERS IN THE EXELON SERVICE TERRITORY

ESB charging loads have the potential to be highly predictable as ESBs follow fixed routes and dwell at the same locations every day. However, the utility company serving the operator does not have insight into the constraints on the operations of ESBs. As discussed previously, some ESBs have highly constrained operations while others are more flexible. This will impact the operator's onsite infrastructure costs. The differences in operators' operational flexibility, and therefore the difference in charging power levels and duration, will also impact offsite utility infrastructure. These impacts can be harder to predict, especially for ESB charging sites utilizing DCFC. An operator's high-power load might occur during a time that does not impact the distribution feeder, but changes to how they operate and charge their vehicles could result in impacts to the feeder.

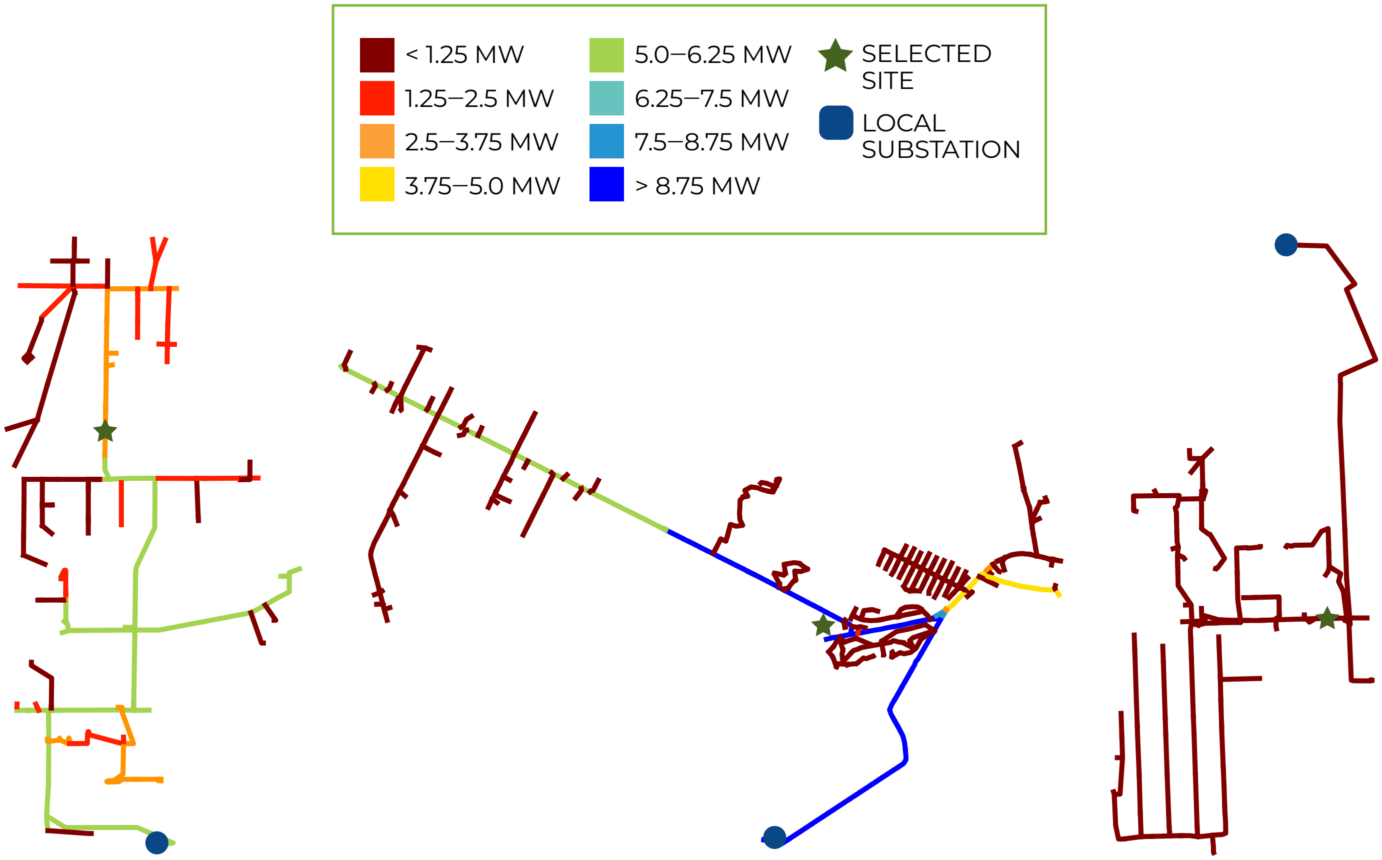
EPRI analyzed three distribution feeders across Exelon's service territories. Feeder 1 is in a medium-sized city in the Midwest; Feeder 2 is in a rural area in the Mid-Atlantic; Feeder 3 is in a large metropolitan area in the Midwest. Feeders 1 and 2 represent existing school bus depots while feeder location 3 is an urban area without a school bus depot where capacity may be more limited. The chosen feeders capture a range of conditions observed across Exelon's operating service territories to encompass a representative range of load behavior.

A hosting capacity (HC) analysis can be used to determine the amount of load or generation that can be accommodated without adversely impacting feeder power quality or reliability and thereby creating the need for potential capacity upgrades. HC was calculated on three sample feeders to demonstrate differences in the capability of distribution systems to accommodate the electrical demand from ESBs. More information on the methodology of this hosting capacity analysis can be found in **Appendix A**.

The current approach to distribution planning utility companies use considers peak load conditions to assess grid capability and identify infrastructure investments. This is because load growth has traditionally worsened the existing peak demand. However, electricity demand from ESBs has inherent temporal characteristics that, in some cases, could shift the time at which peak demand occurs on distribution feeders. While there may be a shift in the behavior of the load on the system, the uncertainty of when the electricity demand from ESBs will manifest itself within a 24-hour period creates challenges for distribution planners to assess the worst-case scenario.

A heatmap, seen in **Figure 4**, is plotted and colored by HC for new demand across each feeder. Values shown represent the ESB penetration that could be accommodated at each specific location before a violation occurs somewhere on the feeder. The value shown assumes no ESB load growth on other locations (i.e., HC might be reduced if load were accommodated elsewhere). A colder color represents a higher HC while a warmer color represents a more limited HC. Feeder 1 has about 5-6 MW of capacity on the backbone but only about 3 MW where the school bus depot is currently located. Feeder 2 has more than 9 MW of capacity on the backbone and 5-6 MW further away from the substation. Feeder 3 shows limited capacity below 1 MW across the entire feeder. This demonstrates that the HC is feeder-specific and can vary significantly across locations within a feeder and between feeders within a service territory.

