Driving the Future
How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition

By Ian Elder
Senior Researcher, Jobs to Move America
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TABLE OF CONTENTS

About the Author ................................................................. iii
About Jobs to Move America ................................................... iii
Acknowledgements ..................................................................... 1
Methodology .............................................................................. 1
Foreword .................................................................................... 2
Executive Summary ..................................................................... 3
  Performance and Economics of Electric School Buses ............... 3
  Grid Integration ......................................................................... 4
  School Bus Workforce ............................................................ 4
  Policy Recommendations ......................................................... 6
Introduction ................................................................................ 9
  The Student Transportation Industry .......................................... 10
Part I: Electric School Bus Economics and Performance ............ 13
  ESB Performance and Reliability .............................................. 13
  Case Study: Twin Rivers, California .......................................... 21
  ESB Economics ......................................................................... 24
  Current Funding Sources ......................................................... 31
    The Clean School Bus Program at EPA ................................... 35
Part II: Grid Integration - Electricity as a Fuel Source ............... 39
  Infrastructure Requirements of ESBs ....................................... 39
  Electricity Pricing ..................................................................... 42
  Bidirectional Charging and Vehicle-to-Grid Technology ........... 44
TABLE OF CONTENTS (CONT’D)

Case Study: Cajon Valley School District ................................................................. 48
Case Study: White Plains V2G Demonstration ....................................................... 54
Utility Investment in ESBs ............................................................................................... 58
Case study: Dominion Energy Deployment of ESBs in Virginia ........................... 59
Charge Management as a Business ................................................................................. 61

Part III: School Bus Workforce .................................................................................. 63
School Bus Operations ................................................................................................. 64
Spotlight on Workers: The School Bus Driver Shortage ........................................ 66
Case Study: Montgomery County Public Schools .................................................. 70
School Bus Manufacturing ............................................................................................ 72
Electric Vehicle Infrastructure Installation ............................................................... 81

Part IV: Transitioning to Clean School Buses: Policy Considerations ................. 85
ESB Mandates .............................................................................................................. 85
ESB Subsidies ............................................................................................................. 87
Promoting Environmental Justice ............................................................................... 87
Minimizing Cost .......................................................................................................... 89
Creating Good Jobs and Strengthening the School Bus Workforce .................. 90
Mineral Sourcing and Recycling .............................................................................. 93
Fair and Equitable Access to Student Transportation ............................................ 95
Summary of Recommendations ................................................................................... 96

Appendices .................................................................................................................. 99
Annotated Glossary ...................................................................................................... 99
Abbreviations ............................................................................................................. 102
ABOUT THE AUTHOR

Ian Elder, senior researcher at Jobs to Move America, is leading research on how to maximize the social and environmental benefits that can be achieved through electrification of the nation’s school buses. Before joining JMA, he conducted policy and industry research with UNITE HERE Local 25 in Washington, D.C. in support of hospitality workers organizing to win fair pay and working conditions. He received his Masters of Urban and Regional Planning from UCLA, where he focused on economic development and served as co-managing editor of the department's journal Critical Planning. His previous studies were in mathematics, physics, and music.

Contact: gelder@jobstomoveamerica.org

ABOUT JOBS TO MOVE AMERICA

Jobs to Move America (JMA) is a strategic policy center dedicated to building an equitable, sustainable society by creating good jobs for all. JMA research has been used by policymakers in cities and states across the country to ensure that public investment in infrastructure counters climate change, holds corporations accountable, and expands access to good, clean jobs for all working people. JMA has built powerful coalitions of labor, community, and environmental groups to advocate for equitable policy solutions that offer a roadmap to transforming our economy.
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METHODOLOGY

This report provides an overview and analysis of considerations important for a successful and just transition to electric school buses. A wide body of existing literature informed the study, including academic literature on health and educational policy, electric vehicle technology, and economic development; policy and market reports; news releases; and public reporting on the student transportation, electric, and manufacturing sectors. This synthesis was grounded and given context through dozens of interviews with officials from school districts, private fleet operators, government agencies, electric utilities, retrofit manufacturers, charge management companies, and labor organizations representing workers in the sectors discussed. Public information including data from the Census and Bureau of Labor Statistics, SEC filings, and public records requests added additional valuable insights.
FOREWORD

The report you’re about to read represents a trailblazing effort to document the opportunity of school bus electrification in all its complexity. JMA’s research and analysis are grounded in a serious commitment to the values of fairness and equity in the transition to clean and healthy transportation for all students. It concludes—correctly, we believe—that there are massive potential benefits to be realized by investing in electric school buses, and that it is imperative to do it the right way by prioritizing the needs of workers and overburdened communities. And it lays out smart policies to do just that.

Our organizations, Chispa and the United Auto Workers (UAW), share with JMA the belief that communities and workers are central to transforming our economy into one that protects our environment, promotes racial justice, and provides our families with what they need to thrive. We also share a deep stake in school buses. Chispa organizes with low-income communities of color across the country to advance climate justice and community health. With the leadership of Latinx families, Chispa launched the Clean Buses for Healthy Niños campaign for our kids to be able to breathe fresh air on their way to school, and co-founded the Alliance for Electric School Buses, a coalition of non-profit organizations committed to equitably electrifying the nation’s school bus fleet. The UAW represents more than a thousand workers at two of the three largest school bus manufacturers in the United States, Thomas Built in North Carolina and IC Bus in Oklahoma, both of which are building electric buses. These UAW members have collectively fought for and won family-supporting wages and benefits, as well as safe working conditions and respect in the workplace.

The need to electrify our school bus fleet is clear. Studies show that exhaust from school bus tailpipes harms kids and drivers, and that low-income children and communities of color are disproportionately exposed to these fumes. Students who take cleaner buses have demonstrated better academic and health outcomes. Meanwhile, U.S. manufacturing workers cannot be left behind as the world shifts to electric transportation. Instead, we can show environmental and economic leadership by building and deploying electric school buses in the United States with high-road labor standards.

Driving the Future takes on the big questions that communities have been asking about for this transition, from the state of the technology and the promise of V2G, to the school bus workforce, environmental justice, and mineral mining and recycling. And we are left with a host of good ideas about how to make this transition work for all.

We have a brief window of opportunity to get this right, and JMA’s seminal research will be a crucial resource for the advocates, policymakers, and education officials who are working to create a society where all children can grow, learn, and pursue a healthy and happy life. We are excited to continue partnering with JMA as together we seek to achieve our shared vision of clean air, healthier communities, and justice for workers.

Johana Vicente
National Senior Director
Chispa

Cindy Estrada
Vice President
United Auto Workers
EXECUTIVE SUMMARY

Millions of U.S. students rely on the nation’s nearly 500,000-strong school bus fleet to travel to and from school every day. For decades, most of these buses have been powered by diesel engines because despite the harmful pollution these buses emit, there haven’t been viable alternatives that are significantly better for the environment. But with the arrival of electric school bus technology and ever-improving batteries, the nation’s student transportation fleet is on the cusp of a radical and badly needed transition to zero-emissions vehicles.

State and federal subsidies helped districts invest in a growing number of ESB pilots over the past five years and have put a few hundred ESBs on the road. In 2022, however, governments have seriously ramped up their funding proposals for the coming years—at least $4.5 billion just between the EPA and California, with more in other states. With the right policies, these investments can help bring ESBs to scale: lowering prices, increasing quality, and spreading the needed knowledge and experience to catalyze a nationwide transition.

This report by Jobs to Move America provides a comprehensive look at many of the most pressing questions for advocates, school district officials, and policymakers who want to fully understand the transition to electric school buses. The research relies on a wide variety of sources and is grounded by insights shared by more than two dozen representatives from school districts, private fleet operators, utilities, unions, and other stakeholders.

PERFORMANCE AND ECONOMICS OF ELECTRIC SCHOOL BUSES

Performance and reliability

Electric school buses (ESBs) have emerged as a viable way to provide zero-emissions transportation for students. ESBs perform driving tasks well: they climb hills more easily and efficiently than diesel buses, they accelerate quickly and excel at stop-and-go driving, and have thrived in extreme North American climates. Existing bus models can cover a majority of U.S. school bus routes, and are expected to be able to take on most routes as battery technology improves and high-power charging stations at schools and public installations proliferate.

As to be expected for any new technology, the first generations of ESBs have presented reliability issues as manufacturers hasten to master the technology. Districts have reported that school bus manufacturing companies are quickly improving ESB engineering as they learn from hundreds of deployments across the U.S. and Canada. As a mature supply chain for batteries and electronic components develops, electric buses will continue to improve. Fleet operators and funding agencies can help maximize the time ESBs are in good working condition by requiring that manufacturers and dealers provide comprehensive training to school bus mechanics. This lets local workers quickly resolve issues in the bus depot instead of waiting for help to arrive or having to send buses far away.

Economics and funding

Electric school buses are expensive: they currently cost three to four times the price of a comparable diesel bus. At the same time, they can provide significant reductions in operations costs, as districts interviewed for this report reported between 40 and 90 percent savings in fuel and 20 to 40 percent savings on maintenance, though data on maintenance savings is limited. ESBs do not yet have total cost of ownership parity with diesel buses, but it has been predicted that electric buses could be cost-competitive with diesel in the next three-to-eight years.

There are good reasons to believe that with the right policies, ESB prices could fall swiftly. Batteries are the main reason electric buses are more expensive than diesel, and if school bus manufacturers could purchase batteries at the
lowest current prices, they could sell ESBs much more affordably. Research and development is another major cost for school bus manufacturers. **Major government investment in ESBs can help build scale, increasing manufacturers’ ability to buy or produce affordable batteries in bulk, while decreasing per-vehicle spending on R&D.**

Governments should design subsidies carefully to ensure that ESB manufacturers have an incentive to compete to provide the highest-quality buses, at the best prices, with the most highly trained and well-compensated workforces. For example, **state governments can conduct solicitations to make bulk purchasing contracts for the school buses that provide the best public value in terms of price, quality, and jobs.**

The newly adopted Infrastructure Investment and Jobs Act created the $5 billion Clean School Bus Program within the EPA, half of which is exclusively dedicated to ESBs. California, already a leader in funding ESBs, is proposing nearly $2 billion towards ESBs over the next few years, and other states are considering additional investments. While this spending will not convert the entire U.S. fleet, it will help the market mature and give thousands of districts the opportunity to deploy ESBs.

Many fleets should be able to start replacing most or all of their retiring school buses with electric models between 2025-30. Since the average school bus age in the U.S. is fifteen years, **this could result in all-electric fleets by 2040-45,** or even sooner for some fleets.

**GRID INTEGRATION**

The most complex challenge for school bus fleet operators is learning the logistics and financial impact of delivering electric power to ESBs. Fleet operators and experts with experience in ESBs recommend planning for installing bus chargers as far ahead as possible. Electric utilities are crucial early partners for fleets seeking to electrify, and should be consulted early, both to determine what infrastructure upgrades will be necessary, and to figure out how electric buses will impact fleets’ electric bills.

Level 2 AC chargers can replenish today’s ESBs overnight in about eight hours and are much more cost-effective than DC fast chargers. On the other hand, DC fast chargers can fill up bus batteries in two or three hours during the middle of the day, effectively extending their daily range significantly, but they can be very expensive to purchase, install, and operate. Fleet owners should plan ahead to figure out which chargers—also known as EVSE (electric vehicle supply equipment)—are the best fit for their needs.

There are various funding sources available for fleets to help pay for the installation of EVSE. Several states have approved policies that allow utilities to help pay for infrastructure upgrades, sometimes known as “make-ready” programs. And many school bus subsidy programs, including the federal Clean School Bus Program, can include funding for electrical upgrades.

Electric school buses are a promising application for vehicle-grid integration technology (VGI). The most basic version of VGI is managed charging, which automatically charges buses on an efficient schedule during off-peak hours; **managed charging is crucial to save electricity costs and extend battery lifetimes.** Some school bus fleets are also testing out vehicle-to-grid (V2G) technology, which enables buses to store up cheaper (and often cleaner) electricity, and sell it back to the grid. **V2G and vehicle-to-building (V2B) technologies are still in the pilot stage, but show promise for promoting a greener electrical grid, saving districts money, and providing emergency power.**

**SCHOOL BUS WORKFORCE**

Transporting all of the nation’s students is an enormous logistical undertaking that requires the dedicated labor of hundreds of thousands of workers to build, operate, maintain, and repair school buses. The ESB transition will have major impacts on maintenance and manufacturing workers, but it also provides a chance to help
reverse decades of job losses and wage stagnation in manufacturing. Electrification will also provide career opportunities for thousands of electricians.

**School bus operations and maintenance**

In 2020, there were an estimated 409,000 school bus mechanics, drivers, and attendants. The largest occupation is drivers, with more than 314,920 working across the U.S. School bus driving is a highly responsible position which requires safely operating a heavy-duty vehicle while simultaneously providing childcare. Still, drivers are paid significantly less than other holders of commercial driver’s licenses (CDLs)—earning a national median between $34,000 and $38,000 a year—with the predictable outcome that school bus fleets are chronically understaffed, a shortage that has swelled into a crisis during the pandemic. School bus attendants, also known as monitors, provide additional care for students on buses, especially those with special needs. In 2020, there were 78,210 school bus attendants, who earn less than drivers at a national median of approximately $29,000 per year. In the same year nationwide, there were approximately 16,060 mechanics, who earned a national median wage between $46,600 and $50,000.

The COVID-19 pandemic has had a major impact on school bus operations. Tens of thousands of workers in the field were laid off in 2020, while many others retired. Because of persistently low education funding, school bus jobs are generally underpaid and districts were not able to hire enough workers to replace those who left.

School bus drivers, attendants, and mechanics breathe large quantities of diesel exhaust in the course of their work. **Electrifying school buses will create a much healthier work environment for school bus workers.** Quieter buses also make it easier for drivers and attendants to keep students safe. At the same time, it is essential that drivers and mechanics receive training in the new technology. The powertrains of electric buses are dramatically different from diesel or gasoline powertrains and require an entirely new set of skills to repair and maintain. **Mechanics are highly skilled workers, and fleet operators must ensure that they are providing the training workers need to successfully take care of ESBs.**

**School bus manufacturing**

School bus original equipment manufacturers (OEMs) assemble school buses and typically also manufacture the body and/or chassis (frame). OEMs typically procure most of the other parts from suppliers. There are three companies that dominate the market for traditional large (Type C and D) school buses: Thomas Built, IC Bus, and Blue Bird. All three have electric models available. Other companies are emerging to manufacture ESBs. Among eight of the largest OEMs, there are more than 6,000 workers manufacturing school buses. The number of workers involved in school bus manufacturing, however, is much larger when you consider the entire supply chain.

Broadly speaking, manufacturing is a critical sector for U.S. workers. Unfortunately, jobs in manufacturing have steadily declined over the past few decades, while wages have stagnated. Automotive manufacturing can provide good jobs for workers from diverse backgrounds, but corporations have employed tactics to reduce wages, and often fail to provide equitable opportunities for career advancement in the industry. **High-road manufacturing, in which companies compete by investing in highly skilled labor through training and fair wages, is an alternative model that has proven successful around the world.**

Among jobs related to school buses, manufacturing jobs face the most risks from electrification. Research on light duty vehicles suggests that ESB manufacturing may require the same amount of labor as other jobs. However, key ESB components, including electronics and batteries, are manufactured outside of the U.S., so unless a network of domestic suppliers can be developed, many workers in the school bus manufacturing supply chain could lose their jobs. Electrification has also
led to the emergence of new, often non-union companies which undermine wages and working conditions.

Through smart policies, the U.S. can grow its supply chain for medium/ heavy-duty EVs, while also creating equitable career opportunities with high wages and family-sustaining benefits. To do so, federal and state agencies should invest in electric school buses while providing incentives for companies to create good U.S. jobs with high wages and benefits, and to hire, train, and promote inclusively. Governments should also provide assistance for factories that make diesel engine parts to retool, rehire, and retrain workers so they can build components for the clean buses of the future.

**Electrical charging equipment installation**

The installation of charging equipment (EVSE) for school buses alone could create an estimated 12,000 to 23,000 jobs, including 3,700 to 7,400 jobs for electricians. The median wage nationally for electricians is $26.52 per hour, while wages can be nearly double that in large metropolitan areas. Electricians can progress from apprenticeships, in which new workers can “learn while they earn,” to journeypersons who can work on projects without direct supervision, to master electricians who can plan and manage projects and supervise apprentices and journeypersons.

The Electric Vehicle Infrastructure Training Program (EVITP) is a national program administered by a non-profit training and certification organization. The certification is available to journeyperson electricians, and includes 18 to 20 hours of training on EVs, charging station types, electric load calculations, and safety standards for EVSE installation. California, which leads the nation in EV deployments, requires the participation of EVITP-certified journeypersons in most state-funded EVSE projects, which helps ensure safe and proper installation.

Electrical careers can provide opportunities for highly skilled and well-paid work, and apprenticeships usually don’t require more than a high school diploma or equivalent. Given the continued growth in the field, it’s critical to ensure that electrical contractors hire and recruit apprentices from disadvantaged communities, and ensure that such workers have an equitable opportunity to succeed. Pre-apprenticeship programs can be an excellent way to help ensure that workers are fully prepared to thrive in apprenticeship programs.

**POLICY RECOMMENDATIONS**

This report recommends the use of state and federal subsidies as a central strategy to accelerate the transition to electric school buses. The U.S. government has committed billions of dollars to the ESB transition, and some states, especially California, have committed significant additional sums. Further investment is likely warranted. All government subsidies, current and future, for electric school buses, should adhere to the following principles:

**Promote environmental justice**

Prioritize funding for disadvantaged communities. The transition to electric school buses provides an opportunity for state and federal agencies to reduce the severe racial and economic inequality that exists in the geographic distribution of air pollution sources such as school bus depots. Funding programs should create explicit, well-defined, and accountable preferences for disadvantaged communities.

Fleets serving disadvantaged communities should not only be first in line, but they should also receive deeper subsidies. Over the next several years, this will mean awarding subsidies greater than the incremental cost between diesel and electric, at a minimum, plus infrastructure costs and technical assistance. Agencies should engage communities directly to ensure that funding programs are meeting their needs.

**Promote good jobs for school bus drivers, attendants, and operators**

Workforce impact assessments. Funding applications should include workforce impact
assessments, in which fleet operators evaluate the expected impact of ESBs on school bus drivers, attendants, and technicians, and provide their plan to ensure that workers retain their positions, receive the training they need, and maintain wage and benefit levels.

Procure for training. When purchasing ESBs, a best practice is to require the OEM or dealer to thoroughly train drivers and mechanics in the skills they need to continue operating, maintaining, and repairing school buses. Government subsidies for ESBs should also provide funds for employee training.

Promote good jobs for manufacturing workers in the school bus supply chain

Incorporate the U.S. Jobs Plan (USJP) in funding streams and solicitations. ESB funding programs should promote the development of a high-road ESB supply chain. One of the best ways to do this is through the U.S. Jobs Plan. With a USJP, manufacturers make enforceable commitments on the creation of good jobs and the use of equitable hiring and training practices.

Depending on the design of the program, the USJP can be used to provide greater subsidies for vehicles that create better jobs and hire more inclusively, establish job quality criteria for program eligibility, or as a factor in statewide or local purchasing solicitations.

Adopt Buy America provisions, where possible. While the USJP includes incentives for domestic manufacturing, Buy America has additional requirements that can help ensure that public investments in ESB technology support the development of a domestic supply chain for ESBs.

Ensure safe and proper installation of charging infrastructure

Require the participation of electricians trained using the Electric Vehicle Infrastructure Training Program (EVITP). ESB funding programs that subsidize electrical infrastructure installation should require that EVITP-trained journeyworker electricians participate in the installation. Requiring EVITP will help guarantee safety, high training standards, and proper installation of school bus EVSE.

Require prevailing wages. Whenever possible, funding agencies, school districts, and fleet operators should require the payment of prevailing wages when they procure electrical contracting services to install school bus charging equipment.

Promote equitable employment practices

Incorporate the USJP for school bus investments. For manufacturing workplaces, the USJP includes incentives for OEMs and suppliers to develop concrete, enforceable plans to recruit, hire, train, and promote inclusively, ensuring the equitable participation of workers from disadvantaged communities. A simplified version of the USJP could also be adapted for the procurement of electrical contracting services, giving priority to contractors that create good jobs and hire and promote inclusively.

Encourage the use of inclusive and well-designed apprenticeship and pre-apprenticeship programs. Agencies can support and promote the use of apprenticeship and pre-apprenticeship programs that equitably recruit workers from underrepresented communities, workers with barriers to employment, or workers displaced by COVID-19 or from the transition to clean energy and zero-emissions transportation, providing workers a chance to learn on the job.

