ELECTRIC SCHOOL BUSES: A ROADMAP FOR ADOPTION AND EXPANSION

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Strategies for Policymakers, Advocates and Other Stakeholders

Joseph A. Murphy
Fellow

Electric School Buses: A Roadmap for Adoption and Expansion
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INTRODUCTION

Electric school buses (ESBs) are a key emerging technology for climate change mitigation, provide significant health benefits to students and local communities, and will yield long-term cost savings relative to traditional diesel internal combustion engine (ICE) buses. Their adoption, however, has been slowed by price and technological hurdles, bureaucratic inertia and a lack of coordination among stakeholders. This White Paper identifies key roadblocks to adoption of ESBs and strategies that can be taken by municipal and state officials and other stakeholders to accelerate their rollout.

I. The Benefits of Electric School Buses

The benefits of ESBs[1] are many and varied, encompassing climate change mitigation, community and student health, grid and local resilience and long-term cost savings.

A. ESBs Mitigate Climate Change

ESBs and other Electric Vehicles (EVs) emit no greenhouse gases (GHGs) during their operation. Their emissions from electric "fueling" are much lower than from burning diesel, and decreasing as power grids transition to more renewable sources such as wind, solar and hydro.[2]

B. ESBs are Healthier than ICE Buses

ESBs eliminate emissions of fine particulate matter and other pollutants, including nitrogen oxides (which cause smog and ground-level ozone), hydrocarbons, carbon monoxide, and many carcinogens such as benzene, arsenic and formaldehyde. These pollutants are a problem not just for local communities near bus routes, but for child bus-riders. Diesel pollution inside school buses has been measured up to four to 12 times higher than in the surrounding air (Beatty & Shimshack, 2011, p. 988). ESBs are also quieter.

C. ESBs Can Provide Battery Storage for the Grid and Local Emergency Power

With their large arrays of electric batteries and predictable downtimes, ESB fleets can serve as critical sources of energy storage for the power grid. Vehicle-to-Grid (V2G) technology enables two-way energy flows between ESBs and the grid.[3] During non-peak hours, ESBs store surplus energy from the grid, and when demand is higher, they feed power back. Like other school buses, ESBs are typically idle during early evenings and throughout the summer -- exactly when energy use is at its highest. This energy time shifting smooths demand peaks and enables storage and re-use of intermittent wind and solar sources.

[1] In this White Paper, ESB refers to a plug-in battery electric bus, which is the predominant type of electric bus. Hydrogen fuel cell electric (HFC) buses are the other leading type, but with different cost, equipment and infrastructure parameters. ESBs and HFC buses can serve complementary roles. For example, HFC buses typically have a longer range than battery electric buses and have capital cost curves that become more affordable with larger fleets (National Academies of Sciences, 2020, p. 3-3).
[2] In 2016, New York City electric transit buses emitted 84% less GHGs than their diesel counterparts (Aber, 2016, p. 13, Figure 5).
[3] As discussed further in this White Paper, V2G benefits can be paid directly to school districts or their vendors and can also be internalized by utilities that finance ESB and charging equipment.