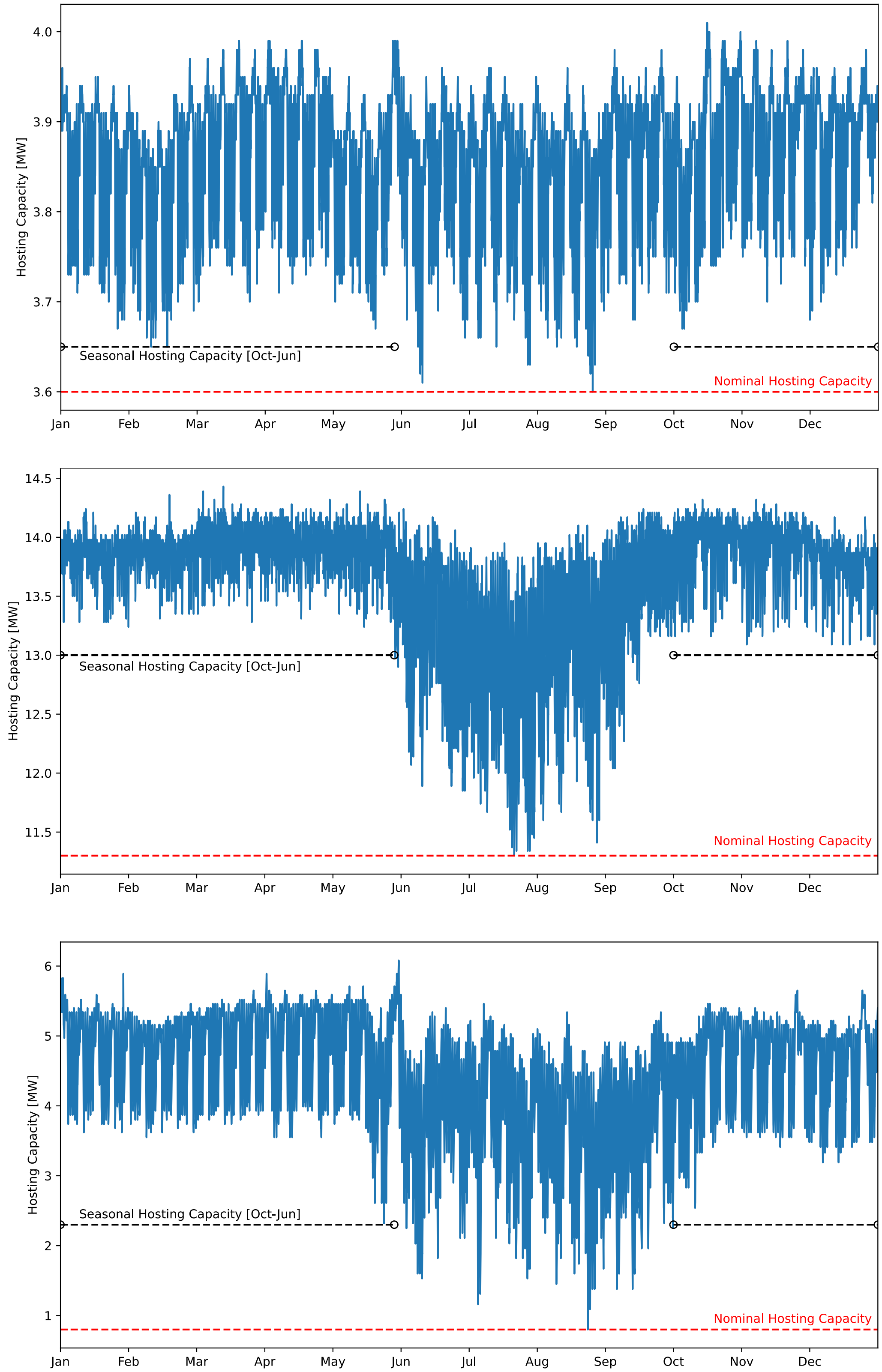
Figure 4. Hosting Capacity of Feeders: Feeder 1 (medium-sized city), 2 (rural), and 3 (major metropolitan area), from left to right



Because electricity demand from ESBs has inherent temporal characteristics, such that they are more likely to charge overnight, it is important to not only consider the feeder HC during peak load condition as plotted in **Figures 5 and 6**, which are the most constrained time of day and year, but also to consider other times of the day and days of the year. These off-peak conditions may be a better indicator of actual capacity for fleets that are using charge management software.

EPRI performed an hourly, year-long time series hosting capacity analysis at the selected sites (represented by stars in **Figure 4**) within each of the three selected feeders. The existing load on the respective feeders impacts the HC throughout the year and will have a distinct seasonal and daily behavior that is relevant when considering the capacity of distribution feeders to host ESBs. The resulting time series plot showing seasonal variations is presented in **Figure 5**.

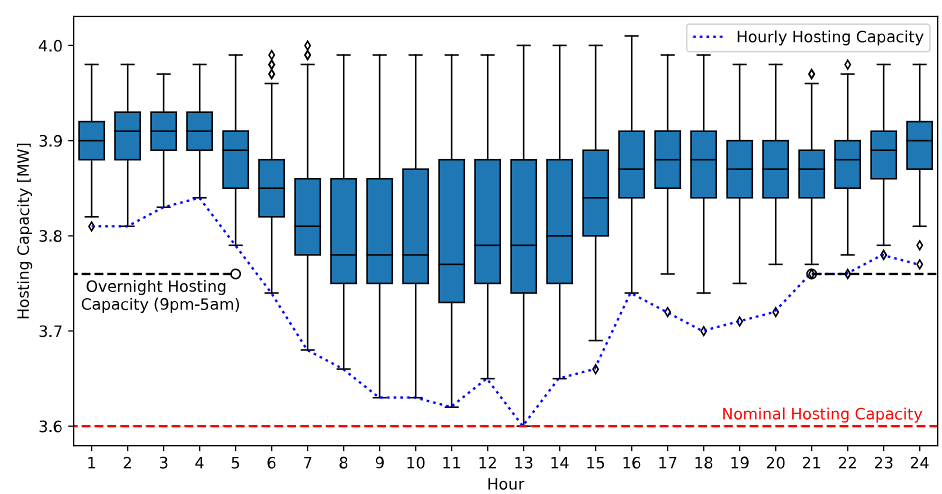
Figure 5. Time Series Plots (in Months) of Hosting Capacity for Selected Sites for Feeder 1, 2, and 3 (from top to bottom)

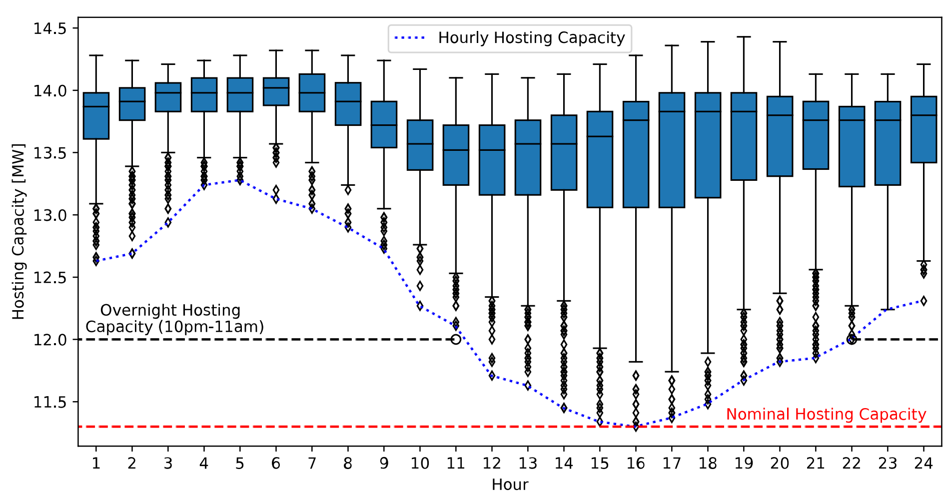


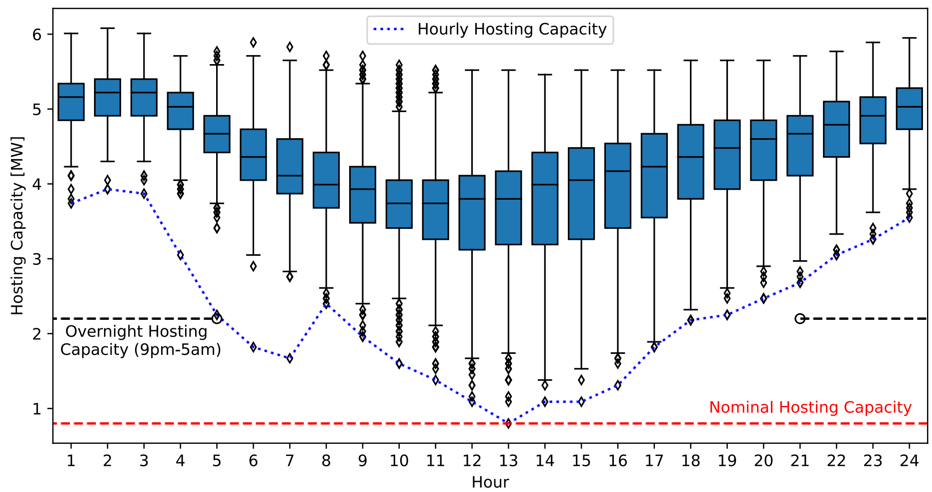
Hosting capacity of the selected site on Feeder 1 did not vary drastically across seasons (top plot in **Figure 5**). This is because the HC depended on the existing load on the feeder, which was predominantly commercial. However, EPRI observed some seasonality at the selected sites in Feeders 2 and 3 (middle and bottom plots in **Figure 5**). The seasonal HC difference at the selected site on Feeder 3 showed more opportunity for charge management based on the magnitude of the hosting capacity – limited in the summer at ~0.8 MW but around 2.2 MW in the October through June timeframe. These findings could have useful policy implications for utility-designed rates that account for hourly and seasonal implications.