Promote recycling and responsible mining

Although electrification has the potential to greatly reduce the harmful climate and air quality impacts of vehicles, sourcing the raw materials needed for EV batteries poses unique environmental and social challenges. ESB funding programs should investigate the use of incentives for school bus manufacturers and their suppliers to recycle their vehicles at end of life and use recycled or responsibly mined materials. Funding programs and procurements can also include best practices such as labeling batteries with their chemical components.
Facilitate ESB adoption and technology improvements through data collection, information sharing, and transparency
Agencies should take the opportunity to facilitate collective learning between districts, school bus fleet operators, OEMs, dealers, government, and the public. By collecting and publicly sharing data on government-funded ESB deployments, agencies can help develop best practices for dealers and fleets, ensure transparency, and promote technology improvements.

Incentivize lower school bus prices
Use statewide centralized procurements to encourage competition. Conduct statewide best-value procurements to determine which buses will be eligible for subsidies. Agencies can evaluate bidders on cost, quality, and service, while also including criteria on environmental impact and the creation of good jobs. The USJP is a valuable tool for such procurements. In order to provide flexibility for school districts while still creating a strong incentive to compete, agencies may consider making two or three awards in each category of school bus.

Invest in electrical infrastructure for school bus fleets and public access
Agencies should work with utilities and regulators to actively plan the transition to ESBs. School bus lots across the country will need major power upgrades.

In order to serve students on longer field trips, ESBs will need access to high-power public charging stations. Therefore, governments should help ensure the development of a robust network of public charging stations across the nation, including high-power charging stations with at least 50 kW (or preferably higher) so that buses can recharge quickly on the road.
INTRODUCTION

On November 15, 2021, the iconic yellow school bus took a sharp turn in the road with the passage of the bipartisan infrastructure law. Thanks to the new law and its Clean School Bus Program, electric school buses (ESBs) may quickly become the dominant student transportation vehicle over the course of the next ten years.

That’s good news for students. Diesel exhaust is poisonous to kids’ developing lungs and impacts their health, happiness, and even their school performance. Electric buses are also good news for neighborhoods that have to deal with the toxic miasma exuded by warming and idling buses near schools and parking lots. And they’re good news for the school bus drivers, attendants, and mechanics who spend most of their day on a bus or at the depot, breathing in the dangerous fumes their workhorses breathe out.

School buses are serious business. They are the nation's largest transportation fleet by far, with roughly 480,000 buses transporting over 21 million students daily. For many families, buses are a major convenience; for others, they are the only way their children can take classes. School buses are the safest and surest way for kids to travel, and they make it more likely for students to be able to attend school.

Because of the size and significance of the fleet, the urgency of providing clean air for kids, and that are relatively short shifts, advocates for zero-emission vehicles have identified student transportation as a trailblazing application for medium- and heavy-duty vehicle (MHDV) electrification. Buses and trucks contribute 27 percent of U.S. greenhouse gas emissions from transportation, despite only representing 10 percent of vehicles on the road. Even in the states with the most polluting electrical grids, electric school buses produce significantly lower emissions than their diesel counterparts; replacing all diesel school buses with electric would reduce annual climate emissions by at least 4 million tons.

Deploying electric school buses (ESBs) can help clear the way for EV technology for MHDVs and take a big step forward on the path of addressing climate change.

As with any crucial public service, student transportation isn’t just a service: it’s a career for hundreds of thousands of dedicated working people. Drivers, attendants, and mechanics are fundamental to the proper functioning of our public schools. Before that, the buses themselves must be manufactured, a process which employs tens of thousands of people across the supply chain: in materials mining and processing, components production, and vehicle assembly. To run, buses need fuel, which means that workers in the energy sector are also critical.

The transition to electric buses may seem inevitable at this point, but how that transition transpires matters deeply for everyone involved, from the families who rely on school buses, to the communities who share space with them and the workers who build, power, operate, and maintain them. Fortunately, the Justice40 initiative and the Biden Administration’s executive order on the implementation of the bipartisan infrastructure law

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6 O’Dea, Ready for Work; calculated using the Argonne National Laboratory’s AFLEET Tool 2020, using the following assumptions: 480,000 school buses, 95 percent of which are diesel; electric school bus efficiency of 1.5 kWh/mi; diesel bus mileage of 7 mpg; annual school bus mileage of 8,000 miles; and the average U.S. mix of electricity sources. This figure will improve with the integration of more renewable energy sources into the grid.
both include clear priorities to center the needs of workers and disadvantaged communities when the government makes investments in clean energy and transportation, such as the Clean School Bus Program.\(^7\)

Are electric school buses ready to take on the responsibilities of safely bringing kids to and from school and, if so, how long will it take to transition? Can we afford them? What does it mean to use electricity as a fuel? What will be the impacts on workers, both in the U.S. and around the world? And, what are the policies we need to make sure the transition does right by communities, promoting shared prosperity instead of putting all of the risks and burdens on the backs of workers, low-income families, and people of color?

This report seeks to shed light on many of these questions. It sets the stage with a brief background on the student transportation industry. Part I provides an overview of ESB technology, with a focus on their cost and performance. Part II is a primer on the most novel and complex aspect of electric buses: fueling them with electricity. Part III shares an overview of the three main sets of occupations that are central to the school bus sector, and considers the potential impacts of electrification on each. The last part, Part IV, considers the policy implications of the preceding sections, and provides suggestions on how government policy can promote a successful and equitable transition to electric school buses. The Appendix includes an annotated glossary and a list of abbreviations. Throughout this report, glossary terms are bolded the first time they appear in a part of the report.

**THE STUDENT TRANSPORTATION INDUSTRY**

**School bus fleet operators**

Roughly 29 percent of school buses in the United States are owned by private companies, referred to as contractors or *private fleet operators*, which manage school bus services on behalf of districts.\(^8\) The other 71 percent of buses are owned by the school districts themselves or sometimes by the state (1.7 percent). In most cases, districts that own their buses also operate them, but there are examples of student transportation contracts

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\(^8\) “Pupil Transportation Statistics 2018-19.” School Bus Fleet.
in which the district retains ownership of the bus while outsourcing driving and maintenance services. Whether or not districts own their buses, they are typically the main entities responsible for providing student transportation, and are a major stakeholder in school bus electrification.

**School bus terminology**

School buses are divided into Types A, B, C, and D according to their size and shape. Type A is the smallest type of school bus, and they are often used to transport special education students who
receive door-to-door service. Drivers sometimes refer to these as “vans.” Type A buses typically run on gasoline, though diesel, hybrid, and electric models also exist.

Type C buses are the conventional size school bus with the engine in front of the windshield. Type B buses are in between Type A and Type C in size, and are relatively uncommon. Type D buses are also called transit-style buses and seat the largest number of passengers. The vast majority of Type C and D buses run on diesel, though propane, compressed natural gas (CNG), liquefied petroleum gas (LPG), gasoline, and electric models exist. There are currently several models of electric Type A, C, and D school buses.

Based on data from School Bus Fleet Magazine, between 2011 and 2020, approximately 19 percent of buses sold in the U.S. were Type A or B, 70 percent were Type C, and 11 percent were Type D.

**Zero-emissions school bus technologies**

Zero-emission vehicles (ZEVs) are vehicles that do not emit tailpipe emissions because they have propulsion systems that do not directly generate emissions. There are currently two common ZEV technologies: batteries (typically lithium-ion) and hydrogen fuel cells. This report focuses exclusively on battery electric school buses, mainly because they are the only zero-emission school buses available on the market. Battery electric vehicles are currently less expensive, more efficient, and easier to deploy than hydrogen fuel cell vehicles. The main advantage of fuel cells is that they can be refueled quickly and thus achieve greater daily range and longer duty cycles. However, the vast majority of school bus trips are short enough to be within reach for current models of ESB, or for models likely to be developed within the next few years, especially as charging infrastructure becomes more widespread at schools and fueling stations.

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9 Neither technology actually produces zero emissions currently: batteries charged using grid power still rely at least partly on fossil fuel combustion plants, and most hydrogen available on the market is generated from natural gas. However, both types of vehicle are more efficient than buses powered by fossil fuels, and do not produce emissions on the vehicle itself. Both electricity and hydrogen can be generated using renewable energy which will drastically reduce the total emissions produced by ZEVs.
According to the World Resources Institute, more than 1,800 electric school buses have been funded, purchased, or contracted for lease or purchase in the United States. It is unknown how many of these buses have been deployed so far; however, based on media reports, the number is probably between 500 and 900, representing 0.1 - 0.2 percent of the nation’s total school bus fleet. Major new investments and policies by federal and state agencies will significantly increase the demand for these buses over the next few years.

PART I: ELECTRIC SCHOOL BUS ECONOMICS AND PERFORMANCE

ESB PERFORMANCE AND RELIABILITY

Do electric school buses work? In addition to cost, this is the primary question that concerns school districts. This section examines available information on ESB reliability and performance and considers how range, climate, and terrain may affect these buses, drawing on reporting and interviews from several ESB deployments across the country. Because ESB technology is extremely new and continues to develop rapidly, the facts in this report are likely to change. This report’s intention is to describe how the buses currently on the road have performed over the roughly five years that ESBs have been in use, so that policymakers, districts, and communities can make informed decisions about how to advocate and plan for the transition to zero-emission buses.

Note on findings and report limitations

The vast majority of ESBs on the road today are Type C buses. Consequently, most of the reporting on ESBs in the media and in reports—including this

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Electric buses use regenerative braking to reclaim energy when going downhill. When a bus climbs a hill, it’s converting stored energy from the battery or fuel into potential energy from increased elevation. When the bus descends, it converts some of gravity’s work into running the motor backwards as a generator, thereby generating electricity to recharge the battery while also preventing the bus from accelerating too quickly downhill. Diesel buses, by comparison, waste most of that energy in the form of heat when braking. A 2017 study of light-duty EVs in Japan modeled the effect of road gradient on power consumption, and found that EVs are more efficient than gas-powered cars on hills.

In October 2021, the author was invited on a driving tour on a Type C ESB in White Plains, New York. The driver, José Mota, intentionally included several steep hills on the route to show off the bus’s capabilities. He said it was much easier for him to go up hills in the electric bus, that he loved the bus’s acceleration, and that it felt really good to drive.

When the buses were first deployed, he said, the parking brake didn’t work, so all the drivers avoided the electric buses. But after they fixed that issue, he said, everyone wanted to drive them.

Although ESBs can handle hills more efficiently than diesel buses, driving uphill can negatively impact range, which is a much more significant issue for electric than diesel. Research on the effect of hills on EV transit bus energy consumption suggests that impacts from hills may be minimal, but could be greater for routes with a significant net elevation gain. Range impacts on hilly routes

Mechanically, electric motors have two inherent advantages over internal combustion engines when it comes to hills. First, electric motors are capable of producing their maximum torque (the rotational equivalent of force) at low speeds. This means that electric motors have the potential to climb hills more quickly and efficiently.

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should be tested and factored in when planning routes.

A final issue worth considering is whether brake lights turn on when regenerative braking is engaged. Regenerative braking is typically gentler than friction braking and occurs when drivers let off the gas without depressing the brake pedal, but it still decelerates the bus. The brake light systems on some ESB models reportedly rely on the driver pushing the brake pedal; others turn on the light any time the bus slows down. It’s a good idea as a safety matter for regenerative braking to trigger the lights, but some state regulations may not currently allow it.

**Effect of climate on operation**

Climate is another factor fleet directors will want to consider when planning to deploy electric school buses, including the effect of temperature on batteries, the energy needed to heat or cool the interior of the bus, and other impacts.

The Massachusetts electric school bus pilot program analyzed by VEIC, a nonprofit with extensive experience in electric school buses, closely examined the effect of temperature on the buses’ range and efficiency. It found that both range and efficiency were negatively, but not dramatically, impacted by cold weather. A 2019 study by the Center for Transportation and the Environment using a large sample of battery electric transit buses reported similar findings, and noted that extreme temperatures, both cold and hot, had a moderate but negative impact on efficiency, despite the use of diesel heaters.

Electric school buses can be equipped with either electric or fossil fuel-burning heaters. California, the leading state for ESB deployments, does not need or allow fossil fuel heaters in most cases. Diesel heaters have been commonly used in colder climates such as the Northeast, but they can produce significant emissions within the bus. The challenge with electric heating is that it can quickly sap the bus’s main battery. Lion Electric buses, for example, can be purchased with 4-6 kW electric heaters. Assuming a 120 kWh battery and two 2.5-hour duty cycles, the bus should expend 20-31 percent of its usable capacity heating the bus if it runs the heater the entire time.

Depending on the length and terrain of the bus route, this loss of energy may or may not be a serious problem. Many bus routes are shorter than the bus’s listed range. Bay Shore School District in Long Island, NY uses electric heaters on its four Blue Bird Type C electric school buses, which run approximately 3-hour duty cycles. The fleet operator reportedly charged the buses in between duty cycles. However, many buses run duty cycles long enough to be impacted by energy used for heating, so these losses are an important consideration for route planning. Rapidly improving battery technology will help mitigate this issue over time, but OEMs should also explore the use of more energy efficient heating technologies, such as heat pumps.

Two of New York State’s major ESB deployments experienced initial issues with cold weather impacting bus performance; in both cases, the operator was able to address the issue. Bay Shore Schools found that some of the electronic controls did not work and that the battery did not perform well in cold weather. They solved both issues by affixing a wind-blocker to the front of the bus and wrapping the battery in a blanket.

In the White Plains, NY demonstration, the project team initially had difficulty working their two-way charger (needed for V2G applications), and suspected that cold weather was the problem since they did not experience the issue with vehicles parked inside. At the same deployment,

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16 Independent of heaters; the MA pilot used diesel heaters.
18 Richard Gallagher (transportation director, Bay Shore Schools), conversation with author, September 22, 2020.
20 Gallagher, conversation with author.
the general manager of the private fleet operator noted that their electric buses had better traction in the snow than their diesel buses, attributing the difference to ESBs’ lower center of gravity and greater weight due to the battery.22

In a remarkable example of cold weather operation, Tok Transportation has operated a Type C electric bus for Alaska Gateway School District near Fairbanks, AK since 2020. The fleet director reported the buses had been highly reliable as of November 2021, performing in temperatures as low as -48 degrees Fahrenheit.23 Extremely cold conditions quickly drain the battery to run the bus’s heaters; on one cold day at -38 degrees, the bus registered a 122 percent increase in per-mile energy usage.24 Even so, the fleet director did not report difficulties completing the bus route. To mitigate the effects of the cold, the bus is parked indoors and the battery and engine compartment are insulated.25

Range and route planning

Range is a core challenge for electric vehicles, since it currently takes much longer to charge an EV than to refuel a vehicle with petroleum. Fortunately, battery technology has advanced to the point that it is possible to manufacture electric school buses that are capable of covering many of the nation’s school bus routes on a single charge.

In a 2013 study on school bus duty cycles by the National Renewable Energy Laboratory, the average driving duty cycle for school buses was 31.73 miles with a standard deviation of 15.17 miles.26 Roughly 68 percent of school bus daily mileages were between 33 and 94 miles, and 95 percent of daily mileages were between 3 and 124 miles.27 It is unclear how representative this data is, since it draws from school bus routes in only three states. Field trips and sporting events can also be considerably longer than typical daily routes and may present challenges for current models of ESB.

School bus manufacturers currently offer buses that, based on their listed range, could cover the majority of these daily routes. Lion, for example, offers Type C buses with listed battery capacities between 88 and 220 kWh and listed ranges between 65 and 155 miles respectively.28 Similarly, Blue Bird’s Type C Vision electric bus comes with a 155 kWh battery and 120 miles listed range, and Thomas’s C2 Jouley electric bus can be ordered with battery capacities up to a 220 kWh and stated ranges up to 134 miles.29

Many transportation officials reported actual ranges 10-20 percent lower than the listed ranges, which limited which routes they could assign to the electric buses. One way to effectively extend bus range is through the use of faster charging technology. DC fast chargers, though much more expensive than Level 2 AC chargers, can often charge buses completely between duty cycles, thus enabling buses to take on longer routes.30 Depending on region and rate plan, midday charging can have a major impact on electricity bills.

A significant portion of a bus battery’s capacity is not available for driving. The top 10 percent is reserved for longevity of the battery; batteries last longer if they are not quite fully charged. And the bottom 10 percent should not be used either; first,

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27 Author’s estimate based on the report’s observation that mileage data was normally distributed. Daily mileages are estimated here as twice the distance of duty cycles, since school buses cover two shifts. Buses can potentially charge in between duty cycles, though this can result in higher energy costs.
30 Mike Breivogel (fleet manager, Antelope Valley Schools Transportation Agency), conversation with author, November 18, 2021.
to improve longevity, and second because the battery may perform poorly or stop working below 10 percent charge.\textsuperscript{31} Thus, a new 220 kWh battery will likely have approximately 176 kWh available for use. Manufacturer estimates of driving range should already take this into account, though it is uncertain whether they do.

Batteries degrade over time, which manifests in the battery losing capacity as it ages. VEIC has estimated that school bus batteries will typically lose 30 percent of their range after 10 years and will likely need replacing after 12-15 years.\textsuperscript{32} Fleet operators could develop a strategy of cycling buses with older batteries to shorter routes as they age, covering longer routes using buses equipped with newer batteries.

Limitations due to bus range can be addressed over time in two major ways. First, improved availability of public high-speed chargers and chargers at school bus parking lots should make it much easier for buses to provide transportation for field trips and inter-scholastic events. Second, battery and charging technology are improving rapidly, and have the potential to eventually eliminate most range concerns for school buses.

Reliability
Precise data on the reliability of ESBs is hard to come by. Given that less than 0.2 percent of the nation’s buses are electric and that most of the electric buses on the road are less than a couple years old, any information on ESB reliability is necessarily anecdotal. For this report, officials from 11 school bus fleets representing more than 90 electric school buses were interviewed in the hopes of discovering broad trends and lessons learned from the first couple batches of school buses on the road today.

The major school bus manufacturers have decades of experience building school buses. Electric buses, however, are an extremely new product, and the initial experiences of transportation officials and fleet operators have often included the kinds of growing pains that typically come with the adoption of new technology. At the same time, most officials expressed that manufacturers appeared to quickly incorporate product improvements and that they believed electric school buses were destined to become the predominant technology soon.

In 2016, one of the nation’s first ESB deployments launched in three Massachusetts towns. A 2018 report by VEIC showed that the pilot was beset by problems, including inefficiencies in charging the buses, delays in receiving parts, software and firmware issues, and breakdowns.\textsuperscript{33} Overall, the districts using the buses reported being in good operable condition approximately 80 percent of the time—a metric known as uptime—and that the ESBs had enough problems to disrupt operations. Industry-wide average uptime figures for diesel school buses were not available; however, National Express, the second-largest private fleet operator in the United States, has indicated an expectation of 95 percent uptime for its diesel buses.\textsuperscript{34}

According to Brian Foulds, an activist who was closely involved with the project, the manufacturer has since overhauled the buses used in the pilot and the buses are now operating at a high level of reliability.\textsuperscript{35} The manufacturer reportedly corrected the design flaws it discovered for its next model of buses.\textsuperscript{36}

ConEdison’s V2G demonstration project in White Plains, NY, has kept careful records which it has submitted to the state Public Service Commission on a quarterly basis. These reports are an invaluable source of information on the ups and downs of one of the first V2G school bus projects in the U.S., and are discussed in greater detail in the case study on White Plains in Part II. Since the buses were first put into service in September

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\textsuperscript{35} Conversation with author, June 2, 2021.
Driving the Future: How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition

2018, the operator has reported consistently high driving performance and driver satisfaction, while reliability has been more variable. Over the first year and a half of operations, the buses had an average uptime of approximately 95.3 percent, meeting the operator’s target for diesel buses. Through most of 2020, buses were out of service due to COVID-19, during which time three of the buses were upfitted for V2G. Since 2021, uptime has ranged between 94 percent in the first quarter and 61 percent in the second quarter, with an average of 76 percent for the year. Overall, the buses have had an average uptime of 86.7 percent across the whole pilot. Throughout the entire project, it appears that the majority of reliability issues have stemmed from complications with charging technology.

One district interviewed for this report, Everman Independent School District near Fort Worth, Texas, expressed strong satisfaction with their electric school buses and did not describe any serious difficulties aside from the procurement process. Jason Gillis, the district’s transportation director, shared that their fleet consists mostly of Type C buses, but there were not any electric Type C models available that included air conditioning and complied with Texas state specifications and requirements. Instead, they purchased three Type D ESBs using funds from the state’s VW Fund allotment. Gillis estimated that based on route distance and hills, they could probably use comparable buses for about 85 percent of their routes. The biggest concern he expressed was that the heaters use a lot of energy; interestingly, in Texas the heaters had a bigger impact on energy usage than the air conditioning because heaters typically have to run all day, as opposed to AC which they typically only need in the afternoon. Higher battery capacities would allow the district to use ESBs on even more routes and reduce the impact of heating and AC.