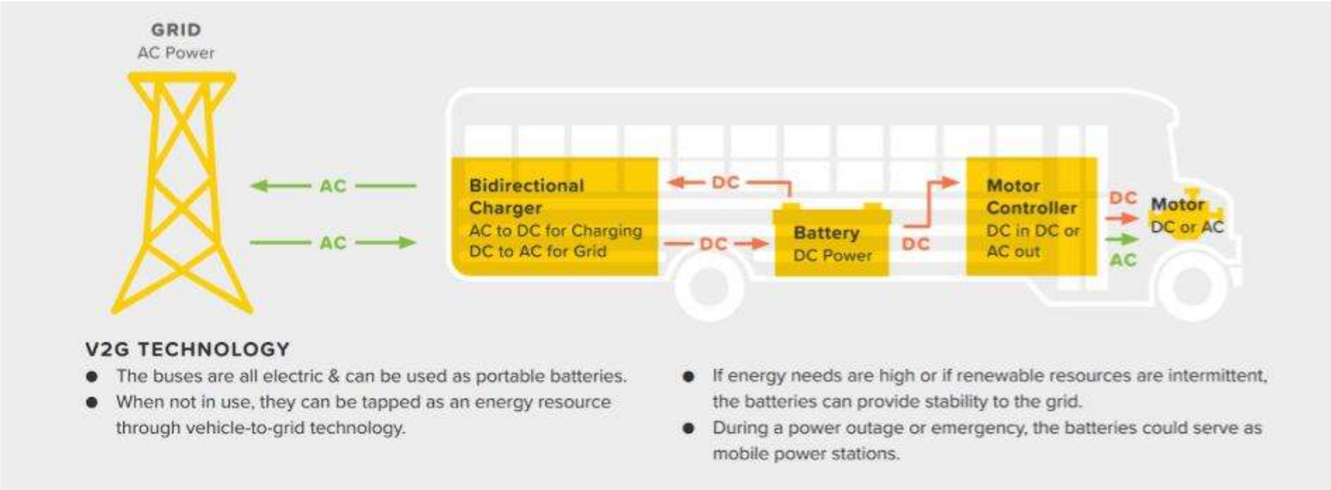

Image Source: New York League of Conservation Voters Education Fund, Clean Bus Guide (2020).

ESB batteries can also be configured to discharge power back to a building (Vehicle-to-Building, or V2B), so ESBs can serve as a back-up power supply during power outages. A single ESB battery could provide 20 to 60 kW for up to five hours -- enough to power critical energy needs, such as communication equipment, lights, refrigeration, or building ventilation (Morse et al., 2016, p. 19).

II. Challenges and Strategies for Adoption of Electric School Buses

Although their numbers are increasing, ESBs so far have been adopted by relatively few school districts across the country, usually in small pilot projects. Challenges that have prevented faster adoption of ESBs include several related categories of funding, technology, and administration. Fortunately, each challenge can be addressed by various strategies.

Problems in the Rearview Mirror In addition to the major challenges addressed in this White Paper, several other features that have traditionally burdened ESB operators have either been solved or are in the process of attenuating as the market and technology mature. Battery performance during extreme weather has improved, and recent pilot projects demonstrate that ESB batteries are reliable and robust in cold weather and high temperatures (Horrox & Casale, 2019, pp. 20-27). Longer trips are less problematic, as ESB ranges now are typically between 100 to 150 miles and growing, and states and the U.S. are rapidly building out networks of EV charging stations, including fast-charging stations, at public places. Infrequent, long trips such as for sporting events and field trips can be performed by remaining ICE buses as schools transition to ESB fleets over several years.

A. The High Purchase Price of ESBs: Challenges and Strategies

As of 2020, the purchase price of an ESB is about three times as much as an ICE bus.[4] For example, the price range for a large "C" or "D" size ESB (carrying 64 to 65 students) listed in the New York State Office of General Services School Bus State Contract is $354,765 to $362,605, whereas comparably-sized ICE buses range from $105,743 to $135,683 (New York State Office of General Services, 2020). As an emerging technology, ESB prices have dropped annually as a result of greater efficiencies in electric batteries, which are the most expensive component in ESBs.[5] This trend is expected to continue so that ESBs will achieve non-subsidized, up-front price parity with ICE buses by around 2030 (Bloomberg New Energy Finance, 2018, pp. 29-30). Until that parity is achieved, the existing price differential is considered prohibitive by school transportation managers, who continue to select ICE buses in the absence of additional resources for ESBs.

This price differential can be closed and ESB adoption accelerated through a combination of two strategies: (1) bridging the price gap by providing external funding through grants or other sources, and (2) reducing the price gap by driving down the cost to manufacture and operate ESBs.

1. Funding the ESB Price Gap

(i) Capital Grants

ESB-ICE price differentials typically have been closed through grants from state and federal authorities. However, that solution has been limited by the availability and size of grants, which mostly have been financed from a jurisdiction's general budget, through bonding, or from a dedicated but limited funding stream such as penalties or litigation awards from polluters. Grant programs that promise greater stability and scale are sourced from cap-and-trade or carbon-credit markets that redirect payments for emission credits to EV programs and other climate and pollution-mitigation efforts.