The previous figures were then processed to show the variation in hosting capacity for each hour of the day at the three selected sites, as plotted in **Figure 6**. The existing load on the respective feeders impacts the HC throughout the day and will have a distinct behavior that is relevant when considering the capacity of distribution feeders to host ESBs.

Figure 6. Time Series Plots (in Hours) of Hosting Capacity for Selected Sites at Feeder 1, 2, and 3 (from top to bottom)







It is important to note the daily behavior in the hosting capacity at each location. The respective hourly box plots provide insight on the likely available capacity at each hour of the day, regardless of the day of the year. Feeder 3 shows the most significant difference in daytime versus nighttime capacity. Where daytime HC is limited at 1pm to 0.8 MW, there is more than 2.1 MW of available capacity between 9pm and 5am. In scenarios where a school bus depot's demand is hypothetically 2 MW, managing the charging time to 9pm-5am might enable that depot to electrify without grid upgrades.

While this study demonstrates the variability in the hosting capacity, it is important to recognize potential challenges in capitalizing on off-peak capacity. Traditionally, grid planners determine upgrade requirements based on the potential peak load on a feeder that could be incurred from new ESBs. However, smart charging technologies and software that facilitates curtailments can enable flexible new service connection. The mechanisms to enforce dynamic charging limits to a customer would require changes to typical utility policies and practices and would need to be defined prior to allowing customers to connect chargers capable of drawing more load than what the grid can handle during peak load conditions. It is important to recognize the potential opportunities of dynamic charging limits, charge management, and V2X for the industry to fully understand the grid implications and help inform future policy and regulations.

OBSERVATIONS AND IMPLICATIONS

While EVs can create challenges to electric distribution companies, ESBs may not be as significant of a challenge to the industry because of their predictable behavior and lower electricity usage compared to other heavy-duty EVs. EPRI made the following observations from the analysis:

- **Grid impact of ESBs can vary widely depending on the flexibility of operators' schedules and the percent of non-route time the ESB is able to charge.** ESBs that can be plugged in for more of their non-route time can be charged with lower cost, lower power equipment that will trigger fewer grid upgrades and potentially lower demand charges. However, it is important for operators to recognize the potential trade-offs and downstream impacts when choosing between low-power and high-power charging solutions as it relates to operational considerations, overall deployment costs and the ability to extract any potential ancillary benefits.

- **The ability for distribution feeders to accommodate ESBs will vary from one feeder to another.** Depending on the specific characteristics of the feeder (e.g., existing load, topology, line rating), the available capacity to host ESBs will vary. This was demonstrated with the three feeders' hosting capacity ranging from 0.8 MW to 10.5 MW. School bus operators who are required to electrify may need to consider an additional depot with a higher hosting capacity.
- **Certain distribution feeders may be able to accommodate some ESB depots in the short term, but grid infrastructure updates will be required in the longer term as other fleets electrify.** It is important to recognize that feeders with current available capacity may not be immune from requiring grid infrastructure upgrades especially considering the electrification transition holistically.
- **While there is variability in hosting capacity across feeders, there are also potential challenges in leveraging off-peak capacity.** Specifically, incentive-based or technology-based mechanisms to manage the load are still in a nascent stage that will only advance with additional pilot projects. Nonetheless, it is important to recognize the opportunity to the industry to help inform future policy and regulations.
- **V2G services represent a potential incremental value stream for school bus operations; however, the ultimate value can be widely variable.** There are many factors that determine the value for school bus operators of participating in V2G activity, including time of day, location of ESBs on the system, and the market price of power.

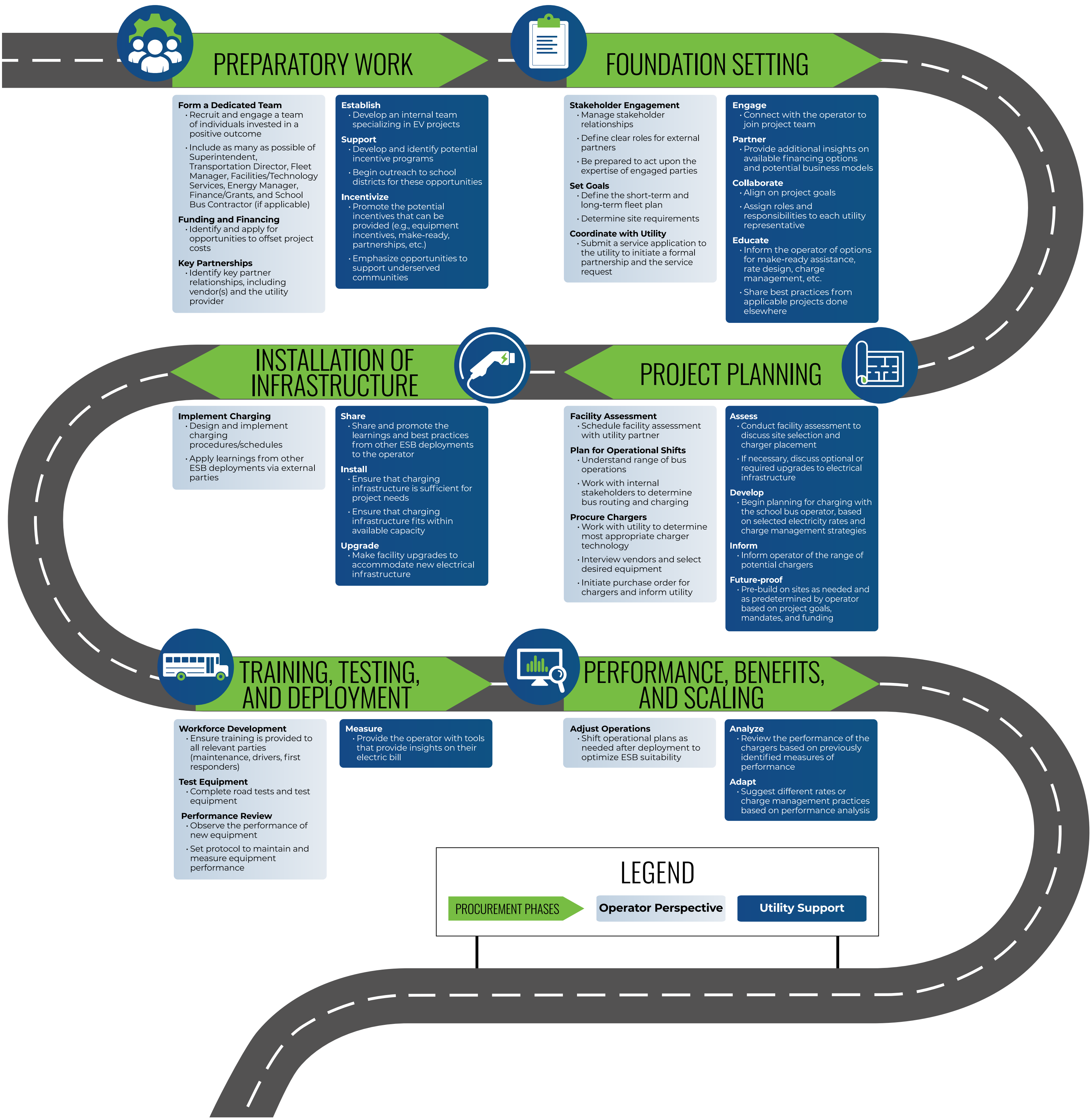
CHAPTER V

THE ROLE OF THE UTILITY COMPANY

The School Bus Electrification Journey Map (**Figure 7**) illustrates the various ways that utility company representatives can offer assistance and guidance throughout the electrification process and enhance equity. It is important that school bus operators contact their local utility company early and work directly with them to better understand the types of services that they are capable of offering. While the process can vary across utility companies, this report aims to provide a generalized roadmap for utility companies and highlights both existing and future roles that the utility company can play to support school bus electrification. These steps are evaluated emphasizing the utility company's critical role in addressing the potential barriers that operators face.