The most common report from school districts was that their buses were mostly working well, but that they had to deal with significant bugs. For example, at Cajon Valley Union School District in San Diego County, the transportation director did not share any complaints about the buses’ performance, but mentioned they were facing major challenges with the charging infrastructure due to the implementation of vehicle-to-grid (case study). At Bay Shore on Long Island, officials said that despite the buses’ temporary issues with cold weather (described above), both the district and private contractor were very happy with the buses and seeking to expand their electric fleet. And in Fairfax County, Virginia, officials described a process of correcting several minor issues, the most important of which being a problem with the charging equipment software (see case study on Dominion).

A couple of districts experienced more serious complications. The Antelope Valley School Transportation Agency near Los Angeles had seven electric buses: four Type As, two Type Cs, and one Type D. Their fleet manager, Mike Breivogel, said that the buses drive extremely well when they work: they’re smooth, they accelerate well, and his staff appreciated that the heating and cooling operate without having to idle the bus. In terms of reliability, he reported that they hadn’t been able to drive the buses much due to extensive downtime. Problems on the Cs and D included battery management system failures and software issues. The Type As were even more difficult; they came with two-speed transmissions that failed almost immediately after delivery, and had to be returned to Canada for repair. Additional challenges with the Type As included a loss of

38 The main reason for the severe drop in uptime between the first and second quarters was that five on board chargers on four buses failed during the quarter.
39 Averaging quarterly figures may not be statistically sound since use will vary between quarters, especially Q3 which includes most of summer vacation. However, Q3 figures are not outliers in most cases and the average still should provide a helpful overall idea of bus reliability during the demonstration.
40 Thomas Smith (vice president for operations, Suffolk Transportation Service), conversation with author, August 5, 2021; Gallagher, conversation with author.
41 Breivogel, conversation with author.
power steering and power brakes and issues with inverters.

Ann Arbor’s deployment, which includes four Type C buses, similarly faced major setbacks. Transportation officials explained that the buses had been out of service several times, sometimes for a month at a time. The buses broke down a few times during operation which required the buses to be towed. Sometimes, they said, the driver would see error codes and the bus would just shut down. Their dealer had not yet learned to resolve the issue in many cases, so the district often had to work with engineers from across the country. The district’s officials said they had previously relied on a different manufacturer which was well supported by the dealer network in their area, and that switching companies was challenging.

A final critical example is that of the Twin Rivers school district in California, the most experienced and advanced school district in the United States when it comes to ESB deployment (case study). The district has already electrified half of their fleet, deploying at least forty-one electric school buses with eleven more on order out of a total fleet of eighty-two buses. Twin Rivers has several different types and models of buses and deliberately tries out new buses so it can share experiences with other districts. Their example demonstrates that it is possible to run a successful student transportation operation that relies heavily on ESBs. They are installing enough electrical infrastructure to power an entire fleet of ESBs and focusing on taking on their final challenges: field trips and athletic events.

As discussed in the case study, Twin Rivers has not been completely spared of hitches in its electrification program, but they argue that the challenges are not substantially greater than with new buses with internal combustion engines (ICEs). Rather, by adopting ESBs at a brisk pace, they’ve learned quickly and benefited from productive relationships with school bus manufacturers.

**Analysis and lessons learned**

**Causes of downtime.** If ESBs have greater downtime than their diesel counterparts, there is probably one main reason: they’re new. Newness causes a lot of difficulties that may be best resolved by thoughtfully investing in nationwide deployments on a large scale, while ensuring that dealers and districts have the resources, support, and training they need to succeed with the new buses. First, many issues can be resolved by original equipment manufacturers and powertrain manufacturers tweaking their engineering. (Original equipment manufacturers, or OEMs, are the companies that perform final assembly of buses.) Over time, OEMs should be able to improve their designs and perfect the technology. Second, parts for ESBs are much less prevalent, so it can take longer to repair buses. This has been particularly true during the 2021-22 global supply chain adjustment, in which delays of several months have been common for ESB components. Third, many of the difficulties encountered in school bus deployments arose from chargers or charging software, rather than the buses themselves, and may resolve themselves as high-power charging technology becomes more common and standardized. Finally, dealers and districts have not yet received enough of the training they need to repair the buses themselves, which has often resulted in having to wait for mechanics to fly out, or having to send the bus across the country to the OEM for repair.

**Need for training.** The level of electric bus training at dealerships and districts seems to have been a determinant of success in many ESB deployments. When dealers are not highly trained with electric buses, districts may need to work directly with the OEM, which can be convenient when the manufacturer is located nearby, but otherwise can be burdensome.43

42 Liz Margolis (executive director of student & school safety, Ann Arbor Public Schools), Edward Gallagher (general manager, Durham School Services), and John Nikolich (fleet manager, Durham); conversation with author, October 18, 2021.

43 One transportation official interviewed for this report even admitted that one of their preferred manufacturers of ICE-powered buses wasn’t of the highest quality, but was still a top choice because of the convenience of having the OEM nearby for sales and repairs.
Training all of the mechanics at all of the dealerships, districts, and fleet operators in electric will take some time. Since the technology is still undergoing engineering, protocols for repair and maintenance are not fully established. But purchasers of ESBs can help make sure that their mechanics are given the best possible chance to repair their buses by including adequate, continuing training in their procurements for electric buses.

**Differences between bus manufacturers.** From the interviews conducted for this study, it was not possible to discern significant trends in reliability between different bus OEMs. Districts and fleet operators reported difficulties with buses produced by all ESB manufacturers. Some specific issues seemed more common to certain manufacturers. However, the dataset is too small and the technology is changing too rapidly to justify drawing conclusions from these observations. For example, buses from one manufacturer were noted to work poorly in cold weather, but it was also reported that the manufacturer had since upgraded the battery system to resolve the problem.

**Differences between bus types.** Most of the successful deployments have involved Type C buses. Not many Type A electric buses have been deployed. Some transportation officials interviewed for this report described serious malfunctions with their Type A buses. Other experts noted that the dimensions of Type A buses could pose an engineering challenge, since there is less room for battery systems. Type A buses also currently rely on truck chassis designed for ICE powertrains, and improvements may be possible from the use of purpose-built electric truck chassis. Not all districts had problems with their Type A buses: Twin Rivers is successfully operating nine of them, albeit on shorter routes.

Type D electric buses were even less common, and only two owners of this type of bus were interviewed for this report. Performance and reliability for these buses were comparable to Type Cs.

**Rapid improvements over time.** A common theme among officials was a perception that OEMs were learning quickly from ESB deployments and using those lessons to improve the buses. Several transportation directors spoke of “generations” of buses; another preferred to describe it as an “evolution.” A few districts described a process of frequent feedback with OEMs: the district would report a problem, the OEM would then fix it and then try to learn from the malfunction to prevent it in their design for subsequent iterations of ESBs. Other districts heard directly from OEMs about improvements between generations of bus. For example, officials at Montgomery County Public Schools in Maryland were given the option of receiving a previous generation of bus early, or waiting a few months for the next generation to be available. The district opted to wait for the next generation of buses, which have since been delivered (see case study).

Most of the buses considered in this study are early-generation buses. Since the conclusion of interviews for this report, many districts have received updated buses, which may have incorporated significant improvements to address reliability issues. However, as of March 2022 limited data was available on the performance of these buses.
CASE STUDY: TWIN RIVERS, CALIFORNIA

Twin Rivers Unified School District, near Sacramento, California has by far the largest fleet of electric school buses in the United States. Tim Shannon, the district’s transportation director, has been a vocal advocate of the technology, and the district is far ahead of other districts in deploying ESBs in large part because they started early with aggressively pursuing grants. Even though the Twin Rivers example is well known, it is worth considering in detail because it is the first—and so far, only—example of a fleet that has made substantial progress towards deploying ESBs at scale and electrifying their entire fleet.

![Type C ESBs deployed at TRUSD. Source: Twin Rivers Unified School District.](image)

**PROJECT DETAILS**

**School district:** Twin Rivers Unified School District (TRUSD), Sacramento Co., CA

**Utility:** Sacramento Municipal Utility District (SMUD)

**OEMs/dealers:**
- 5 Blue Bird Type Ds
- 27 Lion Type Cs
- 8 TransTech Type As
- 1 Collins Type A

On order: 5 additional Blue Bird Type Ds and 6 Thomas Built Type Cs

**Additional partners:** Charging and V2G: Electrify; EVSE manufacturers: Clipper Creek, Nuvve, and BTC

**Number of ESBs:** 41, with 11 on order, out of 82 total buses in the fleet.

**Charging:** Mix of DCFC and Level 2 charging, specialized Clipper Creek chargers for nickel-sodium TransTech buses; have installed infrastructure for 82 chargers.

**V2G:** In development; collaborating with SMUD on planning V2G.

**Funding sources:** Early grant from California Climate Investments (cap-and-trade funds) which paid for 16 ESBs (plus 13 ESBs at nearby school districts); California’s Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), Carl Moyer Program (CA) funds provided by Sacramento Air Quality Management District; California Energy Commission (CEC) School Bus Replacement Program.
SCHOOL BUS FUNDING AND OPERATIONS

Twin Rivers has been a pioneer in adopting ESBs, and has sought to quickly deploy the buses at scale. Working with a group of school districts in 2016, they secured a grant from California’s cap-and-trade program to fund the purchase of 29 ESBs, sixteen of which went to TRUSD. By comparison, those sixteen buses alone, which the district received in 2016, are more than any other single district had as of January 2022. By pursuing all possible funding opportunities, the district has been able to purchase an additional 36 buses.

![Type D ESBs deployed at TRUSD. Source: Twin Rivers Unified School District.](image)

District transportation officials reported that, after replacing 50 percent of their school buses with electric, the department has maintained its ability to provide transportation for students. They have also cited remarkable savings in fuel and maintenance, including a 78 percent reduction in fuel costs and lower maintenance costs due to a 30 percent decrease in the time needed for routine maintenance; savings on oil, filters, and other diesel-related expenditures; and reduced wear on tires and brakes.

The district’s effort has benefited from California’s Low Carbon Fuel Standard (LCFS), which provides payments for using less carbon-intensive fuels. At first, they were even saving on fuel costs despite not using smart charging, because they saved so much from low electricity prices, the high efficiency of electric bus powertrains, and earnings from LCFS. As they scale up, the district is implementing smart charging and working with SMUD to develop a business model for vehicle-to-grid services.

Twin Rivers is playing a leading role in promoting school bus electrification. The district is building a diverse ESB fleet with several different bus models, in large part so they can test out the different buses and provide advice to other school districts. They have modeled their school bus procurements so that
their purchase contracts can be “piggybacked” by other districts, and use a variety of factors including service record, maintenance, and distance from the nearest service center. They also include training in their procurements in order to ensure that their drivers and mechanics receive the tools and instruction they need to operate the electric fleet.

In light of the reliability issues that many districts have encountered in their initial deployments of ESBs, Twin Rivers’ maintenance director, Raymond Manalo, provided a valuable perspective. He said that in his experience, all new technologies have similar growing pains, including new ICE buses. He noted that all of the ESB manufacturers they have worked with have had some issues. Some of the problems they confronted early on included battery issues and faulty power inverters. However, by working closely with the manufacturer and other partners, they have been able to resolve most technical issues.

As TRUSD has incorporated electric models into its fleet, they have sent feedback to the OEMs that the OEMs in turn have used to improve the subsequent year’s crop of ESBs. By this process, the manufacturers have been able to quickly improve their product and correct issues. When it comes to working with Lion specifically, both the district and the manufacturer have benefited from having a service center in Sacramento.

Even with challenges, the district has made rapid and remarkable progress towards an all-electric fleet and is focusing on the future: in particular, how it will be able to use electric buses for field trips and athletic events. For field trips, the district believes that it will be possible to use ESBs once truck stops and other locations start installing public DC fast chargers. (Ideally, these stations would include high-power chargers faster than 60kW, so that buses could charge up during a normal rest break. For example, a 155 kWh school bus could charge completely in 50 minutes using a 150 kW charger, or in 21 minutes using a

**Figure 7** ESBs charging at TRUSD. Source: Twin Rivers Unified School District.

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350 kW charger, compared to over two hours with a 60 kW charger. For athletic events, Manalo hopes that as other districts electrify, they can come to mutual agreements to share charging equipment.

The district is collaborating closely with their utility to implement vehicle-to-grid services on its buses. Carol Kay, SMUD’s project manager for V2G at TRUSD, commented that, while nothing had been finalized, the buses would most likely be used for load balancing and potentially for emergency power facilities (vehicle-to-building). In one potential business model, the utility would provide some up-front compensation for use of the buses, plus an additional payment for each time V2G is engaged.

Twin Rivers’ success owes in large part to the transportation department’s determination and commitment to making ESBs work. It demonstrates that it is currently possible for a major school district to electrify large portions of their fleet, and that doing so can provide significant environmental, health, and financial benefits. The district’s experience also demonstrates the benefit of having talented, dedicated, and innovative staff who will work hands-on to make electrification succeed.


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**ESB ECONOMICS**

According to publicly available purchase contracts, ESBs typically cost between three and four times that of their diesel counterparts. On the other hand, most fleet operators have experienced significant savings in operating costs, especially in fueling costs. Some buses even have the potential to earn revenue or save money by serving as a grid resource. Even so, in the absence of major subsidies, the total cost of ownership of ESBs is currently much higher than that of diesel buses.

**Current market prices**

Electric school bus manufacturers do not publish the prices they charge for buses, but some states have conducted solicitations for ESBs that can provide a helpful idea of what most school districts have been paying for ESBs. One instructive solicitation was conducted by the California Energy Commission (CEC), which has led the nation’s largest funding program for ESBs to date, the School Bus Replacement Program. This program included a competitive solicitation to establish bulk purchase pricing for ESBs in six categories: Types A, C, and D, each with and without wheelchair lifts. These prices may be on the low side, since the solicitation required relatively low minimum battery capacities (70 mile listed range for Type A and 100 mile listed range for Type C/D). Lion Electric won in each of the categories but one. The prices for selected buses are shown in the Table 1 (rounded to the nearest dollar).

Similarly, the New York State Office of General Services (OGS) competitively bids out for goods and services to establish contracts which can be used by state agencies and other public entities, including school districts. OGS offers contracts for several models of ESB as well as school buses using internal combustion engines (ICE buses). The contract prices are noted in Table 2 (rounded to nearest dollar).

It is unclear why there is such a large differential between electric school buses and their diesel counterparts. According to an April 2021 interview with Trevor Rudderham, a senior vice president at

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44 Assumee charging from 10 percent to 90 percent to protect battery lifespan.
Blue Bird, the main reason for the price differential is the price of the battery pack. By the end of 2020, the average price of battery packs had fallen to $137 per kWh. A 155 kWh battery pack at that price (which is the size advertised for the Blue Bird Vision Type C electric bus) would cost $21,235, compared to the price differential of approximately $240,000 shown above.

As the Blue Bird representative mentioned, school bus manufacturers are relatively small buyers of battery packs compared to other companies like auto manufacturers, and aren’t able to obtain batteries at the lowest prices. In order to explain the difference in price they would have to be paying $1,594 per kWh, or over ten times the average market price. Information obtained from public records suggest that one school bus manufacturer was able to obtain EV batteries at $350-400 per kWh, which would suggest a price of $54,250-$60,000 for a 155 kWh battery.

There are additional reasons to think lower prices for electric school buses may be possible in the near future. As discussed in the section on school bus repowers or retrofits, companies have cited an approximate cost of $150,000 for repowering a Type C diesel bus into an electric school bus. This includes the entire cost of the powertrain, suggesting that using the same technology in a new bus could cost even less.

The California Air Resources Board (CARB) conducts extensive investigations into the cost of electric vehicles in order to determine the appropriate incentive amount for its Hybrid and...
Driving the Future: How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition

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<td>• Phoenix Motorcars ZEUS 600 Type A</td>
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<td>Class 4 (Type A or B)</td>
<td></td>
<td>• Motiv on Ford E-450 Electric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Micro Bird G5 Electric</td>
</tr>
<tr>
<td>Class 6 (Type B or C)</td>
<td>$140,250</td>
<td>• Lion Electric LIONA Mini Electric</td>
</tr>
<tr>
<td>Class 7 (Type C or D)</td>
<td></td>
<td>• Lion Electric LIONC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Blue Bird Vision Type C Electric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Thomas Built eC2 Jouley School Bus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Navistar (IC) CE Electric School Bus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Blue Bird All American Type D Electric</td>
</tr>
<tr>
<td>Class 8 (Type D)</td>
<td>$198,000</td>
<td>• Blue Bird All American Type D Electric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lion Electric LIOND Electric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BYD Type-D Battery Electric School Bus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• GreenPower BEAST Type D Electric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• GreenPower SYNAPSE 72 Type D Electric</td>
</tr>
</tbody>
</table>

Table 3 California HVIP incentives for electric school buses of different classes. Source: HVIP website.

Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). The amount of each incentive is intended to approximate the difference in cost between a hybrid or zero-emission vehicle and its fossil fuel equivalent.49 Vehicles in the same category generally receive the same voucher amount regardless of market price. The Air Resources Board collects information about the costs of individual vehicle components as well as manufacturers’ suggested prices, which together help them make a determination of what is the appropriate incremental cost.

For electric school buses, HVIP’s voucher amounts are noted in Table 3 above.

As noted above, the typical price differential for a Type C ESB is roughly $250,000, over $100,000 more than the voucher amount provided by HVIP.

Finally, battery prices have fallen dramatically over the past decade, and may continue to fall as technology improves and the battery industry continues to build scale.50 School bus prices should also decrease if OEMs are able to take advantage of these cost savings.

The above discussion suggests that there may be significant room for price reductions in the near future. In order to achieve these reductions in price, it will likely be necessary for ESBs to achieve scale, which will allow school bus OEMs to buy batteries more cheaply, recoup R&D costs, and

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49 Patrick Chen (air pollution specialist at CARB), conversation with author, June 28, 2021.
50 It is unclear why this model appears in two different weight classes; it may account for different seating capacities.
improve manufacturing and other technological processes.

Governments can help OEMs achieve scale by providing major subsidies for ESB purchases. However, there is a risk of the public paying more than necessary for the transition to electric buses. To minimize the risk, policymakers at all levels of government—but especially the federal and state levels—can design policies to ensure high levels of competition. For example, state governments can use competitive solicitations to encourage manufacturers to offer ESBs at affordable prices.

In addition to creating a strong incentive for vendors to lower prices, solicitations can consider additional factors to maximize the public benefits of investing in ESBs. Part IV of this report includes a discussion of how best value procurement policies can be used to promote high-quality jobs with inclusive hiring and sustainable environmental practices, while also wisely investing public dollars to sustainably transition the nation’s bus fleet to clean electric technology.

Electric repowers

In addition to purchasing new electric school buses, it may be possible for districts to convert some of their existing diesel buses to electric, a process often referred to as repowering or retrofitting. In this nascent business model, retrofit manufacturers will replace the ICE powertrain of a school bus with an electric powertrain. There are at least two companies that offer this service, with the proposition that repowering a school bus is much less expensive than buying a new ESB. School bus electric retrofitting is very new and has yet to see large-scale road testing; based on media reports, there appear to be fewer than a one or two dozen repowered ESBs on the road today.

One company that has deployed repowered school buses is Long Island-based Unique Electric Solutions (UES). The company is working with fleet operator Logan Bus and Amply Power, a charge management company, (see Part II) to convert five diesel school buses in New York City.
to electric for the 2021-22 school year.\textsuperscript{53} They have cited prices between $125,000 and $175,000 to convert a diesel school bus to electric, compared to the $250,000 price differential between electric and diesel.\textsuperscript{54}

Another company that has made progress in the school bus repower business is SEA Electric, which is based in Torrance, CA. In December 2021, the company announced a deal with a large Midwestern school bus dealer to convert 10,000 of their buses to electric drive.\textsuperscript{55}

It is too early to report on the performance and reliability of repowered school buses. Some districts have expressed a strong interest in repowers due to their competitive price, while others have shared a reluctance to try repowers because of the risk that the investment could be wasted if other parts of the bus were to deteriorate faster than the electric powertrain.

Depending on a variety of factors, including the real-life performance of repowers and the remaining lifespan of non-powertrain bus components, it is possible that some repower projects may be cost-effective over the lifetime of the bus, even without subsidies. In the case of Logan Bus in New York City, the fleet operator had access to a subsidy that was easily large enough to pay for a repower, although challenging for a new ESB purchase. With a significant subsidy, the financial case seems clear: repowers offer fleet operators more fuel-efficient, less maintenance-intensive, and cleaner buses for a relatively small investment.