Grants from state and federal general budget funds and bonding vary widely among jurisdictions. The U.S. EPA funds the Diesel Emissions Reduction Act (DERA) program, which provides rebates and grants for EVs and other low- and no-emission vehicles to replace older diesel trucks and buses. DERA funding has fluctuated significantly since its inception in 2007, and in 2019 DERA School Bus Rebates were capped at just more than $10 million to fleet owners and $15,000-20,000 per bus (U.S. Environmental Protection Agency, n.d.). The California Energy Commission provides grants for ESBs through its School Bus Replacement Program and for charging infrastructure through its Alternative and Renewable Fuels and Vehicle Technology Program. These funds were authorized under the California Clean Energy Jobs Act

[4] Costs cited in this White Paper do not include non-market costs or externalities such as negative health impacts and climate change caused by ICE buses. Many tools are available for calculating such costs for a more complete and rational allocation of resources. For example, the value of reduced health impacts has been calculated to be between $40 and $93 per metric ton of carbon dioxide reduction (Balbus, et al., 2015, p. 13).
[5] Battery prices fell by 79% between 2010 and 2018 (Bloomberg New Energy Finance, 2018, p. 21).

(Proposition 39), a voter initiative that adjusted the corporate income tax code and allocated revenues to schools for energy improvements.[6]

The Covid-19 recession is likely to make the financing of EV grants and other environmental measures from state general funds or bonding more challenging. Bonding should be less subject to short-term economic pressures because repayment periods typically extend over many years, and the immediate benefit of bonded projects may provide needed stimulus in a downturn. In reality, though, decision-makers can be reluctant to take on new debt in a recession.[7]

The largest source of EV grants from litigation settlements is the Volkswagen Diesel Emissions Environmental Mitigation Trust. Of the $4.7 billion penalty agreed to by Volkswagen in settlement of the emissions case, $2.7 billion has been dedicated to funding state diesel reduction programs, including EV expansion (In Re: Volkswagen "Clean Diesel" Marketing, Sales and Products Liability Legislation, 2016).[8] In settlement of a similar emissions testing case, Daimler recently agreed to pay $110 million to the California Air Resources Board for emissions mitigation projects (California v. Daimler AG, 2020). Although large, such settlements occur only intermittently and are divvied up among many programs designed to mitigate climate change and local air pollution. They therefore are not a predictable, reliable source of funding at the scale needed to quickly electrify the nation's school bus fleets.

ACTION: Source ESB grants from scaled-up cap-and-trade and carbon credit markets and ICE vehicle user fees.

Grants with dedicated funding sources such as cap-and-trade or carbon offset markets are better suited to providing reliable and extended funding to finance an ambitious, scaled-up transition to ESB fleets. California operates several EV programs financed by cap-and-trade fees and ICE user fees.[9] The Regional Greenhouse Gas Initiative (RGGI), a cooperative effort among ten Mid-Atlantic and Northeastern states to

[6] In 2018, the Commission provided grants totaling $75 million for ESBs and $13 million for charging infrastructure (California Energy Commission [CEC], 2018). The Commission approved $70 million for ESBs in 2019 (CEC, 2019).

[7] New York announced that as a result of financial instability from the Covid-19 pandemic, the State was postponing for one year a planned 2020 ballot measure to approve the $3 billion Restore Mother Nature Bond Act (Gormley, M., 2020).

[8] New York is using VW settlement funds for the purchase of electric trucks, school and transit buses, and charging stations (New York State Department of Environmental Conservation, n.d.). Florida is devoting $57 million for ESBs in air quality priority areas (Florida Department of Environmental Protection, 2020).

[9] The California Climate Investments cap-and-trade proceeds include ESB funding through projects such as the California Air Resources Board's Rural School Bus Pilot Project ($63 million allocated through 2019 for ESBs and alternative fuel buses) (California Climate Investments [CCI], 2020, p. 47), Clean Mobility in Schools Project (CCI, 2020, p. 39), Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (California HVIP, n.d.), and Community Air Protection Program (CCI, 2020, p. 33; California Energy Commission, 2019). California air pollution control districts and air quality management districts provide grants of up to $400,000 for ESBs funded from motor vehicle registration, tire and smog check fees (California Air Resources Board [CARB], 2016; CARB, 2019a).

cap and reduce GHG emissions from the power sector, in 2018 invested $248 million in auction proceeds in various energy and consumer benefit programs, including EV rebates (Regional Greenhouse Gas Initiative [RGGI], 2020, p. 5).[10] The Transportation and Climate Initiative (TCI), a regional collaboration of 12 Northeast and Mid-Atlantic states and the District of Columbia, in 2019 issued a draft Memorandum of Understanding outlining an auction of pollution allowances projected to generate up to nearly $7 billion annually (Transportation and Climate Initiative, 2019).