The following section overlays the different areas and levels of support a utility company could provide operators during their electrification journey. The operator journey is based on a Step-by-Step Guide for School Bus Electrification developed by WRI that identifies the common steps for electrifying a school bus fleet, which can be found in the Hyperlinked Websites section. The transition to ESBs typically follows a general roadmap and can take around two years of planning before the ESBs are fully operational. Exact timing and steps will depend on bus ownership, staff capacity, internal processes, financing and funding, facility upgrade needs, local grid capacity, and the availability of ESBs and chargers.

Figure 7. School Bus Electrification Journey Map: The Role of the Utility Company



PHASE 1: PREPARATORY WORK

Operator Perspective: In the Preparatory Work Procurement Phase, a school bus operator sets the groundwork for successful electrification. This initial phase involves establishing a dedicated internal team to manage the project and delineating their roles and responsibilities for clarity and accountability. The operator also delves into the landscape of funding opportunities, seeking viable financial support for the initiative. The operator can continue to research available incentives to offset costs where possible throughout the project. They begin engaging potential external partners, such as dealers, utility companies, and contractors, fostering relationships that will be critical to collaboration, and problem-solving as the project advances. This is also where the school bus operator can engage their communities, such as parent-teacher associations, environmental advocacy organizations, and other community leaders to aid in incorporating equity strategies throughout the project.

Utility Support: From the utility company's perspective, in the Preparatory Work phase of the School Bus Electrification Journey Map, the emphasis is on assembling a committed, internal team and actively initiating outreach to the school bus operator. The utility company focuses on forming a team that can proficiently handle EV projects and maintain consistent communication with the operator. Simultaneously, it strives to increase awareness and accessibility of funding opportunities for the operator and, in some cases, can aid in acquiring funding from federal and state grant programs. The utility company also may offer operators a variety of innovative incentives, such as make-ready provisions or partnerships, if available in their respective jurisdictions, to encourage school bus operators to participate in the electrification process, especially those in underserved communities.

The Preparatory Work Procurement Phase begins with the **establish** step, where the utility company can form an internal team dedicated to electrification projects. This team becomes a critical resource to the school bus operator that it serves. From collaborating on project management to providing technical expertise, the utility company's knowledge can help ensure the school bus operator is well-equipped to understand and handle the challenges and steps of electrification projects. The utility company is well positioned to take on this role for smaller installations, limited pilots, and larger scale ESB deployments.

Once the internal team is in place, the utility company can take on the next role, the **support** step, by helping to promote funding opportunities for ESB-related projects. Utility companies can work with their regulators to identify potential incentive programs to make available to the jurisdiction. They can aid in reaching out to school bus operators and the local community, providing information about potential grants, loans, and other forms of funding. Their experience and network can be invaluable for the operator in securing the necessary funding. The utility company can also assist in crafting compelling narratives and applications that highlight the benefits of the school bus fleet's electrification efforts. The utility can also expand its role in this step beyond identifying funding and can help prioritize site deployment based on available capacity, suggest managed charging platforms, and onsite resilience measures. Utility companies will want to account for differences in staff capacity across districts based on structural inequities and be sure that attention, resources, and support are directed to the districts that most require support.

In the **incentivize** step, the utility company can identify and promote the potential bus and charging equipment incentives that could be provided to operators, if available in their respective jurisdictions. These types of programs could include rebates or incentives for the cost of battery, make-ready programs for infrastructure investments, and other opportunities to support underserved communities.

PHASE 2: FOUNDATION SETTING

Operator Perspective: In the Foundation Setting Procurement Phase, a school bus operator focuses on shaping the organizational and financial structures needed for a successful transition to ESBs. This includes defining the roles of all team members, securing viable funding, and exploring potential business models. The operator sets clear project goals encompassing the short-term and long-term fleet electrification planning and site design requirements. The operator can leverage external stakeholder knowledge to learn about ESBs and the necessary infrastructure, ensuring a solid base of understanding for the project's next steps. Once the initial site-design requirement work is complete, the operator can begin to work with utility to submit a service application and begin the formal planning process. This phase lays the essential groundwork for effective collaboration and informed decision-making throughout the electrification process and begins the formal engagement for a new service connection.

Utility Support: The utility company should become an integral part of the school bus operator's project team in this phase, playing a pivotal role in helping to initiate conversations about infrastructure technicalities and incentives, sharing learnings and best practices from prior deployments and educating operators on the service application process. Infrastructure technicalities encompass both customer- and utility-side upgrades. Customer-side infrastructure upgrades include service transformers, electrical system components such as wiring and conduit, and EVSE, while utility-side upgrades include feeders and substations. This phase underscores the utility company's collaborative role in defining project goals and delegating appropriate responsibilities to its representatives. It can extend to educating the operator about rate design, charge management, potential electricity bill implications, and industry best practices to promote a smooth and efficient transition to electrified school bus operations.

Ideally, the Foundation Setting Procurement Phase for school bus electrification is when the utility company and operator begin to develop regular communications. In the **engage** step, the utility company representative can play a pivotal role by actively offering the school bus operator guidance and assistance with electrification. This engagement could include sharing case studies, providing best practices, and outlining the potential benefits of proactively adopting ESB infrastructure. The engagement step leads to an in-depth partnership wherein the utility company becomes an active participant in the fleet's electrification efforts.

In the **partner** step, the utility company can inform the operator about potential financing solutions or alternative business models that in some cases the utility can facilitate, such as battery financing or make-ready programs offered as part of a school bus electrification pilot or program, if available. These could significantly reduce the cost of upgrading the electrical infrastructure and installing the chargers. The utility company leverages its comprehensive knowledge of regional and national incentive programs and partnerships with charger manufacturers and installers to help the school bus operator maximize the financial feasibility of the electrification project. The utility company presents its offerings as one of the many options that the operator can consider.

As the project team moves forward with goal setting, the utility moves to the **collaborate** step by mapping out the project goals and determining the roles and responsibilities of their team members. This process involves clearly defining objectives, setting realistic timelines, and assigning tasks based on expertise and resources. With their broad knowledge of EV infrastructure deployment, the utility company representative can provide strategic advice on goal setting, both short-term and long-term, helping the new service connection aspects of the project stay on track for success.

In the **educate** step, the utility company is essential in providing the operator with knowledge about rate design, charge management programs, V2X requirements, infrastructure planning, and other technical aspects of electrification. The utility representative can provide insight into load management strategies, time-of-use rates, and demand response programs, helping the operator optimize energy consumption and minimize costs when possible..

PHASE 3: PROJECT PLANNING

Operator Perspective: In the Project Planning Procurement Phase, the school bus operator focuses on practical, on-the-ground aspects of the transition to ESBs. This includes scheduling detailed facility assessments to map out charger placements and necessary infrastructure upgrades. Planning also extends to the operational aspects, where they strategize on bus routes and charging schedules, considering factors like route modeling to ensure efficient use of the fleet. The operator also makes critical decisions regarding the specific types of chargers and buses to procure and install. This phase involves translating the earlier strategic goals into tangible, executable plans for the operator to progress to a functioning ESB fleet. Most importantly, the operator should continue to consider and develop the long-term fleet electrification plan to ensure the project can be properly scaled.