It is unknown how quickly repowering operations could scale. Both UES and SEA Electric partner with other manufacturing facilities to perform some of their retrofits of school buses or other vehicles. This could prove tricky early on as ESB technology is still rapidly improving. UES has claimed that retrofitting could help mitigate the supply chain issues that are hindering the production of new ESBs—which is likely true to the extent that shortages are affecting parts that can be reused from old ICE buses rather than electric powertrain components.\textsuperscript{56}

In short, repowering has the potential to serve as a complement to new purchases for fleets that are attempting to convert their entire fleet as quickly as possible. Repowers will be particularly attractive if their cost falls even further, or if small subsidies are provided.

**Operation costs**

One of the major touted benefits of electric school buses is that they can potentially cost less to operate than diesel buses because of lower fuel and maintenance costs.\textsuperscript{57} Theoretically, significant savings should be possible and many districts have reported lower costs. However, operators considering switching to electric school buses should use caution in taking cost savings estimates at face value since savings can vary considerably between projects. Electric motors are much more efficient than internal combustion engines (ICEs), by a factor of roughly 3.6.\textsuperscript{58} Depending on the relative costs of electricity and fossil fuels at a given time and location, this higher level of efficiency can result in substantial fuel cost savings. Many factors determine the fuel cost savings that a given fleet operator can achieve, including the relative prices of diesel and electricity, climate, motor efficiency, driving technique, and charging efficiency. Petroleum prices can be particularly volatile. To obtain a ballpark estimate for annual fuel cost savings per


\textsuperscript{58} U.S. Department of Energy, “Fuel economy - All Electric Vehicles,” accessed September 13, 2020. This figure depends on efficient driving technique including proper use of regenerative braking.
Type C bus, however, the following assumptions noted above in Table 4 may be reasonable.

Reports from a few different bus deployments can help illustrate some of the variety of experiences different fleets have had when it comes to fuel cost savings. The Twin Rivers Unified School District in California currently has the nation’s largest deployment of ESBs (see case study). Their transportation director has stated that their Lion and Trans Tech buses cost between $0.16 and $0.19 per mile to charge compared to $0.82 to $0.86 to fuel their diesel buses, which represents a cost savings between 77 and 81 percent. Northern California’s mild weather probably plays a role in the savings experienced at Twin Rivers. The Everman Independent School District near Fort Worth, TX reported fuel cost savings of up to 90 percent because of their low electricity rates.

The 2016 ESB pilot in Massachusetts had the opposite experience; in fact, the analysis found that fueling costs were actually 64 percent higher than would have been expected with diesel. However, 63 percent of the buses’ fueling costs were determined to have been avoidable with the use of managed charging, which is the practice of using automated chargers programmed so that buses charge efficiently and during off-peak hours. Based on the buses’ observed driving efficiency, the report on the pilot estimated that with managed charging, the buses would have cost 30 percent less to fuel than comparable diesel buses.

In El Cajon, CA near San Diego, the transportation director shared that they were achieving 40 percent fuel cost reductions (see case study). In White Plains, NY, the project has not shared fuel cost savings, but it reported an average efficiency in 2021 of 1.475 kWh per mile (see case study). Using regional figures for electricity and diesel prices, the operator should have had approximate fuel cost savings of 58 percent. Dave Meeuwsen of Zeeland Public Schools in Michigan calculated that their electric buses saved between 50 and 58 percent compared to diesel.

In short, while the magnitude of savings can vary—ranging between 40 and 90 percent in interviews conducted for this report—ESBs that use managed charging are likely to achieve substantial fuel cost savings.
savings. School districts can estimate the money they could save on fuel according to bus efficiency and local energy prices.

Maintenance costs are also expected to be lower with ESBs, though the technology is too young to be able to provide comprehensive data. It is an often-mentioned fact that electric motors have around 20 parts versus 2,000 for a diesel engine. School bus operators believe this will reduce costs for both parts and labor. Furthermore, characteristics unique to electric buses could result in additional savings. For example, in June 2021, the maintenance director at Twin Rivers School District said they were still using five-year-old tires on ESBs with significant tread remaining, whereas on diesel buses, tires typically last between two and three years; he attributed this difference to the ESBs’ lower center of gravity. Twin Rivers’ buses have also used up significantly less brake material because of improved driving efficiency and the use of regenerative braking.

Tim Shannon of Twin Rivers School District has estimated that the simplicity of ESB powertrains and the reduced wear and tear on certain parts has led to a 30 percent time savings in standard maintenance tasks. For example, ESBs do not require oil changes or maintenance to their transmission systems. In the short term, this may not reduce labor costs, since most transportation directors interviewed for this report stated that they would not lay off mechanics as a result of buying electric buses, but in the long term they would reduce their number of mechanics through attrition. Some officials pointed out that there were many maintenance tasks that there often wasn’t enough time for, such as preventative maintenance on cameras, GPS systems, and two-way radios, and that electrification would allow their mechanics to focus on such tasks. In other cases, directors stated they were already understaffed and that electrification would simply reduce the excessive burden on their current mechanics.

The switch to ESBs will also likely lead to a reduction in costs for parts. Todd Watkins, transportation director at Montgomery County Schools in Maryland, which is working with a consulting group to deploy 326 ESBs over the next four years, estimated that costs for parts would decrease between 25 and 50 percent.

An important unknown variable when it comes to maintenance costs for ESBs is the potential cost of maintaining new electronic systems and the powertrain as fleets age; it will take several years to collect solid data on this question.

**Total cost of ownership**

The **total cost of ownership** (TCO) of a vehicle includes both the purchase price of a vehicle as well as the costs of operating and maintaining it over its lifetime. In a TCO calculation, ESBs’ lower operating costs help offset their much higher purchase price. Unfortunately, the cost savings of electric buses are not yet nearly enough, by themselves, to make ESBs cost effective. There are increasingly abundant subsidies available which can help make electric buses affordable.

California’s zero-emissions vehicle funding program, HVIP, has created a well-designed, customizable calculator to help fleet operators estimate the TCO given different variables, as well as the time it would take an electric bus to pay off its higher upfront price through savings. It is impossible to predict the future, but the tool is useful for making estimates, and includes information for all states as well as national averages.

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69 Manalo, “Electrifying News.”
For an idea of what this looks like, the HVIP calculator was used to estimate the time it would take for an ESB to pay for itself under a variety of funding scenarios. °

Assumptions on cost calculations
Where not provided, HVIP calculator defaults are used.

• Type C Thomas Built ESB compared to similar diesel bus according to New York State OGS contract (see ESB Economics in Part I): Differential = $237,987.

• $0.35 per mile fuel cost savings (using assumptions from Table 4 above), 63.46 miles per day based on NREL study on school bus duty cycles, and an estimated 200 days of operation. 75

• Maintenance costs 30 percent lower for ESBs (parts and labor). 76

• Discount rate of 1.5 percent. 77

• Useful battery/vehicle lifetime of 12 years. 78

• Electric bus retrofits are not included because of uncertainty about the diminished value of used buses, and the extent to which the retrofitting process may add value or extend the lifetime of the bus.

Achieving total cost of ownership parity with diesel will be a major milestone for electric school buses, and will enable many school districts to transition without additional assistance. Even at that point, however, some subsidy will be needed because many school districts are not in a financial position to borrow money to invest in new technology. Districts are often short on capital or lack financial or administrative flexibility to take advantage of loans or grants.

These figures are not meant to discourage fleet operators from considering electric school buses. Rather, they demonstrate the need for effective subsidies in order to promote increased production, which will result in lower prices over time.

### CURRENT FUNDING SOURCES

#### School districts
School districts typically fund their school buses through their own transportation budgets which, in underfunded schools, have to compete with district budgets for facilities and instruction. In many cases, states provide some assistance to help districts pay for some of their transportation expenses including the purchase of buses.

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### Table 5
Estimated TOC for Type C school bus under different funding scenarios. Source: Calculated using HVIP total cost of ownership calculator. See Assumptions below for parameters used in calculations.

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>SUBSIDY</th>
<th>TIME TO BREAK EVEN</th>
<th>REAL SAVINGS OVER 12 YEARS</th>
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</thead>
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<tr>
<td>No subsidy</td>
<td>$0</td>
<td>never (&gt;20 years)</td>
<td>-$174,509</td>
</tr>
<tr>
<td>DERA School Bus Rebate</td>
<td>$65,000</td>
<td>never (&gt;20 years)</td>
<td>-$109,509</td>
</tr>
<tr>
<td>HVIP Voucher (CA)</td>
<td>$140,250</td>
<td>never (19 years)</td>
<td>-$34,259</td>
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<tr>
<td>DERA National Grant</td>
<td>$200,000</td>
<td>9.5 years</td>
<td>$25,491</td>
</tr>
</tbody>
</table>

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75 Duran and Walkowicz, “A Statistical Characterization of School Bus Drive Cycles.”

76 Rough estimate based on interviews.


78 VEIC, “Electric School and Transit Bus Program.” It may be that in 12 years, batteries will be easily and cheaply replaceable; however, including a battery replacement complicates the model.
School budgets can be volatile, and many districts are chronically underfunded. Districts in states that require school districts to provide transportation and retire old buses are likely to have more predictable capital budgets for new buses. In states where it’s optional for districts to provide transportation to general education students, such as in California, school boards have often resorted to cutting bus service in order to save money.

In districts that employ the services of private fleet operators, the contractors typically purchase their own school buses. As private (usually for-profit) businesses, school bus contractors are unlikely to invest in much more expensive equipment unless they are required to do so, or if the equipment provides enough savings or revenue to reach total cost of ownership parity. However, since private fleet operators are entirely dedicated to the provision of transportation services, they may be financially better positioned to switch to electric.

In all of the above situations, the much higher cost of ESBs is currently prohibitive for most school districts without significant external funding. Many districts and contractors may feel they even lack funding to replace old school buses with new diesel buses when necessary.

**National-level funding sources**

Traditionally, the federal government hasn’t provided significant funding for school buses of any type. Even so, national sources helped spark many of the initial ESB deployments around the country and have been especially critical outside of California. On a much greater scale, the Infrastructure Investment and Jobs Act (IIJA), passed in November 2021, will invest between $2.5 and 5 billion towards replacing old buses with new electric school buses. This section briefly describes some of the national programs that have been most helpful for electric buses early on and provides an overview of the new investments under the IIJA.

**VW Fund.** Until 2022, the most important source of national funding for ESBs had been the Volkswagen Diesel Emissions Environmental Mitigation Trust (VW Fund), a $2.93 billion trust fund established when VW settled a lawsuit with the EPA for evading diesel emissions requirements. The VW Fund allocates money to states, which they can spend on projects aimed at replacing diesel engines with cleaner technology.

Thanks in part to the activism of groups like Chispa and Mothers Out Front, several states have dedicated significant portions of their VW Fund allotment to replacing old school buses with electric buses. For instance, Florida has dedicated $57 million for ESBs; Virginia is investing $20.9 million, and Vermont is spending $1.9 million. Illinois has proposed investing approximately $41 million of its allocation in ESBs, which, assuming a 25 percent cost share by districts and a $350,000 price tag per bus, could subsidize the purchase of approximately 150 ESBs.

**EPA DERA funding.** Federal spending has also helped to germinate the ESB market. Most importantly, the Diesel Emissions Reduction Act (DERA), administered by the U.S. Environmental Protection Agency (EPA), provides grants and loans for projects to reduce dangerous emissions from diesel engines. Since 2013, DERA has so far helped fund around 53 electric school buses nationwide: 36 from the National Grants Program and 17 from the School Bus Rebate Program. The National Grants Program provided approxi-
mately $46 million in competitive grants in 2021 to public agencies for a wide variety of projects to reduce diesel emissions, including one award of $326,579 to fund two electric school buses.

The School Bus Rebate Program disbursed a total of $10.5 million for the replacement of old school buses in 2020, and for the first time offered enhanced funding for ESBs of $65,000 per electric bus compared to a previous maximum of $30,000 (for CNG-powered buses, which are rare). A subsidy of $65,000 is still much less than the incremental cost, and in 2020, 3 percent of the buses funded by the program were electric, compared to 70 percent diesel, 13 percent propane, and 14 percent gasoline.

In 2021, the EPA allocated an additional $7 million specifically for electric school buses using funds appropriated to DERA in the American Rescue Plan Act (ARP), also known as the COVID-19 relief bill.66 The ARP Electric School Bus Rebates program awarded rebates of $300,000 per bus replacement, which comes out to 23 buses.

In order to maximize the impact on promoting environmental justice, the EPA limited eligibility to buses serving students from a list of 946 high-poverty school districts or students receiving transportation from federally recognized tribal governments.

EPA Clean School Bus Program. The Infrastructure Investment and Jobs Act allocates $5 billion to the EPA over five years to create a new Clean School Bus Program (CSBP) to replace older school buses with new buses. Advocates had urged a much larger sum in order to shepherd a rapid transition to electric. For example, the Clean Commute for Kids Act of 2021 would have invested $25 billion to replace nearly half of the nation’s school buses over the next ten years. However, the $5 billion figure is remarkable in the context of EPA’s other spending programs, dedicating an annual amount to school bus replacements ten times the size of the entire budget for DERA.

The legislation divides the funding evenly into two categories: $2.5 billion ($500 million per year) for zero-emission school buses (of which ESBs are currently the only existing technology) and $2.5

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billion for “clean school buses”—a term defined by the legislation to include both zero emissions buses and alternative fuel buses. To determine which fuel technologies to subsidize for the clean school bus pot of money, the EPA must consider several factors including emissions reductions, cost of replacement, local needs of school districts, and the potential to bring new technology to scale.

The IIJA provides general requirements for the Clean School Bus Program, but there are many choices about implementation that will be left up to the EPA. The Biden Administration has issued guidance that will likely impact the program, including its Interim Guidance on the Justice40 Initiative’ and the Executive Order on Implementation of the Infrastructure Investment and Jobs Act.89 These directives prioritize clean energy investments in disadvantaged communities, ensure high labor standards, and bolster the U.S. manufacturing supply chain. The EPA is expected to open the application for its first round of CSBP funding in May 2022.

89 “Executive Order 14052 of November 15, 2021”; Young, “Interim Implementation Guidance for the Justice40 Initiative.”
THE CLEAN SCHOOL BUS PROGRAM AT EPA
Overview of Program Features*

YEARS OF PROGRAM
2022-2026

ANNUAL FUNDING
• $500 million per year for zero-emission school buses, and
• $500 million for clean school buses

CLEAN SCHOOL BUS DEFINITION
a. a bus that reduces emissions and uses an alternative fuel or
b. a zero-emissions bus

ALTERNATIVE FUEL DEFINITION
liquefied or compressed natural gas, hydrogen, propane, or biofuels

ZERO-EMISSIONS BUS DEFINITION
a bus with a drivetrain that does not produce any air pollution or greenhouse gasses

POSSIBLE PROGRAM COMPONENTS
The IIJA authorizes the EPA to support the deployment of clean school buses in the following ways:

a. Providing grants and rebates to eligible recipients to replace existing school buses with clean school buses, including up to 100 percent of the costs for purchasing a clean school bus and installing fueling infrastructure. Eligible recipients include state or local government entities including school districts, school bus vendors, nonprofit school transportation associations, and federally recognized American Indian tribes.

b. An education and outreach program for potential award recipients on the process for applying, comparison of available technologies, and best practices for deployment, infrastructure, and workforce development, training, and apprenticeships.

POSSIBLE PRIORITIES FOR APPLICATIONS
a. high-need school districts, based on Title I funding metrics;

b. schools funded by the Bureau of Indian Affairs or Title I schools serving students who live on government-recognized American Indian land;

c. schools in rural or low-income areas; or

d. applicants proposing to secure additional sources of funding for clean school buses

Additionally, the EPA cannot award more than ten percent of program funds to recipients in any one state in any year of the program.

*This is a summary and paraphrase of the statutory provisions of the Clean School Bus Program – see Title XI of the Infrastructure Investment and Jobs Act of 2021 and upcoming EPA guidance for exact details of the program.
State funding initiatives
Aside from allocations from the VW Fund, not many states have provided significant funding for ESBs. The main exception is California, which has several funding streams dedicated exclusively to reducing air pollution.

The most prominent example so far is the California Energy Commission’s (CEC’s) School Bus Replacement Program, which is exchanging 236 old diesel buses with electric models. As of March 2022, this program had deployed more ESBs than any other in the country, pioneering several noteworthy program elements.

First, the program was particularly generous to school districts because it paid for the entire price of new school buses and the full costs of charging equipment. While such a program is more expensive for the state, it helps ensure more equitable access for less wealthy school districts. The program also prioritized replacing older buses and buses in low-income and environmental justice communities.

Second, the Energy Commission launched a competitive solicitation to establish bulk pricing for the buses. The process ensured compliance with state specifications and helped to establish lower prices for ESBs. School districts were awarded grants based on the prices that resulted from the vendor solicitation—though schools could purchase whatever brand of ESB they chose.

Third, the CEC program dedicated $1 million towards creating a training initiative for drivers and mechanics. As discussed in Part III of this report, training is essential for drivers to have the skills they need to drive buses safely and efficiently, and even more crucial for mechanics to retain as much responsibility as possible for maintaining the new buses. According to Larry Rillera, who manages workforce equity initiatives such as the ESB training program for the Energy Commission, OEMs provide some training but it is generally not adequate to fully prepare drivers or mechanics.

There are a number of other statewide programs in California that have also enabled districts to transition some of their buses to electric. These programs are funded through a variety of sources including smog abatement fees, license plate surcharges, and cap-and-trade auction proceeds. These dedicated funds have made it possible for California to invest in ESBs more than any other state.

California officials have recently proposed investments of a much greater magnitude. The Air Resources Board and Energy Commission’s investment plans detail a total of nearly $450 million for spending on electric school buses and related infrastructure over the next three years. And the Governor’s Budget for 2022-2023 proposes an additional $1.5 billion from the Proposition 98 General Fund to support student transportation and electric school buses. If these proposals come to fruition, the state will likely continue to lead the nation on ESB implementation for the foreseeable future.

Other states have taken steps towards school bus electrification as well. In New York, the state budget approved in April 2022 mandated the use of zero-emissions vehicles for all new school bus purchases by 2027 and for all school buses in the state by 2035. The budget also set the stage for $500 million in ESB subsidies if the Environmental Bond Act ballot measure is approved by voters in November 2022. New York City previously passed a requirement for all school buses to be electric by 2035.

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92 Larry Rillera, conversation with author, April 20, 2021.

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Colorado and New Jersey are also considering significant investments. Governor Jared Polis has proposed $150 million for ESBs in his 2022-23 budget. Meanwhile, New Jersey’s legislature is contemplating a bill to spend $45 million over the next three years for a statewide ESB pilot that would support school bus electrification while collecting data on performance and best practices from deployments around the state.

Possible timelines for the ESB transition

After considering the performance, range, reliability, and cost trends for electric school buses, it is possible to speculate about how long it might take to convert most or all of the nation’s school bus operations to electric. Several hard-to-predict factors will impact this timeline, but for an optimistic estimate, the following assumptions may be reasonable:

- Electric school buses could reach cost parity, or at least TOC parity, with ICE buses by 2025-2030. As discussed in the section on current market prices, there are good reasons to believe that a rapid fall in ESB prices is possible.
- By 2025-2030, ESB technology and electrical infrastructure could plausibly advance to the point where most or all bus routes, field trips, and school sporting events are reachable by ESBs.
- Diesel school buses typically last fifteen years. However, there is considerable variation between fleets on how long they keep their buses in service.
- Over the next five years, it may be possible for OEMs to ramp up ESB production to match the scale of nationwide school bus demand.

Given these assumptions, school bus fleets could potentially start replacing all of the buses they retire with ESBs as early as 2025, which would result in all-electric fleets by 2040. Some districts may be able to transition even more quickly if they are well-funded, have shorter routes, or are served by a robust electrical grid.

For districts with more challenging routes or fewer financial resources, 2030 may be a more likely target for one hundred percent ESB replacement, resulting in all-electric fleets by 2045. An additional complication is the fact that some districts hold onto their old buses much longer.

The global supply chain realignment of 2021-22 will impact OEMs’ capacity to manufacture ESBs over the coming year. In particular, a shortage of semiconductor chips has wreaked havoc on vehicle production of all types. In January 2022, school bus OEMs shared that they expected to experience delays of between six and twelve months. Analysts predict that the backlog will likely be resolved sometime during 2022.

Government action can significantly impact the above timelines. At the federal level, continued investment in the sector would help improve school bus technology and prices, increase fleet experience with ESBs, and install electrical infrastructure at a faster rate. At the state level, fleet electrification mandates or incentives could help make sure that the last few diesel buses are taken off the road in a timely fashion.

At the local or district level, fleets could electrify more quickly though additional investments. One way to accomplish this is to establish mandated schedules for bus replacement. For example, a district could enact a measure that petroleum-fueled buses must be replaced after ten years. Such a requirement would cost extra money, but would shift up the timeline for an all-electric fleet by five years, from 2040 to 2035.