Cap-and-trade, carbon offsets and other programs funded by debiting fossil fuel emissions provide multiple benefits. In addition to disincentivizing GHG emissions, they provide a broad funding base across populations, jurisdictions and economic sectors. This dispersal of financial burdens mirrors the widespread societal benefits accruing from EV replacement of ICE vehicles. The breadth of these programs also enables the amount of proceeds extracted to be increased commensurate with the scope of the climate and pollution problems they are designed to address and the environmental benefits they are expected to support. Critically, cap limits need to increase and other program parameters need to be reformed both to meet emissions goals and to provide sufficient funding for a robust ESB transition and other environmental benefit programs.[11]

(ii) Utility Funding

In another funding model, a utility pays for ESBs and related costs and is reimbursed by a combination of ratepayer fees and V2G grid benefits.

ACTION: Fund ESB programs from V2G benefits and utility cost recovery.

There are several utility-sponsored V2G pilot programs underway across the country in which a utility provides all or most of the funding for ESBs and infrastructure in exchange for capturing the V2G grid benefits.[12] The programs typically range from a handful to a dozen or more buses. The ultimate dollar value of V2G benefits has not yet been established firmly given the early state of V2G development and dependence on some variables that have yet to coalesce, such as new utility tariffs set by regulators. Values

[10] New York uses RGGI funds and other sources for its Drive Clean program, which provides rebates for the purchase or lease of EVs (RGGI, 2020, p. 32). Delaware uses some of its RGGI proceeds to fund the Delaware Clean Transportation Incentive Program (CTIP), which promotes EVs and alternative fuel vehicles (Delaware Department of Natural Resources and Environmental Control, n.d.).
[11] A 2019 study found that the supply of compliance instruments issued by the Western Climate Initiative, a multilateral cap-and-trade program in California and Québec, has been overallocated, persistently exceeding emissions subject to the program (Cullenward, et al., 2019).
[12] ESB V2G pilot projects are taking place in: California, where the San Diego Gas & Electric Company will install charging infrastructure for 10 ESBs to operate as V2G distributed energy resources for the California Independent System Operator markets (Application of San Diego Gas & Electric Company (U902E) For Approval of Senate Bill 350 Transportation Electrification Proposals Regarding Medium and Heavy-Duty Electric Vehicles and a Vehicle-To-Grid Pilot, 2019); New York, where Con Edison and National Express are introducing five V2G ESBs in White Plains (Khan, 2020); Virginia, where Dominion Energy is rolling out 50 ESBs among 16 school districts in 2020 (Dominion Energy, 2020); and elsewhere.

also may differ depending on location, time of year and other factors.[13] Published estimates of V2G values range from $5,000 to $15,000 per bus per year (Crolius, 2018, pp. 5, 9; Noel & McCormack, 2014), although recent estimates are at the lower end.[14] By themselves, V2G payments are presently insufficient to close the gap between ESB and ICE total cost of ownership (TCO), but they can be a significant contributor to a suite of funding streams and cost savings that in the aggregate make ESBs competitive with or even cheaper than ICE buses over the expected bus life of 10 to 15 years.

Utility-sponsored ESB programs can also be based on cost recovery from ratepayers. A large ESB program based on the expectation of V2G benefits and ratepayer fees is underway in Virginia, where Dominion Energy is deploying 50 ESBs among 16 school districts beginning in 2020. The utility planned to replace 1,500 buses by 2025 and eventually all 13,000 diesel school buses in its Virginia service territory. Under its plan, Dominion would be paid back for its $400 million capital investment by ratepayer fees to be authorized by new legislation. Selection of the localities to receive the ESBs would be based on their V2G value to the grid. However, environmental advocates opposed these terms as too favorable to Dominion and proposed alternative bills that would fund ESBs through general block grants. The expansion plans are on hold after all of the bills failed to pass in 2020, although the previous bills or updated proposals may be introduced in the 2021 legislative session (McGowan, 2020).