Utility Support: During the Project Planning Procurement Phase, the utility company takes a proactive and supportive role, assisting the school bus operator in various capacities to streamline the electrification process. Throughout this phase, the utility company acts as a trusted advisor and a strategic partner, helping the operator navigate the complexities of integrating EV charging infrastructure with the utility distribution system. A utility company's in-depth knowledge and experience support the operator in effectively managing this transformative change while informing the operator how to scale for the desired long-term fleet electrification plan.

The team must begin planning for charging infrastructure and operational shifts in the Project Planning phase. In the **assess** step, the utility company initiates this Procurement Phase by conducting a comprehensive facility assessment in collaboration with the school bus operator. This assessment focuses on identifying and providing suggestions for site selection and ideal locations for charger placement, considering accessibility, safety, convenience, vehicle traffic patterns, electrical capacity, and proximity to the energy grid. Simultaneously, the utility company evaluates the current electrical infrastructure, determining if any upgrades or modifications are necessary to accommodate the new charging stations, and can discuss options for how to facilitate these upgrades. The utility company's experience in similar electrification projects makes them an invaluable resource in understanding any constraints or opportunities the operator may encounter to ensure a cost-effective and successful installation.

In the **develop** step, the utility company partners with the school bus operator to begin planning for the charging infrastructure installment. This step involves discussing electricity rates, understanding peak demand times, and exploring charge management strategies, whether passive or active. The utility company can provide expert knowledge on rate designs, potential demand charges, and techniques to manage charging during off-peak hours to save costs and reduce strain on the grid. With the utility company's deep understanding of energy markets and regulations, they can provide valuable insights and suggest strategies that cater to the operator's unique needs, aligning with the operational schedule of the buses and minimizing energy costs.

Next, the utility company can **inform** the operator on charging equipment types and capacity levels to meet the fleet's operational needs. They consider the ESBs' battery specifications, the operator's budget, and future expansion plans. As discussed in **Chapter 4**, the choice of charging strategy may have a major impact on the TCO of ESBs. The utility company can provide recommendations based on the latest EV charging technology trends and regulatory incentives, assisting the operator in investing in a solution that meets their needs. Utility companies can share best practices from other successful implementations, assuring the operator can accommodate new infrastructure while maintaining smooth daily operations.

In the **future-proof** step, the utility company can help the operator prepare for future expansions of the fleet. This highlights the importance of understanding and having a well-developed long-term plan from bus operators. Having this understanding up-front or early may save time and costs in the long run and lead to a more efficient and timely deployment. Within the bounds of the relevant regulatory framework, utility companies collaborate with operators to identify how pre-building could be executed based on project goals, ESB adoption mandates, line extension policies, and funding availability. The utility company's knowledge of trends, grid management, and energy regulations enables them to provide strategic advice on initial site build-out while also keeping larger-scale deployments in mind. They can suggest scalable charger models, recommend energy management strategies to handle increased demand, and identify potential funding opportunities for future expansion.

PHASE 4: INSTALLATION OF INFRASTRUCTURE

Operator Perspective: In the Installation of Infrastructure Procurement Phase, the school bus operator focuses on practical implementation. The operator learns about the utility company’s process to install new equipment on the electric system and the utility company’s experience from other ESB deployments. The operator actively seeks out recommendations and best practices from external stakeholders, thus avoiding potential pitfalls and building on proven strategies. The operator also commences designing and implementing charging procedures and schedules, considering the installed infrastructure, operational constraints, and the overall fleet transition plan. This phase represents a significant milestone, marking the transition from planning to breaking ground in the electrification journey.

Utility Support: During the Installation of Infrastructure Procurement Phase, the utility takes a proactive role by actively sharing best practices based on the experience from previous deployments. There can also be a focus on making necessary facility upgrades during installation to accommodate new electrical infrastructure that aligns with the fleet transition plan, adhering to project goals, mandates, and available funding. This is when the utility can continue to inform the operator on associated timeframes and costs to make facility upgrades, providing information that allows the project to remain scalable. This phase significantly emphasizes the utility's role as an expert advisor, an implementer, and a forward-thinking planner.

In the **share** step, the utility company can take on an educational role by sharing valuable insights and best practices from other ESB deployments with the school bus operator. Learning from similar projects can be beneficial for anticipating potential challenges, streamlining implementation, and achieving optimal operational efficiency. Utility companies with prior EV deployment experience are in an ideal position to share real-world case studies and practical recommendations, helping the operator avoid common pitfalls and adopt proven strategies.

The project team moves to the **install** step, implementing necessary charging infrastructure at the selected site. The utility provides support during the installation by aligning it with capacity needs.

The **upgrade** step is perhaps one of the most significant steps of the process, as it involves tangible changes to the depot's infrastructure. The utility company supports the school bus operator in making the necessary facility upgrades, such as upgrading the electrical infrastructure on the utility side of the grid and adjusting parking or operational patterns on the operator’s side of the grid. With its expertise in electrical systems and energy management, the utility company can offer guidance on these upgrades, aligning them with the new EV chargers' specifications and the fleet's operational needs. Their involvement provides a smooth installation process, minimizing disruptions to daily school operations and meeting safety standards.

PHASE 5: TRAINING, TESTING, AND DEPLOYMENT

Operator Perspective: In the Training, Testing, and Deployment Procurement Phase, the school bus operator steers toward bringing the project to fruition. It invests in its workforce by implementing training programs for staff, including drivers, maintenance technicians, and first responders to equip staff with the knowledge and skills necessary to support the transition to ESBs. The operator undertakes rigorous examinations and equipment testing to meet contract specifications. Performance data tracking systems are observed for potential operational adjustments. This phase culminates with the deployment of the ESBs, involving final insurance inspections, updates to protocols addressing ESB-related needs, and completion of road tests.

Utility Support: In the Training, Testing, and Deployment Phase, the utility can share knowledge and guidance to optimize energy consumption. The utility can empower the operator to make informed decisions that could mitigate the impact on their electricity bills as they begin deploying, enabling the operator to harness the benefits of electrification efficiently and economically.

Once the chargers are installed, the operator begins training their staff, testing the equipment, and deploying them for the first road tests. The next step for the utility is to **measure**, where the utility company can provide automated shadow bills for the operator to review and understand how their existing consumption would have fared on different available rates. The utility can also integrate the necessary charge management software with any online utility energy management or billing systems so the district can continue to in adjust strategies for charge management, such as scheduling charging, utilizing different rates, or potentially using V2G to return power to the grid during high-demand periods.

PHASE 6: PERFORMANCE, BENEFITS, AND SCALING

Operator Perspective: In the Performance, Benefits, and Scaling phase of the School Bus Electrification Journey Map, the school bus operator optimizes ESB operations and prepares for future scaling. The operator now closely monitors the vehicles' and charging infrastructure's performance and operational metrics, refining its procedures based on real-world data. The operator uses feedback from the utility company to make informed adjustments in its operations, optimizing its energy consumption, scheduling, and cost efficiencies. This iterative process of adjustment and optimization readies the operator for potential future expansion of their electrified fleet. The operator is also able to share its learnings and experiences with other districts or contractors considering similar ESB initiatives.

Utility Support: In the final phase, the project team may revise operations and charge management based on vehicle and charger performance. The utility company can then help the school bus operator analyze energy consumption patterns and its effects on the district's electricity bills. After the analysis, the fleet could consider upgrading charge management software, using vehicle-to-grid technologies, or optimizing onsite renewable resources for charging.

After the initial deployments, the project team may consider iterations to operations and charge management based on the performance of the vehicles and chargers. During the **analyze** step, the utility company can provide the school bus operator with guidance to review the energy consumption patterns and the impact on the district's electricity bills.

The **adapt** step follows from the findings of the analysis. Here, the utility company can leverage the performance analysis to suggest improvements or adaptations to the current charging plan and operations. For instance, if the report reveals higher-than-expected demand charges during specific periods, the operator could shift to off-peak hours. Alternatively, if the school bus operator is expanding its fleet of ESBs, the utility company could recommend a different rate structure that better accommodates this increased electricity usage. In addition, the utility company can suggest modifications to charge management practices, such as using more advanced charge management software, implementing V2X technologies, or optimizing onsite renewable energy resources for charging.