It may also be possible to transition much more quickly by supplementing the purchase of new

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buses with repowers of diesel buses. To illustrate how this could work, consider a fleet that starts buying ESBs for all of its bus replacements starting in 2027. In 2027, such a fleet would have ICE buses between one and 12 years old (model years 2015 to 2026). Over the subsequent seven years, the fleet owner could repower buses with model years 2020 to 2026 and replace the older buses (model years 2015 to 2019) with new electric buses at their normal retirement age, thus arriving at an all-electric fleet by 2035. A more aggressive repower strategy could transition the fleet even more quickly. Repowering buses to accelerate fleet transitions will require extra capital expenditures; whether such a strategy proves viable will depend on what we learn in the coming years about the economics and performance of repowers.
PART II: GRID INTEGRATION - ELECTRICITY AS A FUEL SOURCE

The use of electricity as a fuel source is a major logistical and financial change for school bus fleet operators. Transitioning a school bus fleet to ESBs is not as simple as buying new buses. Fleets must work with their power utilities or with charge management companies to build the necessary infrastructure and to understand how their electric bill may be affected. In exchange for these complications, electricity offers the potential for significantly lower fuel costs, cleaner air, and reduced environmental degradation.

In order to fully understand the implications of plugging school buses into the complex, fragile electrical grid, it is worth considering how electricity is priced, what kinds of infrastructure upgrades are required by ESBs, the potential of bidirectional charging technology, how some utilities have considered investing in ESBs, and the development of third-party charge management companies. This part of the report provides an introduction on these topics as they relate to ESB deployment.\textsuperscript{103} The Annotated Glossary at the end of this report includes detailed explanations of many electrical terms used in this part.

INFRASTRUCTURE REQUIREMENTS OF ESBs

In order to integrate with the grid, school bus depots must have the necessary electric infrastructure and communications technology. The most obvious component is the charging equipment itself, often referred to as EVSE (electric vehicle supply equipment). Most chargers can service one bus at a time, though some can charge

\textsuperscript{103} Much of this discussion has been adapted from JMA’s March 2021 report on ESBs in New York, which looked even more closely at the structure of New York’s electric power sector. Ian Elder, \textit{Clean Buses for New York Kids} (New York, NY: JMA, 2021).
multiple buses. Fleet operators or their partners must hire electrical contractors to install wires (often referred to as **conduit**) that lead from the electrical panel to the EVSE.

For very small ESB deployments, installing the EVSE may be the only upgrade needed. However, the power demands from ESBs can quickly escalate to the point of needing upgrades to the distribution system that powers the depot. The distribution network includes a series of facilities, pieces of equipment, and wires, each of which has a limited power capacity. As the power increases, the time and expense needed to upgrade distribution infrastructure grows along with it.

Estimates vary, but one source suggested the guidelines noted in Table 6.104

The time needed to complete these upgrades can range from weeks to several years, depending on the extent of the needed improvements. Who pays for the infrastructure also varies. Often, the utility will pay for everything up to the customer’s meter, and the fleet operator will pay for everything at their facility. That is not always the case; sometimes customers will be responsible for the costs of a substation upgrade if they are the reason it is necessary. On the other hand, under **make-ready** programs, utilities can often pay for some or all of the infrastructure upgrades at the bus lot.

The need for infrastructure could also potentially affect where a fleet decides to park its ESBs. Bus lots vary greatly in their access to the high power levels needed for charging.

Fortunately, the cost and timing of infrastructure improvements don’t generally need to be a surprise. By getting in touch with their utilities as early as possible to discuss their intentions, fleet operators can ensure they encounter the least delay and expense possible, and power companies can start planning for their role in the fleet’s EV transition.

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<table>
<thead>
<tr>
<th>POWER</th>
<th>NUMBER OF ESBs</th>
<th>POTENTIAL POWER UPGRADES</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 1 MW</td>
<td>up to 17-50</td>
<td>may only be necessary to provide upgrades to the bus lot, such as new transformers</td>
</tr>
<tr>
<td>between 1 MW</td>
<td>17-150</td>
<td>upgrades to the distribution system may be necessary, including upgrading the power lines that lead to the bus lot</td>
</tr>
<tr>
<td>and 3 MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>above 3 MW</td>
<td>50 - 150</td>
<td>may require more extensive upgrades to the distribution system, such as upgrades to a substation</td>
</tr>
</tbody>
</table>

*Table 6* Description of possible upgrades needed for ESB installations. Source: Edison Electric Institute, 2019.104

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104 Edison Electric Institute, “Preparing to Plug in Your Fleet: 10 Things to Consider,” October 2019.

105 Edison Electric Institute, “Preparing to Plug in Your Fleet.”
<table>
<thead>
<tr>
<th>ORGANIZATION</th>
<th>EXAMPLES</th>
<th>ORG TYPE AND ROLE</th>
<th>RELEVANCE TO SCHOOL BUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investor-Owned Utilities (IOUs)</td>
<td>• Dominion Energy (VA, NC, SC) • ConEdison (NYC) • Pacific Gas &amp; Electric (Northern CA)</td>
<td>• for-profit corporations • transmit and distribute power; may also generate power</td>
<td>provide electric service to fleet owners; can provide technical or financial assistance with infrastructure and pricing</td>
</tr>
<tr>
<td>Public Utility aka municipal utility or “muni”</td>
<td>• Sacramento Municipal Utility District (SMUD) • New York Power Authority (NYPAA)</td>
<td>• state government authorities • transmit, distribute, and/or generate power</td>
<td>provide electric service to fleet owners; can provide technical or financial assistance with infrastructure and pricing; some can sell bulk power</td>
</tr>
<tr>
<td>Grid Operators includes regional transmission operators (RTOs) and independent system operators (ISOs)</td>
<td>• New York Independent System Operator (NYISO) • Electric Reliability Council of Texas (ERCOT) • PJM Interconnection • California Independent System Operator (CAISO)</td>
<td>• nonprofit • ensure regional grid reliability; regulate wholesale energy markets and transmission</td>
<td>approve tariffs which determine the value of transmission-level grid services that V2G-enabled buses could provide</td>
</tr>
<tr>
<td>Public Utilities Commissions (PUCs) aka Public Service Commissions (PSCs)</td>
<td>• New Mexico Public Regulation Commission • Virginia State Corporation Commission • California Public Utilities Commission</td>
<td>• state government agency • regulate investor-owned utilities</td>
<td>approve tariffs for electricity rates and distribution-level V2G; can approve EV infrastructure programs and pilot projects</td>
</tr>
<tr>
<td>State Energy Office</td>
<td>• West Virginia Office of Energy • New York State Energy Research &amp; Development Authority (NYSERDA) • California Energy Commission (CEC)</td>
<td>• state government authority • coordinate and support research and deployment of energy efficiency technologies and renewable energy sources</td>
<td>can manage and fund projects to promote the adoption of electric vehicles; may fund V2G research projects or initiatives</td>
</tr>
</tbody>
</table>

Table 7 Summary of energy organizations and their importance to electric school buses.
ELECTRICITY PRICING

Charging an electric school bus requires relatively large amounts of power. For a sense of scale, there are approximately 84,000 public schools in the U.S., with an average of roughly five buses per school. An average school building converting its five buses to electric, running them 200 days a year and charging them for 8 hours every night at 19 kW, would increase its electricity usage by about 152,000 kWh per year, or by about 39 percent. Of course, energy usage and student transportation vary widely between schools, and many buses are fueled by private fleet operators which have very different energy profiles. In any case, bus charging will require a significant increase in electricity usage for districts and fleet operators.

In order to minimize their energy costs, fleet operators can work with their utilities to gain an understanding of how they will be charged for their electricity usage. Electricity pricing for commercial-scale customers such as schools and electric school bus operators is complex and variable, and operators can often choose from a variety of pricing options.

Electricity costs consist of supply charges and delivery charges. The supply charge is a charge applied to each kWh of energy consumed. In many states, the price of each kWh is determined by real-time energy markets. Delivery charges, on the other hand, are the regulated rates that utilities charge consumers for delivering that electricity, and ultimately pay for the infrastructure that distributes electricity. Tariffs often specify several factors that make up the delivery charge, including total energy consumed, time of use, maximum power loads, and other fees.

Demand charges

Unlike residential customers, whose electricity bills mostly depend on the total energy they consume, commercial-scale customers (like electric bus fleets) must also pay demand charges based on the maximum power they draw during a billing cycle or other specified period. The idea behind demand charges is that delivering higher power to a site requires more robust infrastructure (analogous to how a fire hydrant needs bigger, heavier pipes than a drinking fountain, even if the fountain uses more water over time).

Electric school bus charging requires a lot of power: 19 kW for a single bus using a Level 2 AC charger, and often more than 50 kW for a bus using DC fast charging. When a district or bus fleet deploys several ESBs, fueling could result in a significant increase in the fleet’s demand charge.

Time-of-use rates

Depending on the utility, commercial-scale customers can elect to be billed flat rates for service regardless of when they use electricity, or to be billed under a “time-of-use” rate. The time-of-use rate is much lower during off-peak hours (typically at night), but higher during peak hours (such as early evening). Time-of-use rates may be favorable to school bus fleets, especially those that can do most of their charging at night. School buses have another advantage when it comes to time-of-use rates: demand charges for off-peak hours can be especially low during the school year (i.e., non-summer months) on time-of-use rate plans.

For illustrative purposes, consider a hypothetical bus fleet in ConEdison’s service territory (New York City and Westchester Co.) with 10 electric buses with 155 kWh batteries that expend their entire usable capacity every day and charge only at night using 19 kW Level 2 chargers. Assume that buses charge 20 days a month. If the buses are the only item on the electricity bill, an approximate calculation of the monthly delivery charges during

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107 In 2012, the average total electricity usage for K-12 school buildings was 386,000 kWh. U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey, Table PBA4, Electricity consumption totals and conditional intensities by building activity subcategories, 2012, published December 2016. This is the latest date for which data is available.
the school year according to fixed and time-of-use rate structures are depicted above in Figure 9.

As seen in the graph, in the above hypothetical scenario, the district would save more than $3,000 per month by using the time-of-use rate. This example also illustrates the importance of demand charges. In both scenarios, they represent the majority of the delivery charge, but are much smaller in the time-of-use plan. On top of these charges, the fleet operator would have to pay the supply charge for the energy consumed, which would be the same in both scenarios. Because the buses charge at night, supply charges would be low.

Managed charging

In order to take advantage of time-of-use rates and minimize demand charges, it is essential to control when buses charge so that charging takes place during off-peak hours and is spaced out to prevent spikes in power demand. This is challenging to accomplish through plugging and unplugging buses by hand, but fortunately there is charging equipment and software that can automatically charge buses in an optimal way. The service provided by these systems is called managed charging and can result in much lower demand charges, lower time-of-use charges, less wasted energy from the charging system, and slower battery degradation. As seen in the Massachusetts pilot project evaluated by VEIC, not using managed charging can result in dramatically increased electricity bills. One expert interviewed for this report who works with medium- and heavy-duty electric vehicles emphasized that managed charging was critical.

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108 Consolidated Edison, Schedule for Electricity Service, PSC No. 10, Current Electric Tariff, September 1, 2020, page 451. The customer charge is a monthly fee charged to all customers using a given rate plan; the energy delivery charge is the amount charged by the utility for the total amount of energy used. This calculation is for any month in the school year except for June and September, which would be more expensive. This calculation assumes all buses are charged at the same time; however, with managed charging, the maximum power could potentially be reduced from 190 kW to 124 kW, which would significantly reduce the demand charge in both pricing scenarios.

for any heavy-duty charging application to avoid excessive fueling costs.

**Electric vehicle incentive rates**

In some states, utilities have experimented with creating special electricity rates to incentivize fleets to electrify. These incentive rates must be approved by the state’s public utility regulators. For example, the California Public Utilities Commission has approved special EV high-power charging rates for California’s three largest investor-owned utilities (IOUs). These rates replaced peak demand charges with subscription pricing plans for commercial electricity customers. Encouraging EV use is a long-term strategy of many utilities, and utilities may be increasingly willing to experiment with new rate structures in order to incentivize transportation electrification.

**BIDIRECTIONAL CHARGING AND VEHICLE-TO-GRID TECHNOLOGY**

Because of their size and predictable duty cycles, school buses may be the ideal vehicle for testing and deploying bidirectional charging technologies. In bidirectional charging, the charging station (or possibly, the bus) uses an inverter to discharge electricity from the battery and send it elsewhere. Power can be sent back to the grid in exchange for payment (known as vehicle-to-grid or V2G), or it can be sent to a building in order to save power costs or help provide power in a blackout (known as vehicle-to-building or V2B). Broadly speaking, technologies that facilitate efficient connections between EVs and the electric grid,

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104 San Diego Gas & Electric, Pacific Gas & Electric, and Southern California Edison


including V2G, V2B, and managed charging, are referred to as **vehicle grid integration** (VGI).

Software in the EVSE can be programmed to decide when to send electricity based on the bus’s duty schedule as well as real-time input from the bus, the utility, and the customer’s electric meter. First and foremost, the software must ensure that the bus has ample charge to perform its transportation duties. For example, if the bus needs to be used in the afternoon to take students home, the software should prevent the battery from discharging beforehand if there is not enough charge left for V2G and its second duty cycle.

School bus advocates have been highly interested in the potential for ESBs to provide V2G services in large part because of their potential to earn substantial revenue to help pay off their higher cost. There are a variety of grid services which ESB batteries could potentially provide, but the most common idea is some version of the following: school buses charge up whenever there is an excess of inexpensive energy, and return power to the grid during peaks in net power load. This process is sometimes referred to as **peak shaving or valley filling**.

Alternatively, ESBs could power nearby buildings, such as a school, during peak periods in order to decrease the use of grid power when power is the most expensive. Such an arrangement could either save the school money by offsetting some of their power needs during peak hours, or could even earn revenue through **demand response** programs, in which utilities or grid operators pay users for decreasing their usage at peak periods.

San Diego Gas & Electric (SDG&E) is working with the Cajon Valley school district (see case study) to test out several V2G services including demand response and peak shaving programs. The utility’s tariff doesn’t currently include a retail rate for V2G; that is, a bus fleet can’t just sign up, plug in, and start selling power back to the utility. Rather, the California Public Utilities Commission (CPUC) approved SDG&E for a pilot which would take advantage of several existing programs, including:

- a time of use rate (which requires grid integration but not V2G)
- automatic response to a rule which penalizes customers for using electricity during high peaks, known as Critical Peak Pricing
- demand response programs from both the utility and from CAISO, the grid operator, and
- CPUC’s emergency load response program, which pays customers $2 per kWh to reduce load or discharge power during certain extreme peaks.

Another commonly discussed grid service is **frequency regulation**, wherein batteries can charge or discharge power to help the grid maintain a constant AC frequency of 60 Hz. The U.S. Department of Energy is currently partnering with Rialto School District in Southern California using eight electric Blue Bird buses to provide frequency regulation to the California grid operator, CAISO. Several sources suggested that although such services can be highly valuable, they can require extra power and there may be a limited market for them.

V2G and V2B are not only useful as a potential source of revenue, but could play an important role in achieving the widespread adoption of renewable energy. Renewable energy sources such as wind and solar have enormous potential for improving our environment, but they also present a huge obstacle: they provide energy only at certain times and in highly variable quantities. At the same time, energy usage varies greatly depending on the season and time of day. That’s a problem, because the grid can work only if the

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114 Joseph Bielawski (project manager at SDG&E), conversation with author, October 21, 2021.

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amount of power being generated is equal to the amount of power being used at all times.

The typical strategy for dealing with uneven electrical demand and generation is to rely on a diverse portfolio of power plants that vary in how quickly they can be dispatched, how expensive they are to run, and the environmental damage they create. For example, coal and nuclear take a very long time to power up, and typically provide base load according to the minimum level of demand. Some other power sources—most importantly gas-fired plants—are often more expensive to run, but can be ramped up or down quickly as necessary. Such plants are known as peaker plants; they are highly polluting and disproportionately located in marginalized communities.

A much better option would be to generate all power from renewable sources, store any excess power, and release the stored power as needed. Unfortunately, utility-scale storage is currently rare and prohibitively expensive. Power storage is a major area for research and development, but at the moment, electric vehicle batteries are one potential resource that could provide significant electrical capacity.

Vehicle-grid integration can also help reduce the costs of delivering electricity. Peaks in usage and generation aren’t just a problem when it comes to generating electricity—they also make it harder to send electricity to customers. Electrical infrastructure, including transmission wires, substations, and transformers have to be ready to handle the maximum possible load. If peaks and valleys can be leveled out, that means that utilities...
can spend a lot less money on building excess power capacity.\textsuperscript{118}

Electric school buses are considered a particularly good first use case for V2G development.\textsuperscript{119} During the school year, school buses are only used for a portion of the day, and during the summer they often go completely unused. Summer also happens to be when most U.S. utilities face the highest constraints and V2G services are most needed.\textsuperscript{120}

As an alternative to V2G, fleet operators can consider implementing V2B to use spare energy stored on the batteries to lower the school's grid electricity demand during peak periods, or to provide energy resilience in the case of grid failures. Adopting V2B instead of V2G may provide more value in some cases, and can have the advantage of posing fewer regulatory hurdles. Many V2B applications are only possible if the customer has a significant load nearby to offset, which means that buses parked in school lots may be the best candidates to provide these services.

CASE STUDY: CAJON VALLEY SCHOOL DISTRICT’S COLLABORATION WITH SAN DIEGO GAS AND ELECTRIC

**Figure 12** Type C ESBs deployed at Cajon Valley. Source: CVUSD, 2022.

**PROJECT DETAILS**

**School district:** Cajon Valley Union School District, San Diego Co., CA

**Utility:** San Diego Gas & Electric (SDG&E)

**OEMs/dealers:** Lion Electric

**Additional partners:** Charging and V2G: Nuvve. EVSE manufacturer: Rhombus Energy Solutions.

**Number of ESBs:** Five Lion Cs delivered in August 2019, ordered two additional Lion Cs and one Lion D. The district also has five electric warehouse vehicles and a solar installation.

**Charging:** Buses came equipped with Level 2 charging only; have since retrofitted buses to charge with 60 kW DCFC

**V2G:** Yes, through SDG&E pilot with technical assistance and software/hardware form Nuvve

**Funding sources:** HVIP (CA), Carl Moyer (CA), School Bus Replacement Program (CA), and DERA National Grants (US). For infrastructure: SDG&E Power Your Drive program
SCHOOL BUS OPERATIONS

Tysen Brodwolf, transportation director at Cajon Valley Union School District in San Diego County, CA, was initially skeptical of electric school buses. When she arrived at the district, the transportation department had just received funding awards to purchase several electric buses, with the help of a consultant. Despite significant hurdles, the district has found that the buses offer many advantages, and the district is seeking additional funding to expand their electric fleet.

Brodwolf reported that the buses have generally run well and perform very well on hills. She is also happy with having five buses that she doesn’t have to worry about fueling. Although she didn’t have comprehensive data yet, she estimated that they were enjoying approximately 40 percent savings in fuel costs. The district’s routes mostly range from 45-70 miles a day, while their ESBs typically have a range of 70-80 miles with air conditioning (they are rated for 100 miles). To be safe, the buses typically charge in the middle of the day between duty cycles. The electric buses serve disadvantaged communities, which also are lower-mileage routes.

The ESBs’ greatest challenges have been related to charging. When the chargers were initially set up, they had data flow problems and issues with the bus and charger communicating. The implementation of V2G posed another challenge: the buses were equipped only to use Level 2 charging, but the V2G pilot with SDG&E required DC fast charging. Lion Electric agreed to retrofit the buses, but the retrofit was significantly delayed because of supply chain issues. After the upgrade, the buses could only charge at 40 kW, though future models are expected to charge at 60 kW.

Brodwolf says that she thinks her district is unlikely to go all-electric very soon. As the district has had to reduce the number of routes it runs from 40 to 30, some routes have gotten too long for current ESB ranges. Like many transportation directors, she also cited the possibility of blackouts or brownouts—particularly common in California—which could prevent an all-electric fleet from providing transportation for students. However, she is hoping to be able to deploy 13 to 15 ESBs in the near future.

For districts that are considering electrifying, Brodwolf noted that the process requires patience, and recommended consulting with the utility, peer districts that have already deployed ESBs, and all other potential partners to successfully plan and execute the project.

Vehicle-to-grid pilot project

Cajon Valley is working with their utility, SDG&E, to implement one of the first V2G pilots in the state. The California Public Utilities Commission approved the investor-owned utility to conduct the pilot in August 2019; the same decision also endorsed a medium/heavy-duty electrification program which authorized the company to pay for all infrastructure up to the meter, 80 percent of the onsite infrastructure costs, and half the cost of the EVSE. The project was approved to run on six buses using DC fast chargers manufactured by Rhombus using Nuvve’s vehicle-grid integration platform. (Conveniently for the project, Nuvve is located nearby in San Diego, CA.)