This impasse in Virginia demonstrates the need for robust coordination among all stakeholders to achieve popular support and the consideration of sometimes competing interests in large ESB programs. EV transition initiatives increasingly include requirements designed to remedy environmental injustices that have resulted in low-income and majority-minority communities being burdened with inordinate shares of polluting transportation infrastructure and higher rates of asthma and other health impairments caused by exposure to fossil fuel combustion.[15] At the same time, the increasing demand for electrification in the transportation and manufacturing sectors and the concomitant need for electric storage to address peak demand on power grids can justify prioritization of ESBs as V2G resources (Briones, A., et al., 2012, pp. 6-7). These potentially-competing demands require transparent public decision making, including participation by all affected communities.

[13] For example, in New York, downstate V2G rates are likely to be higher than upstate because of greater congestion needs in the New York City metropolitan and Long Island regions.
[14] One estimate of V2G payments from recent pilot programs is from $5,000 to $6,000 per bus per year (Matthews, 2020, 40:20).
[15] Under the Congestion Mitigation and Air Quality Improvement Program, funding from the Federal Highway Administration for EV and other surface transportation projects that contribute to air quality improvements and congestion relief must be used in areas classified as non-attainment for one or more pollutants comprising the National Ambient Air Quality Standards (New York State Energy Research and Development Authority, 2020, p. 2). An ESB pilot project in San Diego was designed to give preference to locate the project within a Disadvantaged Community (Goldgraben, 2018, p. 3).

ACTION: Eliminate site prioritization conflicts by (1) accelerating ESB conversion and (2) locating early ESB sites in EJ areas and moving ESBs to aggregated V2G sites in summer.

Notably, such tradeoffs can be minimized through a more aggressive timetable for replacing ICE buses with ESBs. The faster the transition from ICE buses to ESBs, the shorter the need to prioritize among deserving locations. In the interim, a strategy for ameliorating the competition between locating ESBs in V2G-priority areas and environmental justice locations is to prioritize the latter during the school year and then move the ESBs to V2G-priority locations during the summer when buses are not needed by the schools. That scheme would also allow utilities to aggregate the ESBs as grid resources at a fewer number of V2G locations, avoiding the need for more V2G investment at various distributed sites.

(iii) Financing Based on ESB Cost Savings

Another approach to financing the purchase of ESBs is to leverage fuel and maintenance cost savings that accrue over the operating life of the ESB, plus any V2G payments.[16] Cost savings from ESBs do not yet match the price differential between ESBs and ICE buses, but combining them with V2G payments makes ESB TCO comparable to the TCO of ICE buses.[17]

ACTION: Maintain ESB cost savings by requiring utilities to decrease or replace demand charges.

Utilities can improve ESB cost savings by providing electric pricing policies that reduce or replace demand charges, which are typically based on a customer's peak usage during a month. Alternative pricing models such as Time of Use charges and Critical Peak Pricing may allow ESB fleet managers to avoid exorbitant demand charges and help reduce overall grid system costs (Synapse Energy Economics, Inc., 2020).

[16] ESBs have many fewer parts than ICE buses and thus require less maintenance. They also are cheaper to fuel. (Vermont Energy Electric Corporation, 2016, p. 24; Blynn, 2018, pp. 37-42).

[17] A TCO analysis by Blue Bird, a leading ESB manufacturer, concludes that ESBs and ICE buses are cost equivalent, assuming ESB grant funding of $167,000 (Blue Bird Corporation, 2020, p. 8). The estimated range of V2G values of $5,000 to $15,000 per bus per year is sufficient to replace all (high estimate) or nearly half (low estimate) of the assumed grant funding. The Blue Bird analysis uses current ESB prices, which are expected to continue their year-over-year decline, requiring less V2G contribution to bridge the gap.

ACTION: Fund ESB programs through private equity investments based on ESB cost savings and V2G benefits.

Cost-financing can take the form of private investment or public bonding. The ESB private finance model is nascent, with initial vendor entrants offering turn-key ESB services to schools. The services can include provision of ESBs, training and a maintenance cost cap in exchange for annual payments from schools, targeted to be at or comparable to the amount schools pay for ICE buses.[18] This business model is predicated on internalizing the long-term cost savings from ESBs' lower long-term fuel and maintenance costs in addition to capturing V2G payments from utilities. This turnkey model also relieves schools of the administrative burden of obtaining permits, charging stations and related infrastructure, all of which can be handled by the private vendor.