CHAPTER VI

POLICY

Alongside organic technology and economic improvements, school bus electrification has been, and will continue to be, bolstered by policy drivers and supportive programs at both the federal and state level. This section will review some of the important recent policy developments that have shaped the current landscape and offers recommendations on policy measures to expand or hasten the equitable transition toward ESBs nationally.

With unprecedented funding available over the coming years, ESBs are becoming a more viable option for school bus operators. However, these funding programs are primarily designed to reduce upfront costs for school bus operators. Complementary policy initiatives must further accelerate school bus electrification by addressing operating cost uncertainties, potential grid investment costs, and unlocking additional value streams. Balanced rate designs for customers with ESB fleets and V2X are pivotal examples of measures that could further mitigate barriers to adoption and maximize the benefits of ESBs.

Policymakers, utility companies, school bus operators, and communities should work together to develop and implement policies and associated programs to support and accelerate this transition and unlock the full potential of ESBs. In this section we identify some potential policy levers designed to reduce commonly cited barriers to adoption and complement existing federal, state, and local ESB funding programs with a goal of facilitating and accelerating the transition and ensuring the associated benefits are equitably distributed and maximized for all customers and communities.

THE CURRENT POLICY LANDSCAPE

Federal funding is currently the most significant driver of ESB investment. The Infrastructure Investment and Jobs Act (IIJA) established the EPA's CSBP to accelerate the replacement of diesel school buses with zero- to low-emission models, including ESBs. Allocating $5 billion total over a five-year period, the program has already awarded $1 billion to 349 school bus operators in 2022 through the CSBP Rebates (EPA, 2023d), supporting the replacement of approximately 2,500 school buses. The EPA announced a second round of CSBP funding in April 2023 for an additional $400 million to be awarded between February and March 2024 (Electric School Bus Initiative, 2023) as a grant-style program. From the Inflation Reduction Act (IRA), the EPA will also develop the Clean Heavy Duty Vehicle Program with $1 billion allocated to electric heavy-duty vehicles, including ESBs. In addition, the IRA includes tax credits for both the ESBs and EVSE with the option of using direct or elective pay for tax-exempt entities, such as school districts. Authorized through 2032, the tax credits have the potential to account for tens of billions of dollars in additional federal support for ESBs. With $5 billion from IIJA supporting up to 30,000 ESBs, the remaining 450,000 school buses on the road could benefit from up to $40,000 per bus (depending on the incremental price of an ESB), amounting to over $15 billion.

Federal funding is particularly useful in states pursuing regulatory targets for greater zero-emission shares of truck and bus sales. Implemented by the California Air Resources Board (CARB), the Advanced Clean Trucks (ACT) rule promotes the adoption of zero-emission vehicles in large fleets, including school buses. By requiring a specified, increasing percentage of school bus sales to be electric starting in 2027, the regulation pushes OEMs to sell progressively greater proportions of zero-emission medium- and heavy-duty vehicles. As of June 2023, ACT has been adopted by eight additional states: Colorado, Maryland, Massachusetts, New Jersey, New York, Oregon, Vermont, and Washington. Seventeen states in total (plus the District of Columbia) have signed a Medium- and Heavy-Duty Zero-Emission Vehicles Memorandum of Understanding (MOU) to pursue aggressive action to electrify medium- and heavy-duty vehicle (MHDV) fleets, with a target of 100 percent zero-emission sales share by 2050 and an interim target of 30 percent of sales by 2030 (NESCAUM, 2020). Additional MOU states that have not yet adopted the ACT rule are likely to do so in the coming year.

Another major policy impetus for ESB adoption is the EPA's proposed GHG emissions standards for heavy-duty vehicles (EPA, 2023e) that will come into force beginning with model year 2027. Though not yet finalized, analysis of the draft rule (EPA, 2023f) indicates that compliance will result in 35 to 57 percent of vehicle classes, including school buses, to be zero-emission by model year 2032. This policy will push momentum toward the full electrification of school bus fleets in all states after near-term federal funding sources are exhausted.

Beyond manufacturer sales requirements, some leading states have enacted buyer-side mandates to provide additional clarity and urgency on ESB adoption timelines. These mandates commonly outline adoption timelines that require a certain percentage of new school bus purchases to be zero- or low-emission by a specified date and, in some cases, allow for complementary programs and initiatives to be implemented in support of the legislation. For example, New York has adopted legislation requiring all school bus purchases to be zero-emission beginning in 2027 and to have a fully zero-emission school bus fleet statewide by 2035 (Lewis, 2022). New York voters also passed a $4.2 billion Environmental Bond Act in November 2022, which includes $500 million to support the state's transition to 100 percent ESBs. Several states, including California, Massachusetts, New Jersey, and New York, now offer point-of-sale "voucher" incentives to reduce or fully offset the upfront cost premium associated with ESBs. Voucher incentives ease compliance with state procurement mandates and accelerate market progress even in the absence of purchasing requirements.

Elsewhere, legislative actions are working to address some remaining unknowns for ESB adoption, deployment, and grid services. For example, during the 2022 legislative session, the Maryland General Assembly enacted wide-ranging carbon emissions-related and climate-related legislation, the Climate Solutions Now Act (CSNA). Among other goals and provisions, the bill requires the Maryland Department of the Environment to submit a plan by the end of 2023 that sets Maryland on a path to reducing GHG emissions by 60 percent over 2006 levels by 2031, on the path to a net-zero statewide goal by year 2045. CSNA also includes a requirement that any new school bus that enters service in the State of Maryland on or after July 1, 2024, may not be powered by fossil fuels. CSNA authorizes investor-owned utility companies to apply to the public utility commission (PUC) to establish a pilot program to facilitate ESB adoption with V2X capabilities.

Favorable policy can create a regulatory and legislative environment that fosters innovation, reduces barriers and costs, and proactively anticipates future demand. In the context of ESBs, utility companies can advocate for policies that support electrification by addressing the barriers to adoption for school bus operators, such as upfront costs and technical assistance. Additionally, favorable policy can enable utility companies to proactively address future demands on the grid by integrating proactive infrastructure buildouts into standard business operations. This will contribute to decarbonizing the grid proactively in response to the surge in state and federal policies driving ESB adoption. Equity provisions within such policies can include measures to dedicate a portion of financial support specifically to underserved communities and offer technical assistance and workforce training programs to them.

REDUCING THE BARRIERS TO ADOPTION

UPFRONT COSTS

As noted earlier, the upfront cost of an ESB exceeds that of an ICE bus by a significant margin, and this cost differential is greater when taking into consideration the associated infrastructure required to support bus operation. To reduce the upfront cost of ESBs and associated infrastructure, utility companies can advocate for policies and programs designed to reduce these upfront costs. Several utility companies have implemented, or will soon implement, programs providing a range of incentives from targeting the incremental price of an ESB over an ICE bus to covering the total cost of replacing existing diesel buses with ESBs. Another option designed to reduce the upfront cost of ESBs is to offer rebates or incentives directly on the cost of the ESB's battery, which can be up to one quarter of the overall cost of the vehicle. In this type of rebate program, the utility funds the cost of the battery in exchange for controlling certain parameters of charging and discharging the battery for grid-related purposes under pre-defined conditions. These types of programs create a win-win solution by lowering upfront costs for the customer and allowing the utility to maximize the grid-related benefits of the batteries. To reduce the upfront cost of the associated infrastructure, charging equipment, and potential grid investments, utility companies can design policies and programs to provide rebates or incentives for customer-side and utility-side upgrades. Utility companies can also offer rebates or incentives or both for charging infrastructure. These types of programs are complementary to the EPA CSBP, which is currently limited to customer-side infrastructure upgrades.

From a cost recovery perspective, regulatory approval socializing the costs of grid upgrades and associated equipment across the entire customer base can help mitigate the financial impacts on school bus operators and bus contractors, specifically those in underserved communities that could benefit from ESBs as a grid resource the most.