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California Public Utilities Commission, Decision 19-08-026 on Application 18-01-012 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, August 15, 2019. This decision approved the utility to invest in electrical infrastructure for 3,000 medium/heavy-duty EVs at 300 sites.
A major feature of the pilot is that it will test out several VGI applications at both the distribution (utility) and transmission (grid operator) levels. These services include:

- **Time of use rate.** The time of use (TOU) rate charges different rates for electricity according to what time the electricity is used. TOU rates can be beneficial for school buses, which do a lot of their charging at night. In the Cajon Valley pilot, school buses will also charge after they finish their first duty cycle, but that is early enough in the day to avoid peak rates. Although this rate plan is available without V2G, the vehicle-grid-integration software makes it much easier to use TOU rates by automating when the buses draw electricity from the grid, as opposed to manually plugging in and unplugging buses to control charging times.

- **Critical Peak Pricing.** Critical peak pricing is a policy in which, under emergency grid conditions, the utility will impose an extra fee for using energy during peak hours (2-6 p.m.). Most CPP days occur during the summer, and up to 18 CPP days can be called during the year. Similar to time of use rates, critical peak pricing (CPP) does not require the use of VGI software, but the software makes it much easier to avoid CPP charges.

- **Utility demand response.** In utility demand response (DR), electric customers can earn revenue by reducing their energy usage during times of especially high demand. When such peak times occur,
the utility will send a signal that a DR opportunity is available. The bus chargers’ VGI software will evaluate whether it’s feasible for the buses to discharge energy and still be able to complete their duty cycles and, if so, the bus can release energy to the school facility so that the school can reduce its electricity draw from the grid. The district will earn money each time they are able to participate in DR.

• **CAISO Proxy Demand Response.** The CAISO proxy demand response program works similarly to utility DR, except instead of the utility issuing the DR signal, the signal is sent by the California Independent System Operator (CAISO), which manages most of the state’s transmission network. Participating in this program is more complicated because it requires a larger amount of power than the pilot’s six buses can provide. The pilot’s V2G platform provider, Nuvve, will aggregate the buses’ power with other nearby power sources. In order to participate in CAISO markets, the buses must go through an additional interconnection process.

• **Emergency Load Response Program.** In the emergency load response program (ELRP), buses may actually have the opportunity to earn revenue by discharging power directly to the grid. Similar to a DR program, the utility can offer opportunities to voluntarily reduce usage during periods when the grid is particularly stressed; however, under ELRP, buses can also export power directly to the grid. Participants earn $2 per kWh offset or exported. ELRP periods are triggered by alerts issued by CAISO.

In order to participate in demand response, the buses are commingling their electric load with the school facilities and making use of three meters: one meter for the bus lot, one meter for the school facilities, and a meter for total usage. As of January 2022, the pilot’s buses had all been retrofitted, and were working to resolve interoperability issues between the EVSE and the school buses.

Challenges facing V2G

V2G technology holds a lot of promise for bus owners as well as for grid reliability and the environment. However, it faces economic, technical, and regulatory barriers that need to be overcome to achieve its full potential.

The main variable determining the economic viability of V2G is battery degradation. Over time, all batteries experience a reduction in their ability to hold a charge, and using the batteries more intensively to provide grid services is likely to speed up that process. The question is whether the value of V2G is great enough to justify the resulting decrease in battery life.

One recent study suggested that using V2G likely could provide more revenue than costs in battery degradation, but that the potential profits would likely be overcome by the necessary upfront costs. However, the level of battery impact from V2G use has yet to be extensively tested in the field; ongoing pilots in Virginia, California, New York, Massachusetts, and other places will hopefully shed more light on this question shortly. The financial benefits of V2G are likely to increase as batteries and EVSE drop in cost and last longer. Other innovations might help: the White Plains demonstration testing out V2G with Level 2 chargers, which are less expensive to install.

Real world testing of V2G is in early stages, and technical challenges have been prevalent. Vehicle-grid integration doesn’t generally involve radically new technology, but it does require a lot of technology to work seamlessly together. The bus must be able to communicate with the battery, and the battery with the charger, and the charger with the meter and the utility. This communication is controlled by multiple layers of firmware and software, and in many cases currently lacks standard protocols.

Hardware issues have also been common. For example, the White Plains demonstration project dealt with significant delay. A provider of computer boards failed to supply the needed equipment, then later experienced software problems. Additionally, there were issues with the chargers in cold weather and equipment outages resulting from discharging twice a day. In the SDG&E project with Cajon Valley Schools, the OEM needed to retrofit the buses, which were designed for unidirectional Level 2 charging but not bidirectional Level 3 charging, the preferred technology for that pilot. These retrofits were delayed because of supply chain issues. The Dominion Energy project in Virginia also experienced unspecified delays. In all cases, it is too early to report conclusive results from V2G testing. However, there is currently no reason to believe that any of the problems encountered so far are unsurmountable.

Regulatory barriers are another hurdle for V2G. The primary issue is that, in most jurisdictions, there are few or limited options for customers to receive compensation for providing grid services outside of pilot programs. For example, San Diego Gas & Electric does not have a retail rate for V2G compensation, so they are taking advantage of several existing demand response-type programs. In New York, the White Plains pilot will be testing out a rate approved by the NY Public Service Commission called value of distributed energy resources (VDER), but experts consulted for this report suggested that the current compensation model may not be adequate for V2G to be economically viable.

Alternatively, ESB owners could bid into wholesale energy markets with their grid operator. However, as with utilities, not all grid operators currently make it possible for EV fleets to compete in their

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125 Bielawski, conversation with author.

126 Bielawski, conversation with author.
markets. Such services also often require higher power levels and typically involve additional approvals and expense to interconnect. The good news is that in September 2020 the Federal Energy Regulatory Commission (FERC) ordered grid operators to implement rules for small-scale generators and storage technologies of at least 100 kW (such as groups of at least 2-6 ESBs) to be able to participate in wholesale markets.\footnote{FERC Order 2222, September 17, 2020.} This regulation should expand opportunities for EV fleets to generate revenue through V2G in the near future.

In the long term, it is difficult to predict exactly what role V2G may play. Other technologies, such as stationary batteries, may end up being a better source of large-scale energy storage. However, implementing vehicle grid integration is a good idea no matter what because, at a minimum, such technology will make a much more efficient, resilient, and environmentally friendly grid.\footnote{Benjamin K. Sovacool, Jonn Axsen, and Willett Kempton, “The Future Promise of Vehicle-to-Grid (V2G) Integration: A Sociotechnical Review and Research Agenda,” \textit{Annual Review of Environment and Resources} 42 (October 2017): 377-406.}

**How ESB owners can explore V2G**

In most cases, the best way for a fleet to start exploring the possibility of implementing V2G is to reach out for assistance in planning and implementation. Fleet operators can seek help from their utilities, state energy offices, school bus dealers, or consultants (see below, “Charge management as a business”). The use of V2G may affect what is the best choice of school bus and EVSE models, as well as the type of infrastructure and interconnection process needed. Seeking advice early will increase the odds of successful early adoption of V2G. On the other hand, operators can always pursue implementing the technology as they install additional EVSE and purchase more electric buses.

For districts and contractors that decide to pioneer the use of V2G with ESBs, some of the steps that operators (or their utilities, consultants, or other partners) can expect along the way are:

- developing a business model, which includes deciding what kinds of grid services the buses will provide, and whether they will work with the utility, the grid operator (or both), or whether they’ll adopt a V2B approach
- applying for approval from the utility and/or grid operator to interconnect with the distribution or transmission network
- as part of the interconnection process, the utility or grid operator will determine exactly what infrastructure upgrades may be needed for the buses to provide V2G service
- working with the utility and electrical contractors to install upgrades.

Given the current state of V2G technology, it may be inadvisable for fleet operators to assume they will be able to rely on V2G as a revenue source. That said, the potential benefits are considerable, and assistance from utilities and charge management companies can mean that school districts may not have to deal with most of the minutiae of implementing the technology. And in many cases, participating in vehicle-grid integration pilots can provide additional funding opportunities for ESBs.
CASE STUDY: WHITE PLAINS V2G DEMONSTRATION

ConEdison, the investor-owned utility that distributes electricity to New York City and several surrounding counties, is completing one of the nation’s first V2G demonstration projects in the nation. The project, located in White Plains, NY, is testing out five school buses in daily operations while showing how V2G can work in New York State.

The White Plains ESB demo is part of a larger initiative by New York’s Public Service Commission called Reforming the Energy Vision (REV). The initiative seeks to modernize the state’s grid by promoting energy efficiency, renewable energy use, more sophisticated energy markets, and the integration of energy resources such as school bus batteries.

DEMONSTRATION PROJECT DETAILS

ConEdison and its partners are attempting to prove the viability of using electric school buses to provide needed grid storage when they are not being used for pupil transportation. In this demo, the utility is subsidizing the cost of five electric school buses and chargers by 25 percent of their total cost, plus the full costs of implementing V2G technology. The project also took advantage of subsidies from the New York Truck Voucher Incentive Program (NYTVIP), which has used money from the VW Fund and federal Congestion Mitigation and Air Quality Improvement program to subsidize electric trucks and buses.

The district’s private fleet operator, White Plains Bus (National Express), owns the buses and operates them during the school year. During the summer, ConEdison has used the storage capacity of the bus batteries to alleviate peak loads in the afternoon. The plan was for buses to charge from 11 p.m.-5 a.m., when electricity is cheapest and most plentiful. From 1-7 p.m., when energy usage is highest, the buses would send power back into the grid.109

School district: White Plains Public Schools, Westchester Co., NY
Utility: Consolidated Edison (ConEdison)
OEMs/dealers: Lion Electric
Private fleet operator: White Plains Bus (part of National Express)
Additional partners: First Priority-Green Fleet (project manager), Nuvve (V2G coordinator)
Number of ESBs: Five Lion Cs deployed in September 2018

Charging: Level 2
V2G: Yes, three of five buses were upfitted
Funding sources: ConEdison approved demo project funds, New York Truck Voucher Incentive Program (passed through from state’s allotment of federal Congestion Mitigation and Air Quality Improvement program)

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SCHOOL BUS OPERATIONS

ConEdison’s demo began in fall 2018 when the five Lion Electric buses entered service. As summarized in Part I, the buses have performed well and drivers have consistently been satisfied with them. Their reliability has been more variable; though they experienced high uptime throughout most of the pilot, the operator was not able to report statistics during 2020 because of the global pandemic, and in 2021, the buses had significantly increased downtime due mostly to parts failures. At least five onboard chargers failed during the middle two quarters of the year. Overall, averaging National Express’s uptime figures over the pilot provides an estimated 87 percent uptime for the buses between 2018 and 2021.\(^\text{130}\)

At first, the data technologies installed on the bus accurately reported miles traveled and vehicle location but did not provide accurate information on energy metrics. It appears this issue was fixed in 2021, and the operator was able to share statistics on the buses’ energy efficiency in the last year. Averaging the efficiency figures reported for each quarter, the buses had an average efficiency of 1.475 kWh/mi, which was within 6 percent of the project’s target of 1.4 kWh/mi and roughly equivalent to 22.85 miles per gallon, more than triple the mileage of a typical Type C diesel bus.\(^\text{131}\)

\(^\text{130}\) Analysis of quarterly progress reports by Consolidated Edison for REV Demonstration Project: Electric School Bus V2G to NY Public Service Commission re: Case 14-M-0101, from January 2019 to January 2022.

\(^\text{131}\) Compared to 7 miles per gallon for diesel and using the calculation miles per gallon equivalent = mi/kWh \times 33.705. Averaging quarterly figures may not be statistically sound since use will vary between quarters, especially Q3 which includes most of summer vacation. However, Q3 figures are not outliers in most cases and the average still may provide a helpful overall idea of bus reliability.
The project included testing on the impact of V2G on battery degradation, one of the critical variables for determining the economics of ESBs and V2G. The latest documents available as of March 2022 stated that data on battery degradation would be shared in a subsequent final report; however, preliminary analysis suggested that V2G operations appeared to impact battery operation at the same rate (according to battery usage) as driving the buses. This would not be an unexpected finding; however, the project’s analysis will be valuable for future V2G efforts whatever the findings.

Sergio Alfonso, transportation director for the White Plains School District, reported that he was initially concerned about the buses’ ability to handle long or hilly routes and operate in cold weather, and that he had carefully monitored which buses went on which routes. Given the buses’ recent performance, however, he said he no longer had those concerns, and that he now leaves the buses’ use completely up to the fleet operator’s discretion. The buses are used on a variety of routes and sometimes on field trips. Given the health and environmental benefits provided by electric school buses, he said, “I’m not going to stop until we have an entire electric fleet.”

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Britt Lotta, general manager at the fleet operator White Plains Bus, pointed out that drivers had reported the buses actually had better traction in the snow because of the heavy battery. In contrast to the experience described in Texas, the air conditioning seemed to draw greater power than the electric heating units.\textsuperscript{133}

**VEHICLE-TO-GRID IMPLEMENTATION**

The implementation of V2G has been challenging. The project’s initial provider of V2G components, BTG, couldn’t deliver the necessary computer boards, so the team brought on a new contractor, Nuvve, a San Diego-based company which specializes in charging and V2G technology.\textsuperscript{134} The process of setting up V2G required new engineering from Lion and Nuvve, overcoming UL certification issues, numerous software challenges, and charger malfunctions likely related to cold weather. In October 2020, ConEdison completed the standard interconnection process required for a grid resource to connect to the distribution network. To make up for lost time, the project team attempted to cycle the battery for V2G multiple times in a day, but that resulted in equipment failures.

Over the course of 2021, project documents state that the buses discharged high-quality power, and suggest that the partners were able to rapidly improve V2G efficiency—a measure of the amount of energy lost during discharge—meeting their goal of 82 percent by the end of the year. However, the demo fell short of its V2G reliability goal of 98 percent; on average, the buses were available to export to the grid between 51 and 67 percent of the time expected in the last three quarters of the year. Project documents suggest

\textsuperscript{133} Britt Liotta, conversation with author, October 11, 2021.
\textsuperscript{134} ConEdison, 2019 1Q Quarterly Progress Report, April 30, 2019; 2019 2Q Quarterly Progress Report.
it will be critical for V2G services to be highly reliable if they are going to provide revenue.

**UTILITY INVESTMENT IN ESBs**

There are a variety of models under which utilities have supported school bus electrification. Most commonly, utilities are taking advantage of state-approved programs to invest in the infrastructure necessary for electrification—often referred to as “make-ready” programs. In make-ready programs, utilities are granted approval to construct the electrical infrastructure necessary for EV deployments and pass the cost of those improvements onto consumers through higher energy prices. Details vary between programs, but it’s common for utilities to pay for all utility-side upgrades (eg. transformers and meters) and customer-side infrastructure (eg. electrical panel, trenching, conduit), but not for the EVSE itself.

For example, in August 2019, the California Public Utilities Commission approved San Diego Gas & Electric’s proposed “Power Your Drive for Fleets” program, which provides two different options for fleets. In both options, the utility pays for, installs, maintains, and owns all infrastructure on the utility’s side of the meter. However, the customer has an option about whether they would like SDG&E to install, maintain, and own the infrastructure on their side of the meter. If not, customers have the option of installing and owning their own infrastructure, with an 80 percent rebate for the installation costs. Cajon Valley Union School District used this program for its ESB project (see case study). Antelope Valley School District near Los Angeles took advantage of a similar program managed by Southern California Edison, and their transportation director described the process of infrastructure installation as “great … almost a joy.”

Electric utilities have also invested more directly in ESBs. The most ambitious example so far has been Dominion Energy in Virginia, which invested millions of dollars in surplus earnings to help school districts purchase 50 ESBs throughout its service area. The justification for this investment is that Dominion, like all power utilities, is in dire need of large-scale energy storage in order to level out peaks in demand and generation. Storage has always been desirable because electricity demand changes throughout the day and throughout the year, but the need for storage increases significantly as variable renewable energy sources such as wind and solar are incorporated into the grid. In exchange for heavily subsidizing these buses, Dominion retained ownership over the buses’ powertrain and battery, as well as the right to use the bus batteries for grid services (V2G) when not in use for transporting students.

Dominion’s plans did not stop at 50 buses. The utility hoped to subsidize at least 1,000 ESB deployments and pass the costs of this investment to customers through electricity rates. So far, Dominion’s plans to expand its school bus program have faced criticism and had limited success in the Virginia legislature.

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135 Mike Breivogel (fleet manager, Antelope Valley Schools Transportation Agency), conversation with author, November 18, 2021.
CASE STUDY: DOMINION ENERGY DEPLOYMENT OF ESBs IN VIRGINIA

Dominion Energy has deployed 50 ESBs across its Virginia service area and is weighing plans for thousands more. Under the initial pilot, Dominion selected 16 school districts to receive buses. The districts contributed the amount a new diesel bus would have cost, and Dominion paid for the additional cost of an electric bus, plus the necessary infrastructure costs. In exchange, Dominion is retaining ownership of the battery and has rights to use the bus as a grid asset when the bus is not in use. The utility will use the batteries to store energy when it is cheap and plentiful, and release energy back into the grid during peak summer hours.

Dominion announced the program in August 2019, selected Thomas Built as the manufacturer in December 2019 through a competitive solicitation, and deployed its first bus a year later in January 2021. In November 2021, the last of the 50 buses was put into service. The utility hopes to begin V2G operations in the summer of 2022.

One of the districts receiving buses from the Dominion program, Fairfax County Public Schools (FCPS), has been among the most aggressive jurisdictions in the country with respect to electrifying their bus fleet. Advocacy from citizens groups such as Mothers Out Front helped push the school board to adopt a goal of transitioning the entire fleet to electric by 2035, one of the first such resolutions in the country. The district received eight buses under Dominion's program.

PROJECT DETAILS

**School districts:** 15 school districts in Virginia, including Fairfax County Public Schools (FCPS)

**Utility:** Dominion Energy

**OEMs/dealers:** Thomas Built

**Additional partners:** Sonny Merriman (dealer), Proterra (battery and electric powertrain manufacturer)

**Number of ESBs:** 50

**Charging:** DC fast charging at 60 kW

**V2G:** Yes

**Funding sources:** Utility excess earnings, which under VA law can be invested in projects that promote the integration of renewable energy sources

SCHOOL BUS OPERATIONS IN FAIRFAX COUNTY

Francine Furby, transportation director at FCPS, said that students were really excited about the electric buses and loved them, and that the district was eager to seek additional funding. Their first electric buses arrived in January 2021, and by March they had all eight of their Dominion-funded buses. Furby noted that the buses had several minor malfunctions. For most issues, Proterra and Thomas were able to fix the buses remotely or at the dealer, as opposed to having to repair the buses in their own facilities. After the manufacturers finished training the district’s drivers, mechanics, and emergency responders and resolved the buses’ initial problems in May 2021, the district began using the electric buses to transport students. In August, Virginia’s Department of Environmental Quality awarded the district funding for ten additional electric buses from the state’s allotment of the Volkswagen fund.
Joseph Wellborn, the district’s maintenance operator, shared his initial impressions of the buses’ performance. Because of the delays in putting the buses into operation, they had only been in use for a few weeks. Technical challenges included problems with the high voltage critical warning lights, the parking brake, and the master light switch. As with buses from several other manufacturers, the bus had issues with the low voltage battery (as opposed to the traction battery which powers the vehicle), which would prevent the door from opening. Most critically, the district was using EVSE with two cables, and the software was not properly configured to charge the second bus after the first bus was fully charged. Wellborn noted that the manufacturers and dealer were able to help them resolve most of the issues, and that he found it unsurprising that there were minor complications to work through, since ESBs are a new product and the district was using first-generation models.

Training dealers and districts important
According to Wellborn, Fairfax County has benefitted from its close relationship and geographic proximity with its bus dealer, Sonny Merriman. The dealer, he said, was well-trained on the technology and usually able to help the district resolve issues quickly. At the same time, he argued that it would be critical for the county’s staff to become experts in maintaining and repairing the ESBs before they have dozens or hundreds of electric buses, because the dealer would never have the capacity to repair that many buses. For comparison, the county had 80 bays and mechanics dedicated to school buses, whereas the dealer had three or four. Traditionally, the district repairs their own buses because it’s much faster and more cost effective when repair and maintenance can be handled in-house.

Concerns over range
Because of the buses’ range limitations and the requirements of the V2G program, the district had to strategically place the electric buses on routes where they would be successful. Fairfax County has many routes that are at least 60 miles, and the buses have a capacity of 100 miles. For such routes, if the bus can’t return to the charging station during the middle of the day, it won’t be able to complete its second duty cycle. Selecting routes for the ESBs was further complicated by the fact that the Dominion program allowed few options for where charging stations could be located. Wellborn was hopeful that with future generations of ESB with higher energy capacity, they would be able to use the buses for longer routes and field trips.