ACTION: Fund ESB programs through public bonding based on ESB cost savings and V2G benefits.

This savings-internalization model can be adopted on a larger scale by states and school districts, both of which have the ability to issue bonds to finance long-term capital expenses. Replacement of ICE buses with ESBs provides reasonably-certain and easily-calculable annual cost savings, which is the type of low-risk tradeoff that bond markets and other forms of green financing are set up to fund. For example, many states and municipalities finance building retrofits, renewable energy and other green projects that provide cost savings as well as environmental benefits (Shah, n.d.).[19] School districts can replace entire fleets of ICE buses with ESBs over a fixed number of years and finance the transition with the same bonding authority and procedures they use for other capital projects. States can also make their bonding facilities available to school districts. For example, the Dormitory Authority of the State of New York's Building Aid Revenue Bonds Program has issued more than $6.1 billion in bonds on behalf of 280 school districts to finance capital projects or to refinance outstanding indebtedness (Dormitory Authority of the State of New York (n.d.). That bonding facility could be used to finance the purchase of ESBs by individual schools or entire school districts. Fuel and maintenance cost savings (and, potentially, V2G payments) over the life cycle of the ESBs can be dedicated to repayment of the bonds.

[18] For example, Highland Electric Transportation is a new entrant providing such services (Highland Electric Transportation, n.d.). ESB manufacturer Lion Electric Co. also offers a turnkey solution (personal communication, K. King, The Lion Electric Co., November 9, 2020).

[19] New York City runs several lending programs to help property owners finance energy efficiency upgrades and water conservation measures (New York City, n.d.).

(iv) Redirecting Existing Funding from ICE Buses to ESBs

ACTION: Fund ESB programs by redirecting existing funding for ICE buses.

Existing funding for ICE buses can be redirected to ESBs. For example, New York State provides Capital Transportation Aid to public school districts in the form of partial reimbursement for the purchase and lease of school buses and other capital equipment, totaling more than $111 million in Fiscal Year 2019-2020 (The University of the State of New York, n.d., p. 32). Such aid has been predominantly used for the purchase of school buses fueled by diesel or gasoline, although the purchase of electric buses is also eligible for reimbursement. That funding could be redirected to ESBs by increasing the reimbursement rate for ESBs and decreasing the rate for ICE buses, with increasing differentials over several years leading to the eventual elimination of reimbursement for ICE buses.[20] Given the higher initial purchase price of ESBs, the annual budget for State Aid for ESBs would likely increase in the short term, perhaps significantly if the transition of the State's entire fleet of 50,000 school buses were targeted for an ambitious timetable of five to 10 years. Upon completion of that transition, however, the state could decrease its State Aid budget below current levels because schools would be spending less on fuel and maintenance. The state could smooth out this budget fluctuation through bonding -- thus enabling the beginning of a bold transition even in the face of budgetary difficulties arising from Covid-19.

2. Reducing the ESB Price Gap by Scaling up Production and Achieving Economies of Scale

A second major avenue for driving the adoption of ESBs is to accelerate the reduction in ESB purchase prices by ramping up production to achieve economies of scale in manufacturing and administration. That shift has not happened yet, however, because ESB scale and price are the classic chicken-and-egg: purchasers are not able to buy many ESBs while their price is three times that of ICE buses, but manufacturers cannot scale up production -- and lower their prices as a result of economies of scale -- without large orders of ESBs.[21] Enterprising agents in industry and government can work together to break through this logjam.

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[20] Such a change in reimbursement rate would require amendment of the New York State Education Law, Section 3602(7), which specifies a formula for reimbursing school districts for capital purchases (The University of the State of New York, n.d., p. 32).

[21] One leading ESB manufacturer has identified a site to build a manufacturing facility in New York but has not moved forward while sales remain low during the industry's pilot-program stage (personal communication, 2020).

ACTION: Drive down ESB prices by scaling up production through aggregate purchases by states and municipalities.