The role of the utility company in providing financial incentives to support customer-owned or operated equipment has a long track record, specifically related to energy efficiency. In approving expenditures that go beyond the utility company's traditional, to-the-meter scope, regulators must balance many considerations including potential ratepayer impacts, effects on competition, and societal benefits. A strong case can be made for the ESB-related costs described here to be socialized across the entire customer base due to the widespread public health, environmental justice, and grid-related benefits of ESBs. Policies to reduce the upfront cost and socialize costs are categorized as Restorative Equity and can employ fleet electrification to provide opportunities to correct historic disparities while also creating new economic development pathways.

TECHNICAL ASSISTANCE

Some school bus operators cite a lack of understanding ESB technology and limited resources as barriers to adoption. To further accelerate ESB adoption, policymakers should encourage utility companies to consider implementing programs to provide technical assistance and customer-facing resources and tools designed to support ESB deployment. Utility companies can use data from past and current ESB deployments to share learnings and best practices and incorporate those learnings into future deployments. By offering tailored programs and solutions, utility companies can act as an advisor to educate customers about ESB technology and its benefits. Accessible resources that simplify complex technical information and assist in securing funding for ESB adoption can further facilitate an eased transition. A well-designed and robust utility company-sponsored ESB program will allocate a portion of program funds toward these types of assistance programs.

National Grid, an electric utility company, runs a complimentary fleet advisory services program in Massachusetts that caters specifically to public fleets such as transit agencies, school buses, municipalities, federal or state fleets, and public universities. Through this initiative, National Grid provides comprehensive planning and TCO analysis and guides these public fleets on their electrification journey. Through this program, National Grid prioritizes environmental justice communities, which ensures a more equitable transition to electrification in their jurisdiction.

DEMAND CHARGES AND RATE DESIGN

The cost of electricity used to fuel ESBs is a major factor in calculating ESB TCO for school bus operators. Beyond reducing the upfront cost of capital for buses and the associated infrastructure, rate design and managed charging are additional tools that policymakers can use to reduce the overall cost of ownership for school bus operators. These programs can also be used as tools to minimize grid-related impacts of ESBs and, potentially, total grid investment required to integrate the new load.

Policymakers can evaluate the use of smart charging programs to incentivize passive or active managed charging behaviors. This will act to minimize charging costs for operators and mitigate associated load impacts on the grid. Smart charging programs can be designed for passive managed charging by allowing for special, lower rates during predetermined time periods when there is excess capacity on the grid; this is usually overnight. Customers can program their EVSE to only charge ESBs during these predetermined times. Smart charging programs can also be designed to incentivize active managed charging. In active managed charging scenarios, the utility company will send a signal to the EVSE to allow charging to begin or to pause. The intention of smart charging programs designed for active managed charging is to charge ESBs when there is excess grid capacity. The utility company compensates the operator for participation in active managed charging. It is imperative that these programs are designed in a manner that take into consideration the operational and duty cycles associated with ESBs.

School bus operators utilizing high-powered charging solutions may be subject to new or increased demand charges. Policymakers have adopted several solutions to mitigate or reduce demand charges to support EV policy initiatives. A windowed demand charge, or a demand charge that only takes place during specific time periods (such as peak demand), is an example of a program that has been implemented as way to help flatten load curves and incentivize ESB operators to charge overnight. These types of demand charge mitigation solutions are well-suited for ESBs due to their duty cycles. Operators can take advantage of these incentives by adjusting charging times accordingly. It is important to note that demand charges currently vary across utility companies and are based on different criteria specific to particular utility systems.

CAPTURING THE VALUE OF V2X

As the grid undergoes significant transformation due to electrification of transportation and buildings, V2X technology could play a pivotal role both as a grid resource and to lower ongoing operational costs for school bus operators. As previously discussed, by enabling ESBs to store excess energy and feed it back into the grid when needed, V2G can create additional revenue streams for school bus operators. Policymakers can collaborate with utility companies and PUCs to develop policies and incentives to commercialize the adoption of V2G technology and innovative compensation mechanisms, which accelerate the widespread implementation of ESBs and ensure that those benefits are being recognized. To take advantage of these technologies, the government will need to continue to incentivize school bus operators to purchase ESBs to add to their fleets. If school bus operators plan for the electrification of their fleets in advance, utility companies will have the opportunities to maximize the efficient use of existing grid infrastructure by establishing ideal charging locations and future-proofing sites proactively. The development of a coherent market structure at the distribution level is required to measure and capture the appropriate level of value from V2X services. In determining the appropriate levels of compensation, consideration should be given to the type, location, time of day, and magnitude of benefit provided by the exported power. By developing mechanisms to capture the potential value of V2X services, utility companies can create more equitable rate and compensation structures for ESB operators.

By advocating for and supporting policies that reduce barriers to adoption and accelerate the transition to ESBs, utility companies can play a crucial role as influencers and informants of ESB policy. By focusing on solutions to the main barriers of adoption, such as reducing upfront costs, providing technical assistance, enabling proactive grid management, and addressing demand charge issues, utility companies can contribute significantly to the widespread investment and adoption of ESBs.

ANTICIPATING FUTURE DEMAND

GRID MANAGEMENT AND EXPANSION

As adoption levels of EVs increase, the utility grid will need increased investment to prepare for this incremental load and provide adequate resilience to maintain system reliability. Utility companies are responsible for maintaining and managing the grid to provide reliable service. A commonly cited “pain-point” for school bus operators, particularly in large-scale deployments, is their ability to connect to the grid in a timely manner due to required investments or system upgrades to support ESB deployments. In New York, regulators are considering a performance-based mechanism designed to reduce new service connection times for large fleet deployments. Under such a scenario, and to result in successful outcomes, policymakers may need to consider implementing a more proactive grid planning process.

Upgrading the grid to support the transition to ESB fleets is a critical challenge to school bus electrification at scale. Policymakers should consider a multi-pronged approach to support this transition. This includes funding research and development of grid infrastructure, standardizing hardware and software for ESB integration, and promoting public-private partnerships that leverage private sector expertise and resources. Additionally, utility companies need to provide school bus operators with the critical resources to help ease this transition. Tools and educational materials focused on the transition to ESBs, V2X technologies, and future-proofing will help operators better understand the costs and benefits associated with these innovations.

PUCs play a significant role in shaping the policy landscape for ESBs and V2X technology. PUCs must work closely with utility companies and school bus operators to develop coherent regulatory frameworks that facilitate ESB adoption and grid integration. An essential aspect of preparing the grid for ESB deployment is a better understanding of when and where the load growth will occur. This will enable utility companies to better prepare and plan for potential grid upgrades and appropriately manage the incremental load. Having better insight and data on load growth will allow utility companies to determine grid implications, potentially minimizing the cost of upgrades, when required.

There is also an opportunity to implement flexible new service connection, where software enacts grid controls to enforce dynamic charging limits to effectively reduce the net load added to the system. This can be implemented at specific sites and has the potential to reduce the associated grid upgrades. Realizing this opportunity will require adjustments to regulatory frameworks and internal utility company processes and procedures, as well as customer education. Compared to the current, reactive approach to system investment under the traditional regulatory paradigm, policymakers could consider allowing utility companies to proactively invest in the system to prepare for an increasing adoption of ESBs.

WORKING TOGETHER THROUGH POLICY

The importance of maximizing the benefits of ESBs and innovative technologies such as V2X through policy is crucial to extending the benefits to underserved communities. It is essential that policymakers, utility companies, school bus operators, contractors, and PUCs work together to create an environment that supports the widespread adoption of ESBs and enables the transition to a sustainable and resilient energy future. By addressing grid upgrades and fostering partnerships, policymakers can play a critical role in unlocking the full potential of ESBs and shaping a policy landscape that enables the relevant stakeholders to make the best use of funds and incentives.