One major benefit of the Dominion program was that the utility handled the entire process of installing infrastructure. Dominion provided options for charging station locations, selected the electrical contractor, and paid for and oversaw the whole process. The utility’s assistance with infrastructure installation made it much easier for the district to adopt the new technology.

NEXT STEPS FOR THE DOMINION PROGRAM
The utility has faced political challenges in expanding its ESB initiative. During the 2020 and 2021 state legislative sessions in Virginia, the company had legislation introduced that would allow them to invest in thousands of ESBs and incorporate the buses into their rate base; that is, the approved capital investment that is used to determine how much total profit the utility is allowed to earn. Both times, the initiatives failed to pass. Mothers Out Front, a leading advocate for ESBs in Virginia, opposed the measure on the grounds that the utility would deploy buses according to each location’s value to the grid, rather than according to equity or environmental justice concerns, and that Dominion would have too much power over ESB deployments. The concerns of ratepayer advocates also played a heavy role in defeating the legislation.
In the absence of approval for a broader program, Dominion has offered to pay for school districts’ infrastructure, networking, and warranty costs in exchange for the utility having access to the battery for V2G and receiving the battery at the end of its life.


The prospects for this business model are uncertain. Most electricity distribution in the United States is managed by for-profit investor-owned utilities (IOUs), which are typically monopolies that are heavily regulated by government bodies known as public utility commissions. In order for IOUs to invest in electric buses and pay for those investments with electricity bills, they would need the explicit approval of their public utility commission or the state legislature. This can be politically challenging because ratepayer advocacy groups are often opposed to such proposals—especially when the storage provided is as expensive as ESBs currently are.

However, several other proposals for utilities to fund electric school buses have been floated or approved in a variety of states, including:

- Duke Energy in North Carolina has proposed to subsidize the purchase of 60 ESBs.\(^{136}\)

- ConEdison’s V2G pilot in White Plains, NY (case study). The IOU has expressed a reluctance to expand its demonstration project into a larger V2G school bus program without further proof of concept.\(^{137}\)

- In 2021, Portland General Electric funded the incremental cost for the purchase of an ESB, along with training and installation in five school districts, and will offer additional funding in 2022.\(^{138}\)

- The Maryland State Legislature passed a bill that would authorize utilities in the state to apply to the Public Service Commission to implement ESB funding programs paid for through electricity tariffs.\(^{139}\)

- Nevada Energy, an IOU, will invest $2 million towards helping school districts pay for ESBs. And Central Coast Community Energy, a community choice aggregation agency in California which allows consumers to source their electricity from renewable sources, is investing $1 million.\(^{140}\)

**CHARGE MANAGEMENT AS A BUSINESS**

To help fleets address the complications of using electricity as fuel, a new set of companies is emerging to help customers with various aspects of installing and using electric vehicles of all types, including school buses. These companies variously describe themselves as charge management, charging as a service, V2G, or energy management companies. They use a wide variety of business models, but they typically take on at least one, and often several, of the following tasks:

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\(^{137}\) Consolidated Edison, testimony on rate case 19-E-0065 before the NY Public Service Commission, April 14, 2019.


• installing EVSE and managing the customer’s relationship with the utility with respect to infrastructure installation
• working with the utility to determine energy pricing
• designing and implementing software to manage charging and/or bidirectional charging services (V2G and V2B)
• for V2G applications, managing the interconnection process.

Some of the most prominent charge management companies include Nuvve (which also manufactures some EVSE and has provided technical assistance for several school bus V2G pilots), Amply (now owned by BP), Mobility House, and Electriphi, all of which have worked with ESBs. Another noteworthy company is Highland Electric, which leases ESBs to districts and includes charge management as part of its lease (case study: Montgomery County).

It is hard to predict the future trajectory of these businesses. Some districts expressed a hope that customer technology, utility-customer interfaces, and driver/mechanic training would advance to the point that fleet operators could manage their own electricity usage and V2G services. In the meantime, such businesses may serve a helpful niche for fleet operators that are excited to adopt electric school buses but have limited capacity to take on the complexity and risks of managing their own infrastructure installation and charging.

PART III: SCHOOL BUS WORKFORCE

The business of transporting students to and from school is a major undertaking in the United States, and involves the labor of hundreds of thousands of people across several sectors. Manufacturing workers build buses and their components. Transportation directors and private fleet managers procure buses and plan and direct school bus operations. Each of the nation’s school buses requires a driver, and every bus requires regular maintenance provided by fleet mechanics. Many bus routes also require the service of school bus attendants to ensure that all students are receiving the attention and safe environment they need.

Depending on the fuel type they use, school buses can also require the services of workers who install various types of fueling stations. For example, deploying propane and CNG school buses typically involves the installation of new or upgraded fueling stations, and electric school buses require electrical upgrades and electric vehicle service equipment (EVSE). In all cases, the switch to ESBs will have a substantial impact on workers. For some employees, such as school bus attendants, the main difference will be a better and healthier working environment as workers no longer have to contend with the air pollution and noise generated by diesel engines. For others, such as electricians installing EVSE, the transition to ESBs will create thousands of new jobs, and the main challenge will be to ensure high job quality, inclusive hiring, and safety standards. And in other sectors, such as the manufacture of diesel engine components, there is a serious risk that, without high-road industrial policies, electrification will lead to the loss of good jobs.

The goal of this section is to profile some of the major jobs involved with the provision of student transport.
Driving the Future: How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition

transportation and consider some of the impacts that the electric transition could have on each of these occupations, including school bus drivers, technicians and mechanics; electrical contractors; and school bus manufacturing workers.

To date, manufacturing employment has received minimal consideration in discussion about school bus electrification. For that reason, this report pays particular attention to the manufacturing industry and the effects the ESB transition could have on workers across the school bus production supply chain. Part IV on policy builds on this discussion to propose ways to ensure that investments in ESBs create high-paying jobs for the workers who build school buses.

**SCHOOL BUS OPERATIONS**

**School bus drivers**

By far the biggest category of school bus-related jobs is drivers. In addition to transporting students from their homes or bus stops to school, bus drivers ensure a safe environment on the bus, and, in many cases, assist small children or students with disabilities with boarding. Additionally, drivers are often responsible for fueling or performing minor repairs. To legally operate a school bus, drivers are federally required to obtain a commercial driver’s license (CDL) with a special endorsement for school buses.44

According to the Bureau of Labor Statistics (BLS), in May 2019 there were 209,290 school bus drivers who worked for K-12 schools and school districts. These drivers earned a mean hourly wage of $15.92 and a mean annual wage of $33,100.45

Another 157,430 school bus drivers worked for private fleet operators. Drivers working for contractors earned somewhat more on average than those who worked for schools—approximately $17.95 per hour and $37,330 annually on average.

School bus driver employment dropped sharply during the COVID-19 pandemic, especially among those who worked for private fleets. In May 2020 there were 196,100 school bus drivers who worked for K-12 schools and school districts, a decrease of 6 percent from the previous year. Among contractors, employment dropped to 118,820—a nearly 25 percent decrease from the previous year.46

<table>
<thead>
<tr>
<th>INDUSTRY OF EMPLOYER</th>
<th>JOBS 2019</th>
<th>JOBS 2020</th>
<th>CHANGE 2019-2020</th>
<th>MEDIAN ANNUAL WAGE-2020</th>
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<tr>
<td>Elementary and secondary schools</td>
<td>209,290</td>
<td>196,100</td>
<td>-6.3%</td>
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<td>School and employee bus transportation</td>
<td>157,430</td>
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<tr>
<td>Total</td>
<td>366,720</td>
<td>314,920</td>
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<td>$35,467</td>
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</table>

Table 8 School bus drivers working for K-12 schools (“elementary and secondary schools”) or student transportation private fleet operators. (“school and employee bus transportation”). Source: BLS 2019-2020.43

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45 BLS, “Transportation and Material Moving Occupations, 53-0000.”

Driving the Future: How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition
Impacts of electrification on drivers

Drivers are subjected to diesel emissions the entire time they are operating the bus—often at least five hours a day—as well as while they are in the bus depot. Michael Cordiello, president of ATU Local 1181-1061, which represents school bus drivers and attendants, told the New York Daily News in 2021, “You have a schoolyard of 300 to 350 buses all warming up in the morning, there’s a cloud of diesel.”

Tim Shannon, transportation director at Twin Rivers (see case study), shared the comments of one driver with the Associated Press: “I can’t believe the change I’m seeing in my lifetime. I used to have to hold a handkerchief over my face to walk through the yard because of the thick diesel soot.”

The health impacts of exhaust on drivers deserve greater attention and are an important area for future research. In the meantime, it is evident that electric buses have the potential to improve the quality of life of drivers.

Even though driving an ESB is essentially similar to driving a fossil fuel-powered bus, training is needed to ensure that drivers have the full range of skills they need to operate the bus safely and efficiently. The biggest difference is in the braking system: ESBs use regenerative braking, which slows the bus down by converting the bus’s momentum into electricity. Using regenerative braking properly is a skill that must be taught and practiced.

Bus drivers who are responsible for fueling buses will also need to learn how charging works for the fleet’s ESBs, along with some basic maintenance functions. Manufacturers typically provide some training along with the delivery of ESBs, but in many cases this training is not sufficient to fully prepare drivers to operate the new buses to their full potential.

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152 Larry Rillera, conversation with author, April 20, 2021; Manalo, “Electrifying News.”

153 Rillera, conversation with author.
SPOTLIGHT ON WORKERS: THE SCHOOL BUS DRIVER SHORTAGE

Aside from the advent of electrification, school buses have been in the news during the COVID-19 pandemic for another reason—a severe driver shortage. School bus services are essential, and shortages likely have hit low-income and rural families the hardest since many parents have no other way to get their child to school. Districts have had to cancel or change bus routes, to set longer hours for drivers, and to task administrators, mechanics, and teachers with taking over routes. In August 2021, over half of transportation officials responding to an industry survey described the driver shortage as “severe” or “desperate,” and 91 percent said they’d had to change services as a result. So far, at least nine states have requested help from the National Guard to drive students.

A lack of bus drivers is not a new problem, and districts and fleet operators have long complained it is difficult to attract employees to the business. The fundamental problem is that typical pay and benefits in

![Mean hourly wages of driving professions requiring a CDL](Image)

Figure 17 Mean hourly wages of selected heavy-duty vehicle driving professions. Data source: Occupational Employment Statistics, May 2020; chart concept adapted and updated from Burgoyne-Allen, From Yellow to Green.

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the profession aren’t enough to live on, especially for a challenging job that requires caring for students as well as driving them safely." School bus drivers face a unique situation of being paid to work only a few hours, while having to put in two separate shifts, which results in a very long work day with minimal compensation. As with many other school support staff who work part-time hours, school districts and fleet operators rarely offer health insurance to bus drivers. Drivers also point to a lack of respect on the job, despite the high level of skill and responsibility required. Finally, professional drivers with a commercial driver’s license (CDL) often have better-paying opportunities, which all but guarantees that school bus services will suffer.

Some school bus drivers are represented by unions, which gives workers the ability to negotiate higher pay, stronger benefits, and fair scheduling rules as well as a recourse for unfair practices like wage theft. However, many drivers lack representation, and even union-negotiated contracts are constrained by a general condition of austerity in U.S. public education.

The global pandemic has exacerbated an already-bad situation. Particularly in the private sector, tens of thousands of drivers were laid off—and many were forced to find other work. At the same time, demand for delivery services boomed, providing new jobs for laid off workers. Many older school bus drivers took the opportunity to retire; one union representing school bus workers reported a 20 percent increase in retirements during 2020 in addition to decreased hiring. In some cases, districts and fleets may have also neglected recruitment during the pandemic.

Aside from calling in the National Guard, governments have taken other measures to attempt to address the acute shortage. Several states including Maryland and New York announced plans to speed up the testing process for drivers. Some operators are advocating for a change in credentials to make it easier to become a driver, such as offering a school bus-specific CDL with fewer requirements, and in January 2022, the U.S. Departments of Education and Transportation issued a three-month waiver of the requirement for school bus drivers to be able to identify engine components as part of the CDL test. These measures may help districts recruit some school bus drivers in the short term. However, it seems likely that without more fundamental changes to improve working conditions for school bus operations employees, districts will continue to struggle to provide students with the transportation they need.

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159 Liz Margolis (executive director of student & school safety, Ann Arbor Public Schools), Edward Gallagher (general manager, Durham School Services), and John Nikolich (fleet manager, Durham); conversation with author, October 18, 2021.


162 Wright, “Bus Driver Shortage Stresses Rural School Districts.”


164 Corey Muirhead (vice president, Logan Bus), conversation with author, October 13, 2021.

165 “Improved pay and benefits critical to addressing school bus worker shortage,” Amalgamated Transit Union.

166 Lieberman, “No Bus Drivers, Custodians, or Subs.”


Attendants

Bus attendants, sometimes known as matrons or monitors, play a crucial role in getting students to school. Attendants are responsible for helping the bus driver maintain a safe environment on the bus. They are especially crucial in providing services for students with special needs who may need extra assistance boarding and exiting the bus.¹⁶⁹

There is approximately one attendant for every six school buses in service, making attendants the second most numerous position in the industry. Like bus drivers, many attendants lost their jobs after the start of the coronavirus pandemic. However, attendant jobs in public schools actually increased slightly.¹⁷¹

Electric school buses will not change attendants’ essential job functions. Additionally, attendants on ESBs enjoy cleaner air and less noise, which can make their jobs easier and safer. The greatest risk to attendants from electrification is the possibility of districts outsourcing to companies with poor working conditions, discussed below.

Even though they have the enormous responsibility of caring for children, attendants tend to earn low wages, and are impacted by many of the same trends that affect school bus drivers.

Mechanics

School bus mechanics maintain and repair the vehicles used to transport students. Often, their primary job is to keep the school bus fleet in good working order. In some smaller districts, however, mechanics are also responsible for a variety of school maintenance tasks, including fixing weed whackers and lawn mowers.¹⁷²

As with drivers and attendants, school bus mechanics experienced significant job losses during the pandemic, especially those working for private fleet operators. Overall, school bus mechanic jobs fell from 17,460 in 2019 to 16,060 in 2020.

Decreased maintenance costs may be a major benefit of electric school buses, but what will make such savings possible is a reduction in working hours for mechanics and parts manufacturing workers. Depending on how dramatically ESBs reduce the need for labor, diesel mechanics could face significant job impacts. There is limited data on how much ESBs will save on labor, parts, or total maintenance; however, early reported estimates from student transportation officials have typically been in the range of 30-50 percent decreases in labor hours and 25-50 percent decreases in parts costs.¹⁷³

¹⁷² Rillera, conversation with author.
¹⁷³ Tim Shannon has suggested a decrease of 30 percent in work hours; Todd Watkins has estimated 50 percent. Interview by Richard Tackett, School Bus Ride, March 5, 2021.
No transportation director interviewed for this report believed they would have to lay off mechanics if they converted their entire fleet to electric. In most cases, directors expected enough mechanics to retire during the transition period to be able to rely on attrition to account for reduced work hours, or thought that mechanics could take on additional tasks. In some cases, directors did not expect electrification to require a reduced workforce at all, especially given that many districts are already understaffed. (However, the officials interviewed for this report are early adopters of ESB technology and not necessarily representative of the entire profession.)

Over time, electrification will render obsolete many of the most advanced skills diesel mechanics possess, and at the same time create a new set of capabilities to master. In order to keep school buses up and running, fleet operators will need to provide mechanics with ongoing training so that they can transition successfully to the new technology.\(^{174}\)

One of the most novel aspects of ESB maintenance for incumbent mechanics is working with high voltage.\(^{175}\) In the first stage of training, mechanics learn to avoid the newly dangerous parts of the bus. With more advanced training, they can disconnect the battery to access and repair additional components. Manufacturers have reportedly prohibited mechanics from attempting certain repairs under warranty terms.\(^{177}\)

Electric school buses are such a new technology that manufacturers may have not yet developed standard protocols for maintenance; however, dealers and OEMs do not have the capacity to take over all major repair functions that fleets typically perform themselves. As OEMs develop maintenance and repair standards, they should quickly establish comprehensive training programs for mechanics at dealers and school bus fleets.

The ongoing transition to electric transit buses, which began several years before ESBs became viable, provides some lessons on how electrification may impact school bus mechanics. Transit buses require more intensive maintenance and have a higher ratio of mechanics than school buses; however, many of the same issues apply. Mechanics at transit agencies have expressed concerns that they would not receive the necessary training to maintain and repair electric buses and that they could lose their jobs due to the lower maintenance needs of electric buses.\(^{178}\)

<table>
<thead>
<tr>
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<th>CHANGE 2019-2020</th>
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<tr>
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<td>$46,630</td>
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<td>School and employee bus transportation</td>
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<td>Total jobs</td>
<td>17,460</td>
<td>16,060</td>
<td>-8.02%</td>
<td>$48,123</td>
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</table>

Table 10 Bus and truck mechanics and diesel engine specialists working for K-12 schools (“elementary and secondary schools”) or student transportation private fleet operators (“school and employee bus transportation”). Source: BLS, 2019-2020.\(^{174}\)


\(^{175}\) BLS, “49-3031 Bus and Truck Mechanics and Diesel Engine.”

\(^{176}\) Tysen Brodwolf, conversation with author; March 10, 2021; Todd Watkins, conversation with author, June 17, 2021.

\(^{177}\) Brian Foulds, conversation with author, June 2, 2021.

CASE STUDY: MONTGOMERY COUNTY PUBLIC SCHOOLS’ DEAL TO LEASE HUNDREDS OF ELECTRIC SCHOOL BUSES

Montgomery County Public Schools in the suburbs of Washington, D.C. made headlines in February 2021 when it announced it had signed a deal to replace 326 diesel school buses over the next four years with electric models leased by a new school bus leasing company, Highland Electric Transportation. As of April 2022, this was by far the largest ESB deal in the United States. Surprisingly, the deal was initially backed by very little government assistance, though it is likely the district could qualify for federal funds approved under the Infrastructure Investment and Jobs Act.

PROJECT DETAILS

**School district:** Montgomery County Public Schools (MCPS), Maryland

**Utility:** Potomac Power Electric Company (Pepco), owned by Exelon

**OEMs/dealers:** Thomas Built

**Additional partners:** Bus owner, lessor, and charging service: Highland Electric Transportation (HET)

**Number of ESBs:** 25. Contract stipulates 61 additional buses for 2022, then 120 buses each year in 2023 and 2024, for a total of 326 by the end of 2024.

**Charging:** DC fast charging

**V2G:** No, HET intends to implement V2G when there is a pathway to do so through Pepco or the grid operator PJM Interconnection.

**Funding sources:** HET’s corporate funding sources (equity or debt investments); HET purchases ESBs and is compensated by leasing the buses to MCPS.

ESB LEASING BUSINESS MODEL

The district will continue to dispose of its old buses at the rate of about 120 each year. But in the first year of its deal with HET, instead of replacing them all by purchasing fossil fuel buses, MCPS will buy only 95 new fossil fuel buses and start leasing 25 ESBs from HET. The second year, the district would buy 59 new fossil fuel buses and lease 61 additional ESBs (for a total of 86 ESBs). In the third and fourth years, the district wouldn’t buy any new buses at all, but lease all 120 additional replacements from Highland annually, for a total of 326 electric buses after four years. The leases last twelve years.

MCPS will pay Highland a predetermined annual lease payment equivalent to the cost of purchasing, fueling, and maintaining the same number of diesel buses. In exchange, Highland will provide the buses, electricity, service, and training. In order to maintain the buses, Highland will train MCPS’s current mechanics and reimburse the district for any time the mechanics spend working on the ESBs. The main selling point for HET’s business model is that it is revenue-neutral and allows the district to outsource administrative complexity: instead of buying new diesel buses, a district can simply make lease payments and receive all-electric buses fully installed and maintained by the company.

It is not immediately obvious how such a business model can pencil out. As discussed in Part I, the total cost of ownership for ESBs is net yet comparable with that of diesel buses currently, even with fuel and
maintenance savings factored in. There are several potential factors that could have contributed to making this deal financially feasible, in addition to the anticipated savings on fuel and maintenance:

1. Potential for subsidies from the U.S. government or the State of Maryland,
2. The potential for revenue generation from V2G services,
3. MCPS’s strong student transportation budget, which funds top-of-the-line buses for student and driver safety and comfort, and
4. Bulk school bus pricing and anticipated future decreases in school bus price.