States or coalitions of states could place aggregate orders for ESBs and make them available to schools at cost. Large states such as California and New York have sufficient scale to do their own purchasing and distribution.[22] Smaller states can join in compacts among themselves or with larger states.[23] Municipalities could also pool their efforts to aggregate purchases of ESBs, using their own or shared procurement systems or existing procurement collaboration resources.[24]

These aggregate purchases, particularly if placed for multiple-year delivery, would enable manufacturers (current and new market entrants) to build out their facilities to provide increased scale of ESB production and distribution. Those enhancements should create efficiencies and economies of scale that would lead to a significant decrease in costs that could be passed on to purchasers.[25]

Aggregate purchasing would also provide governmental buyers with industrial policy opportunities. For example, states could leverage their purchasing power to require minimum levels of in-state or in-region manufacturing, servicing or training.[26]

B. Adding Charging Stations and Power Infrastructure: Challenges and Strategies

Another obstacle to the rollout of ESBs is the need for charging stations[27] and, in many cases, additions or upgrades to power infrastructure. Utilities typically perform all or most of the "make ready" process of building out or upgrading utility-owned infrastructure to link the grid to charging sites for ESBs and other EVs, such as step-down transformers, overhead service lines, and the utility meter. Site owners or operators typically own and are responsible for providing charging stations and, in some cases, the

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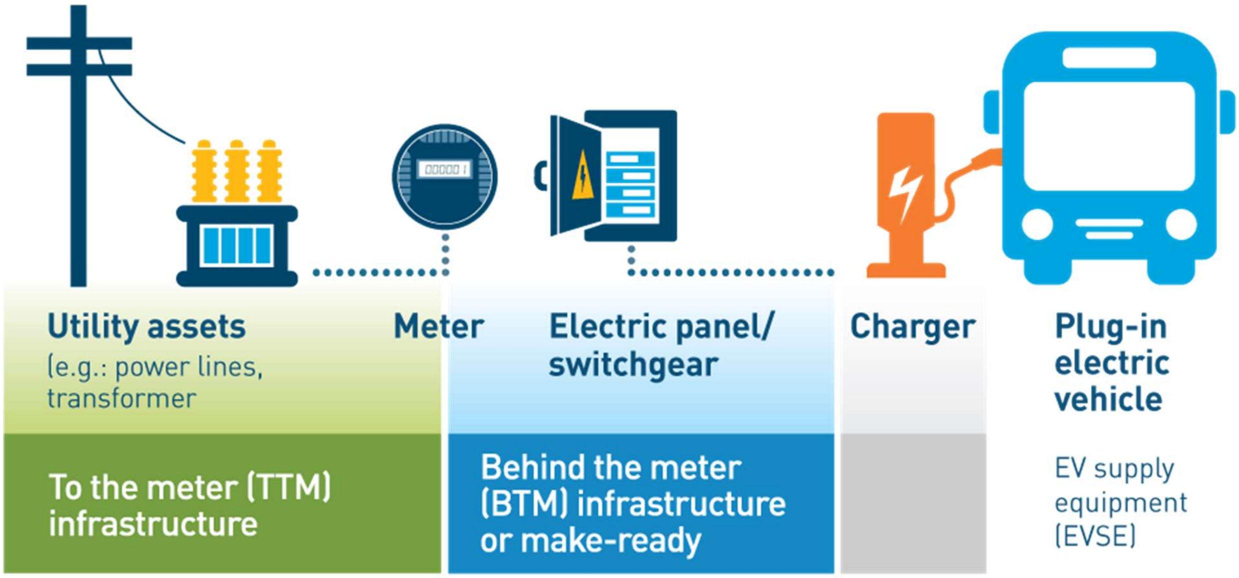
[22] New York's Office of General Services and Department of Environmental Conservation organized an aggregate purchase of EVs for state agencies and municipalities (New York State Office of General Services, n.d., Procurement Section).
[23] One compact that could undertake such an effort is the TCI, which in 2011 launched the Northeast Electric Vehicle Network to coordinate state action and facilitate a regional network of EV charging infrastructure (Transportation Climate Initiative, n.d.).
[24] Examples of procurement collaboration resources include the Climate Mayors Electric Vehicles Purchasing Collaborative (https://driveevfleets.org/) and Sourcewell (https://www.sourcewell-mn.gov/).
[25] Economies of scale from larger manufacturing plants is already an important driver of lithium-ion battery price reductions (Bloomberg New Energy Finance, 2018; Blynn, 2018, p.35).
[26] A public-private partnership for workforce training initiative was recently announced in New York, where offshore wind developers will finance a National Workforce Training Center (NWTC) in Suffolk County, designed to offer curriculum and support services to prepare workers for next-generation jobs in offshore wind and green energy. The $10 million investment by the developers is contingent upon their selection by the New York State Energy Research and Development Authority's for the state's first offshore wind solicitation (Ørsted, 2019).
[27] This White Paper assumes that ESBs will use in-depot plug-in charging stations rather than overhead conductive charging or wireless inductive charging, which are used more often for transit buses.

terminal make-ready tasks such as installing conductors, trenching, and panels for the charging stations (Joint Utilities, 2020, p. 3).