APPENDIX A

THE CHARGING PROFILES AND INFRASTRUCTURE IMPACTS OF ELECTRIC SCHOOL BUSES ON EXELON SUBSIDIARY POWER SYSTEMS: A MEMORANDUM WRITTEN BY THE ELECTRIC POWER RESEARCH INSTITUTE

Appendix A is available here.

APPENDIX B

EQUITY AS A WORKING FRAMEWORK: A MEMORANDUM WRITTEN BY CLEAN ENERGY WORKS

Utility companies are rising to meet this historic moment, providing clean energy for the full transition to zero-emission school buses. However, there is sometimes a struggle to integrate values into structure, policies, programs, and practices. Equity is one such value. We recognize that we are at the leading edge of a rapidly developing field and that no utility or school district has identified all the answers of how to center equity in the electrification of school buses. What we offer here is a framework for beginning to understand equity along several key dimensions and to identify entry points for operationalizing equity in the development and implementation of electric school buses.

Many utility companies have understood equity to primarily mean ensuring access for communities that have been historically underserved. While this is a necessary element, it is not sufficient to fully realize equity. ESBs offer another opportunity to embrace a more expansive and robust approach to create a system that significantly improves and transforms the quality of life for all people. Below we offer a framework that distinguishes among four key dimensions of equity. These dimensions are often confused and used interchangeably which only diffuses their potential impact. They are not a continuum i.e., enacting one dimension does not automatically lead to the others.

1. **Procedural equity** addresses ways to ensure that the communities who will be most impacted by ESBs have meaningful ways to participate in planning and decision making.
2. **Recognition equity** demonstrates that utilities have a comprehensive understanding of the historical developments underlying contemporary disparities in access to energy and transportation options.
3. **Distributive equity** focuses on outcomes and speaks to whether communities equally share in benefits and burdens.
4. **Reparative equity** explores how policies and programs can remedy historical and present-day harms so that affected communities can be in a position to thrive in the future.

There have been two published papers in the past year that have specifically addressed equity in electric school buses, both of which focused primarily on the distributive and procedural dimensions of equity. [1],[2] Below we provide some recommendations to guide utilities to realize a more holistic and balanced approach across all four equity dimensions. We recognize that the electrification of school buses is evolving and that these recommendations, while not comprehensive, are based on experiences from energy efficiency and other utility programs and the most current knowledge on the field of equity.

PROCEDURAL EQUITY

A commitment to equity outcomes must be matched with an equity process that is robust enough to support the opportunities and challenges that may arise with deep community engagement. A critical element of procedural equity is developing trusted relationships with the community that is being served. Those who will most rely on school buses bring invaluable expertise in their own right, which can help to identify unknown obstacles and provide solutions to known ones. A strong and authentic community engagement process also has the potential to reduce overall costs by creating buy-in and a sense of ownership in the community that would pay dividends throughout the implementation process. Below are a few recommendations for building strong community partnerships and for implementing procedural equity:

1. Establish multiple methods to receive community input for the electrification of school buses in their community ensuring the engagement is delivered in a culturally relevant manner at a culturally relevant place, and during a culturally relevant time.
2. Implement a clear and transparent process for showing the community how their feedback was applied to the planning, design, funding, and implementation of ESBs.
3. Provide financial compensation to community groups for their expertise and time to participate in the process to deploy ESBs.

RECOGNITION EQUITY

Everyone wants to be recognized and valued. The first step to building trust within a community is ensuring they feel seen and heard. Recognizing the work that the communities have done is powerful. Recognizing the institutional and systemic inequities to access clean energy, the disparate treatment received by some members of the community, such as high rates of disconnection from service, and lack of trust, are critical to building effective and sustained partnerships with community members and intermediaries. The recognition of these realities is a necessary starting point and without it, even strong procedural equity could still result in less-than-optimal results. Below are a few recommendations to address recognition equity:

1. Provide training to utility personnel who will lead ESBs initiatives to have a basic understanding of the development of the energy and utility sector through a historical and equity lens.
2. Conduct research on a zip code or census tract level to determine if there are disparities to be addressed (rates of disconnection, grid failures, line and infrastructure upgrades, etc.) when electrifying the school bus fleet in the communities.

3. Address how the utility recognizes and acknowledges the needs, challenges, and disparate impacts in the community for ESBs policies and programs and all other related grid upgrades.

DISTRIBUTIVE EQUITY

Prioritization is important under distributive equity when we recognize that not all communities have experienced the same negative impacts from diesel-powered buses. A good example of distributive equity is the Justice40 initiative, whose goal is that 40 percent of the overall benefits of certain Federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution [3]. Utilities can plan and prioritize the distribution of programs and resources by developing metrics informed by recognition equity in their services areas. Below are a few recommendations to orient distributive equity:

1. Engage with communities to develop and build on community-led needs assessments for the planning and deploying of electric school buses.
2. Conduct research to maximize investments based on equity considerations for ESBs (e.g., route selection, siting, and leveraging charging infrastructure and grid upgrades).
3. Plan for scale. This means starting with pilots, sharing data and learning from experiences to advance ESBs deployment and eventually electrifying the entire school bus fleet in the service area.

REPARATIVE EQUITY

Electrifying school buses is about providing access to clean energy technology (distributive equity), ensuring that those who will most make use of ESB are provided legitimate ways to have a voice in decision making (procedural equity), and recognizing and affirming the conditions which continue to give rise to barriers and disparate outcomes (recognition equity). This work also requires a strong commitment to intentionally and actively reversing policies and programs that have perpetuated disadvantages and replacing them with empowering alternatives. Repairing the harms of the past and restoring a community's ability to act on its own behalf also requires ensuring that there are pathways to economic opportunities and distribution of economic value embedded in ESB programs. Utilities and ESB initiatives can be major economic drivers, especially in rural and smaller communities.

Equitable ESB programs should be part of the solution to energy and transportation burdens, i.e., the cost of energy and transport relative to household income, which disproportionately impacts low-income and vulnerable populations. These costs are also increasing due to the extreme weather events. Utilities can design and propose the ways in which ESB costs are borne and repaid with methods that are inclusive and fair. While ESBs and related grid upgrades can require significant upfront investment, utilities can innovate in incorporating the resulting revenues with innovative payment models. One example could be the inclusive utility investment model,[4] which is a rate-neutral, tariff approach mechanism through which capital investments are recovered from the operational savings. More recently, a study from the Environmental Defense Fund [5] demonstrated how investments on charging infrastructure for electric buses and trucks can be rate-neutral depending how utilities manage charging programs. These findings are very promising for finding affordable solutions. Below are a few recommendations to implement restorative equity:

1. Provide resources and programs for training local school district staff and personnel on this transition to ESBs. Specific attention is required to training school staff for operating and maintaining the new charging infrastructure.
2. Implement measures to employ local workforce or local talent and contract local business for any of their services related to the ESBs. This includes employing and contracting minority, women, LGBTQ, etc.-owned businesses.
3. Partner and fund community anchors and innovate on partnerships to ensure that new economic revenues of ESBs stay in these communities.
4. Assess different investments and cost recovery mechanisms that are inclusive, affordable, and scalable for the utility investments on ESBs.

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[3] Justice40 Initiative. White House. 2022. Retrieved from: https://www.whitehouse.gov/environmentaljustice/justice40/

[4] Inclusive Utility Investments for Electric Transportation. Clean Energy Works. 2022. Retrieved from: https://drive.google.com/file/d/1lGLUagWleg1cCr5c3fjBt7ypiUsbAw86/view

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HYPERLINKED WEBSITES

Appendix A is accessible from: https://www.epri.com/research/products/000000003002027849

Full list of current pilot programs is accessible from http://www.electricschoolbusinitiative.org/3-design-considerations-electric-school-bus-vehicle-grid-programs

Full list of state-level funding for electric school buses from WRI is accessible from: https://electricschoolbusinitiative.org/clearinghouse-electric-school-bus-funding-and-financing-opportunities

Step-by-Step Guide for School Bus Electrification is accessible from: https://electricschoolbusinitiative.org/step-step-guide-school-bus-electrification

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