Imaage source: PG&E, https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program.page

Adding or upgrading utility-side infrastructure is a site-specific endeavor that can be complicated and time consuming. The willingness of utilities to provide make-ready infrastructure on a timely basis is directly linked to their financial and regulatory incentives for doing so. Those incentives are largely dictated by state public utility bodies, which impose regulatory requirements and set tariffs by which utilities are paid.

ACTION: Require utilities to provide "make-ready" services of power infrastructure to ESB charging sites.

The transition to ESBs can be accelerated by states requiring their public service commissions or other public utility bodies to incentivize or mandate utilities to provide timely EV make-ready services. California enacted the most comprehensive make-ready mandate in AB 841, passed in September 2020, that requires utilities starting in 2021 to provide make-ready services and provides reimbursement through cost recovery from ratepayers (Cal. Assemb. B. 841, 2020). New York recently announced an expansion of its new make-ready program to include medium- and heavy-duty EVs in addition to the earlier-announced program for light-duty EVs. The New York State Public Service Commission (PSC) issued an order requiring investor owned utilities to (1) develop Medium- and Heavy-Duty Fleet Make-Ready Pilot Program Implementation Plans that will support a direct reduction of diesel emissions located in environmental justice communities through electrification of medium-duty and heavy-duty vehicles, and (2) offer a Fleet Assessment Service consisting of a site feasibility analysis and rate analysis, including for medium-duty and heavy-duty fleet operators (New York State Public Service Commission [NYS PSC], 2020, pp. 128-132). Utilities can apply for cost recovery for these make-ready expenditures (NYS PSC, 2020, pp. 130-131), but the PSC limited this expansion as a pilot program and capped this medium-duty and heavy-duty component of the make-ready program at $24 million.

Charging station capital costs are highly variable and can range from around $3,000 to $25,000 or more (Nicholas, M., 2019, pp.2-3; CARB, 2019b, p. 44). In addition to the cost, school districts often find it challenging to dedicate internal administrative resources to manage the complexities of planning, purchasing and installing charging stations, including coordination with utility make-ready efforts. Fortunately, charging stations are a developing technology, with many manufacturers, dealers and consultants capable of providing integrated solutions to fleet owners and operators.[28] Some schools hire consultants to augment the work of district transportation managers or existing transportation vendors, while other schools choose to outsource the entire process to turn-key vendors. In ESB pilot projects, government or utility partners often are responsible for planning and installing charging stations.

ESB expansion will benefit from lessons learned and standardization of equipment and processes resulting from ongoing pilot projects and early adopters. Expansion can be accelerated by utility regulators promulgating make-ready requirements and cost-recovery incentives beyond the pilot program stage.

CONCLUSION

ESBs are a critical component for plans to meet climate change mitigation goals and public health standards. Regulators and state and municipal officials can accelerate ESB expansion by taking several complementary actions:

<u>Funding</u>

- Source ESB grants from scaled-up cap-and-trade and carbon credit markets and ICE vehicle fees.
- Fund ESB programs from V2G benefits and utility cost recovery.
- Fund ESB programs through private equity investments based on ESB cost savings and V2G benefits.
- Fund ESB programs through public bonding based on ESB cost savings and V2G benefits.
- Fund ESB programs by redirecting existing funding for ICE buses.

<u>Timing and Siting</u>

- Eliminate site prioritization conflicts by (1) accelerating ESB conversion and (2) locating early ESB sites in EJ areas and moving ESBs to aggregated V2G sites in summer.

<u>Scaling</u>

- Drive down ESB prices by scaling up production through aggregate purchases by states, municipalities.

<u>Utility Policy</u>

- Require utilities to provide “make-ready” services of power infrastructure to ESB charging sites.

[28] For example, PG&E has approved more than 20 program vendors selling EV chargers and management solutions (PG&E, n.d.).

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