Under the deal between MCPS and Highland, the school district’s bus drivers will continue to drive the buses and its mechanics will maintain and repair the buses. The decision to employ and train the district’s current workers likely helped avoid harmful disruptions to mechanics’ livelihoods, and should help MCPS employees develop the technical skills they need to care for the electric fleet.

According to Watkins, one of the key factors that made Highland’s deal attractive was the use of Thomas Built buses, which allowed the district to continue to work with its longtime dealer, American Bus Sales. Many districts find dealers to be important not only for selling buses, but also for the role they play in repairing the buses, training mechanics, and interfacing with the OEM.

RESULTS OF DEAL

Originally, the first batch of buses was going to be delivered in the summer of 2021. However, the manufacturer told the district that they were performing important upgrades to the bus design, and that they could either receive the older models on time, or wait until the fall to receive the new versions. The district opted for the new versions. Due to supply chain problems, the first year’s 25 buses were not fully deployed until March 2022. (In interviews conducted for this report, supply chain issues were ubiquitous and affected most or all ESB models in 2021, including repowered buses.) For that reason, it is too early to report results from the deployment.

The deal with Highland Electric includes provisions for the buses to provide V2G services, and the Thomas Built buses are configured to use DC fast charging only, which is more conducive to providing grid services. However, according to Watkins, their utility is not yet ready to support vehicle-to-grid.

As of April 2022, Highland Electric had not announced any deals with school districts comparable to the MCPS deal. The company has, however, succeeded in implementing V2G services in its project at Beverly, Massachusetts, among the first commercial V2G projects in the country.

In March 2022, Highland Electric and Thomas Built announced that they had signed a letter of intent which appeared to include a bulk purchasing agreement.

Outsourcing
The advent of ESBs may be an impetus for some districts to consider privatizing their school bus operations. School districts, which typically are not accustomed to using large volumes of electricity, could decide to outsource not only the task of figuring out and managing the electrification process, but also school bus operations in general. One transportation director interviewed for this report shared that when they solicited help with electrification, private operators responded with an offer to take over their fleet.

School bus contracting can have advantages and disadvantages. One of the major disadvantages of outsourcing is that it often completely displaces the district’s workforce or, if the workforce is rehired, can potentially remove protections and benefits workers had under the district. Additionally, since private fleet operators are usually for-profit companies, contracting is often more expensive than district-run operations.179

Districts seeking to electrify their fleets may have an easier, less drastic approach: seeking assistance from outside parties specifically for infrastructure installation and charging. Some districts have received help from their electric utilities or OEMs. Other schools have contracted with EV fleet charging companies that help install charging equipment and manage the charging process (see Section X, “charge management as a business.”) Over time, school bus staff could be trained to use electricity as a fuel, which could become a core skill of school bus drivers, mechanics, or managers.

SCHOOL BUS MANUFACTURING
As with most complex pieces of equipment, there is no one company that assembles and produces all of the parts of a school bus. The companies that assemble school buses are called original equipment manufacturers (OEMs). OEMs typically also manufacture the body of the bus and, for the larger Type C and D buses, the chassis (base framework). Other companies supply the rest of the parts including the propulsion system (powertrain), the brakes, the tires, the windows, the HVAC systems, seats, and other equipment including two-way radios and GPS systems.

The school bus OEM market is highly consolidated. Currently, the market for standard size Types C and D buses is dominated by three companies: IC Bus, Blue Bird, and Thomas Built. A newer company, Lion Electric, manufactures only electric buses and trucks and could be poised to gain considerable market share as fleets transition to electric. The transit bus company BYD has also announced its intention to begin producing ESBs.180

Smaller Type A buses are produced by a different set of companies, the main OEMs being Starcraft, Collins, Trans Tech, and Micro Bird. Type A school bus OEMs usually source their chassis from automotive manufacturers such as Chevrolet or Ford.

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Overview of major school bus OEMs

<table>
<thead>
<tr>
<th>COMPANY (PARENT)</th>
<th>FACTORY LOCATION(S)</th>
<th>BUS TYPES</th>
<th>NUMBER OF EMPLOYEES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas Built (Daimler)</td>
<td>Highpoint, NC</td>
<td>A,C,D</td>
<td>1,600&lt;sup&gt;181&lt;/sup&gt;</td>
</tr>
<tr>
<td>IC Bus (Navistar)</td>
<td>Tulsa, OK</td>
<td>C,D</td>
<td>1,000&lt;sup&gt;182&lt;/sup&gt;</td>
</tr>
<tr>
<td>Blue Bird</td>
<td>Fort Valley, GA</td>
<td>C,D</td>
<td>1,736&lt;sup&gt;183&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lion Electric</td>
<td>Saint-Jérôme, Canada; Joliet, IL (under construction)</td>
<td>A,C,D</td>
<td>900&lt;sup&gt;184&lt;/sup&gt;</td>
</tr>
<tr>
<td>Starcraft Bus (Forest River)</td>
<td>Goshen, IN</td>
<td>A,B</td>
<td>230&lt;sup&gt;185&lt;/sup&gt;</td>
</tr>
<tr>
<td>Collins Bus (REV Group)</td>
<td>Hutchinson, KS</td>
<td>A</td>
<td>290&lt;sup&gt;186&lt;/sup&gt;</td>
</tr>
<tr>
<td>Micro Bird (joint venture of Blue Bird and Girardin)</td>
<td>Drummondville, Canada</td>
<td>A</td>
<td>250&lt;sup&gt;187&lt;/sup&gt;</td>
</tr>
<tr>
<td>Trans Tech</td>
<td>Warwick, NY</td>
<td>A</td>
<td>60&lt;sup&gt;188&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>6,066</strong></td>
</tr>
</tbody>
</table>

Table 11 Overview of major school bus OEMs. This does not include companies that supply parts for school buses, including powertrains.

**Trends in U.S. manufacturing**

Despite consistent declines in manufacturing wages and jobs over the past four decades, manufacturing is still critically important in the United States.<sup>189</sup> Historically, the sector has been a major source of well-paying jobs, including for workers with less access to education, as manufacturing jobs still pay better than comparable non-manufacturing jobs.<sup>190</sup> As of August 2021, manufacturing provided an estimated 12,438,000 jobs, or 8.4 percent of the nonfarm workforce.<sup>191</sup>

Job losses and falling wages are not inevitable; they are the result of policy choices. This section describes how low-road manufacturing practices, which prioritize the use of tax breaks and low wages, have harmed manufacturing workers, and provides background on an alternative, high-road model of manufacturing. Part IV will build on this discussion to propose concrete ideas about how government investment in the transition to electric school buses can help cultivate a school

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<sup>182</sup> Dun & Bradstreet, IC Bus corporate profile, accessed October 21, 2021.

<sup>183</sup> Blue Bird Corporation, 10-K, December 17, 2020.

<sup>184</sup> Lion Electric, *Lion Electric Announces Second Quarter 2021 Results,* August 13, 2021.

<sup>185</sup> Dun & Bradstreet, Forest River dba Starcraft Bus corporate profile, accessed October 21, 2021.

<sup>186</sup> Dun & Bradstreet, Collins Bus Corporation corporate profile, accessed October 21, 2021.


<sup>188</sup> Miguel Ortiz (sales staff, Trans Tech), email correspondence with author, February 4, 2021.


<sup>191</sup> BLS, Employment, Hours, and Earnings from the Current Employment Statistics survey, November 2021.
bus manufacturing sector and supply chain that, instead of accelerating offshoring and falling wages, can create high-paying, equitable, family-sustaining jobs.

Job quality in U.S. manufacturing: the high road vs. the low road

Many factory owners in the U.S. have prioritized strategies that focus on compensating employees as little as possible. One approach has been to locate new plants in regions of the country with weak labor standards and invest heavily in anti-union campaigns. Corporations have also adopted outsourcing strategies which have tended to worsen working conditions. For example, manufacturing firms often use staffing agencies to avoid paying workers benefits. Such tactics have undermined the power of employees in the manufacturing sector to bargain for fair compensation and working conditions, and have made it harder for companies to compete on the basis of innovation and quality.

A major contributor to falling wages in manufacturing and other industries in the United States is the decline in union membership. In production occupations, members of unions earn 21 percent more in weekly earnings than non-union workers. Since 1983, the percentage of U.S. workers in all sectors who belong to unions has been cut in half, from 20 percent to 10.3 percent.

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195 Ruckelshaus and Leberstein, Manufacturing low pay.
percent. Companies and their consultants have increasingly found ways to bend and break federal labor law with near impunity in order to threaten and intimidate employees to prevent them from organizing.

Some of the tactics companies use are legal—such as the coercive anti-union meetings Amazon forced its employees to attend at its warehouse in Bessemer, Alabama in 2021. Nissan used similar tactics in 2017 when workers tried to organize their plant in Mississippi. The National Labor Relations Board charged the company with threatening to close the factory if the workers voted to join the union—an illegal but ubiquitous and effective anti-union tactic.

Companies are charged with labor law violations in more than 41 percent of union elections, and illegally fire workers for union activity in 20 percent of elections. Such illegal tactics are common because labor law does not provide meaningful penalties for such actions.

There is an alternative to ever-decreasing jobs and wages. The U.S. and its manufacturing sector could pursue high-road strategies in which firms provide continuous training and compensation to their employees and seek their collaboration. High-

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road companies are able to compete according to quality and efficiency, rather than according to how little they can pay their workers. Experienced, highly-skilled workers improve the ability of businesses to innovate, increase productivity, and respond to consumer and industry demands.205

Economic research supports the high-road model of manufacturing. For example, an important econometric analysis of the Japanese automotive industry found that auto supply chain companies preferred to locate in areas with high manufacturing density, high-wages, and highly-skilled workers.206 A recent investigation of high-road practices in wind and solar manufacturing discovered that such policies resulted in small cost increases which were largely offset by increases in labor productivity.207 Another study from Norway found that increases in union density were associated with both higher wages and higher productivity.208

Germany is often cited as an example of a nation successfully carrying out a high-road manufacturing strategy. A report by the Brookings Institution from 2012 showed how Germany has been able to maintain a manufacturing sector with much higher wages than the U.S., while representing twice as large a proportion of the economy, experiencing less than one third of the job losses, and enjoying a healthy trade surplus. Germany has been able to accomplish this through an industrial policy that includes a highly developed research and development (R&D) network, continuous vocational training, access to finance for manufacturing companies, and strong worker protections.209

To build a high-road medium and heavy-duty EV manufacturing sector, the U.S. can invest strategically to create demand for new good jobs, increase support for R&D, and ensure that workers have the training and support they need to excel.210 At the same time, policy changes that promote collective bargaining and worker retention, safety, collaboration, and high wages can help ensure that skilled work is respected and valued. Because the transition to ESBs requires

<table>
<thead>
<tr>
<th></th>
<th>UNITED STATES</th>
<th>GERMANY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing wages (2009)</td>
<td>$33.53</td>
<td>$46.52</td>
</tr>
<tr>
<td>Union membership density, all sectors (2018)</td>
<td>10.1 percent</td>
<td>16.3 percent</td>
</tr>
<tr>
<td>Collective bargaining coverage (2018)</td>
<td>11.7 percent</td>
<td>54 percent</td>
</tr>
<tr>
<td>Mfg as share of jobs (2010)</td>
<td>10.1 percent</td>
<td>21.2 percent</td>
</tr>
<tr>
<td>Mfg job loss 1990-2000</td>
<td>7.8 percent</td>
<td>2.2 percent</td>
</tr>
<tr>
<td>Mfg job loss 2000-2010</td>
<td>28.3 percent</td>
<td>6 percent</td>
</tr>
<tr>
<td>Trade surplus (2010)</td>
<td>-$113.3</td>
<td>$52.3</td>
</tr>
</tbody>
</table>

the development of new products and supply chains, it is an ideal moment to ensure that, from the outset, the industry emerges as a high-road sector.

**Equity in U.S. manufacturing**

Another area for improvement in the manufacturing sector is equity. Although manufacturing provides relatively good jobs to many people from diverse backgrounds, it also sometimes excludes or holds back workers from some groups, including women, people of color, and formerly incarcerated people.\(^{211}\)

Within the transportation equipment manufacturing sector specifically, white, Black, and Asian workers are represented proportionately relative to the general population, while Latinx workers are underrepresented (13.8 percent of workers compared to 18.5 percent of the population), and women are dramatically underrepresented (only 25.4 of workers in the sector).\(^{212}\) Broad statistics can also conceal deeper inequities. For example, Black and Latinx workers are severely underrepresented in higher-level positions as industrial production managers: only 5.7 percent are Black and 10.9 percent are Latinx. Even if the sector as an aggregate is racially and ethnically diverse, there still exist serious disparities in who has a fair chance to advance.\(^{213}\)

A high-road and inclusive industrial policy has to center equity as well as job quality. The first step companies can take is to plan and execute strategies to include workers from underrepresented communities in job and apprenticeship opportunities. Additionally, companies should ensure that there are career ladders that equitably provide workers from all backgrounds a chance to advance in their careers, learn new skills, and take on high-paying positions. Companies that inclusively recruit, hire, train, and promote workers will ultimately benefit from maximizing the potential of a diverse and highly-skilled workforce.\(^{214}\)

**Electric school bus supply chain**

Several studies have considered the likely impacts of the EV transition on jobs related to the manufacture of light-duty vehicles. The discussion on job impacts below draws heavily from this research to consider the likely effects on ESB manufacturing careers. More specific sectoral studies on buses and trucks will provide additional insights.

Fossil fuel-powered buses and ESBs are similar pieces of equipment with one major difference: the powertrain, which is the system that propels a vehicle. Since diesel and electric buses use entirely different mechanisms for storing and using energy, their powertrains use entirely different components. The impact on jobs from electrification will depend on three factors:

1. **The total amount of work hours needed to build the electric powertrain and its components and the work hours needed to assemble an ESB,**
2. **The extent to which incumbent workers will be able to take the newly created jobs, depending on the location of the new jobs, the skills they require, and whether incumbent workers are able to obtain those skills; and**
3. **The quality of jobs at new electric-focused factories.**

**Total work hours required**

Powertrains using an internal combustion engine (ICE) are reported to consist of between 1,000 and 2,000 parts, whereas electric motors can have fewer than 20 moving parts.\(^{215}\) Intuitively, it would seem that the reduced complexity of electric powertrains would result in fewer total

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\(^{215}\) Philipp Schartau and Gianluigi Indino, "Why EVs Don’t Spell Doom for the Aftermarket," Ernst & Young, June 18, 2021.
Driving the Future: How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition

In short, it seems plausible that the transition to ESBs could result in fewer work hours, but the research is mixed. The fact that most of the available studies have concentrated on light duty autos gives rise to further uncertainty on this question.

**Location of new jobs and skills required**

Even if ESBs end up requiring as many total work hours as diesel school buses, it must be stressed that this refers to net jobs. Electrification means that, eventually, jobs producing ICE engines and their components will go away. At the same time, new jobs will be created—potentially just as many. The question is whether these new jobs are accessible to incumbent workers, which depends largely on where the jobs are located and whether workers have the skills for the new jobs.

Currently, the manufacture of EV components predominantly takes place outside of the United States. A recent report by the Economic Policy Institute using input-output analysis estimated...
that the U.S. share of EV components is less than 45 percent, compared to 75 percent for ICE vehicles. If that proportion were to hold constant throughout the transition, it would mean tens of thousands of jobs leaving the U.S. in the next 10 years. Ola Källenius, the CEO of Daimler, the parent company of school bus maker Thomas Built, has acknowledged that even in Europe where the EV supply chain is more developed, the shift to EVs would have a major impact on jobs.

Batteries and power electronics are central to this equation, and batteries in particular represent a major portion of the EV value chain. The United States currently produces less than 10 percent of global battery materials and cells, but represents about a quarter of the automotive market. The policy section of this report discusses how the U.S. can use industrial policy to build up the domestic supply chain for medium and heavy duty EVs through investment in ESBs.

Growing the domestic supply chain will help decrease the number of jobs that are lost to other countries and could even create new jobs. However, if the new jobs are located in a different part of the country, it could be challenging for incumbent workers to take those jobs. When jobs move out of a community, it can have a similar impact whether those jobs go to another state or another continent. For that reason, the best


practice, whenever possible, is for companies to re-tool their factories to produce components for EVs. 221

The new jobs created in the ESB supply chain often involve new skills and sometimes require advanced training. In some cases, workers may be able to adapt with small amounts of on-the-job training. In others, the new jobs may be of an entirely different nature. Either way, government and business have a responsibility to ensure that incumbent workers are not left behind in the transition, which means providing the training and support needed to continue at a re-tooled factory or to access new, comparably compensated jobs in the same area. Doing so will not only protect workers and their families and communities, but also help the burgeoning EV sector to achieve its maximum potential.

**Job quality**

Electrification poses risks for job quality across the school bus manufacturing supply chain, while also presenting opportunities for high-road manufacturing. One factor is that the transition is giving rise to new OEMs, in many cases non-union, that may take market share from union firms. This could have the effect of lowering union density, which in turn tends to lower wages across the industry and increase economic inequality. 222 Unions also play a critical role in improving safety in manufacturing workplaces.223

In the case of ESBs, one of the leading firms, Lion Electric, started building its first U.S. factory in Joliet, Illinois in 2021. As of March 2022, the company was non-union, and had not publicly stated whether it would agree to a fair process for its employees to organize. At the same time, the Los Angeles-based transit bus manufacturer BYD, whose employees are organized through the International Association of Sheet Metal, Air, Rail, and Transportation Workers (SMART), has recently entered the ESB market.224

When it comes to job quality at the factories that supply school bus OEMs, OEMs’ business strategies could have an impact. In order to build ESBs, firms need access to an entirely different set of powertrain components. To acquire these parts, they have several options:

1. Source components from abroad
2. Source components from other U.S.-based factories
3. Build separate factories in the U.S. or
4. Expand their existing facilities to bring production fully in-house.

School bus makers could pursue any or all of the above strategies. For their initial forays in ESB building, companies have relied mostly on sourcing externally from abroad or the U.S. This is understandable, because school bus OEMs do not traditionally have expertise in battery building or power electronics. These industries have lower union density and are currently less concentrated in the United States than the market for diesel powertrains, so outsourcing could lead to fewer U.S. jobs, with lower wages and benefits for the jobs that remain.

Many auto companies are starting to pursue vertical integration for their EV business, and school buses firms may use the same strategy. Tesla has long produced batteries along with EVs, while GM, Ford, Volkswagen, and others have announced new U.S. battery factories.225 Light duty OEMs are traditionally more vertically integrated than school bus companies—for example, they nearly always make their own engines, whereas school bus makers typically outsource their powertrains.226 Even so, Lion Electric is investing in a battery

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221 UAW Research Department, *Taking the High Road: Strategies for a Fair EV Future* (Detroit, MI: United Auto Workers, 2019).


factory near its Quebec production facility, and BYD was founded as a battery company. Vertical integration may increase the chances of creating good jobs through the transition to ESBs, but it’s not the only factor. It’s possible that outsourced electrical powertrain suppliers could choose high-road strategies and create excellent jobs, or that vertically integrated school bus OEMs could build new battery factories and employ a union-avoidance strategy. Regardless of the market strategy companies adopt, communities will benefit if companies hire inclusively, pay employees well, and commit a fair and respectful process for workers to organize a union if they choose.

**ELECTRIC VEHICLE INFRASTRUCTURE INSTALLATION**

In order to run ESBs, it is necessary to install electrical infrastructure and chargers in the depot where buses will park. Electric school buses require large amounts of power, which means that new electrical connections are often needed from the distribution network to the lot as well. Performing these upgrades will take a massive amount of work, creating thousands of jobs.

Infrastructure installation projects involve the collaboration of multiple entities employing workers in a diverse set of occupations. The two most important players are the electric distribution utilities and electrical contractors. Utilities typically handle the job of upgrading the quantity of power delivered to the bus lot, relying heavily on electrical lineworkers. Approximately 54,000 lineworkers work for utilities installing and repairing electrical power systems in the U.S. These employees often work in harsh and dangerous conditions, but many positions are unionized and pay an average wage over $80,000. Most positions require a high school diploma followed by continuous on the job training, often through apprenticeships. As such, they can be an important source of good jobs for those without university training. The rise in EV deployment does not significantly change the nature of this work, but may help to maintain employment levels.

**Electrical contracting**

Electrical contractors are the companies that perform the task of installing charging stations (EVSE), from upgrading the electrical panel, to digging trenches for conduit (pipes or tubing used to protect wires) from the power meter to the parking spots, to physical installation of the EVSE. More generally, the U.S. Census defines electrical contractors as companies that are “primarily engaged in installing and servicing electrical wiring and equipment.”

For ESBs, the school district or fleet operator is usually responsible for hiring the contractor after working with the utility to figure out exactly what upgrades are needed. Utilities, OEMs, or charge management companies can provide assistance with planning and installation, including hiring the contractor. Where state or local regulations have authorized a “charge ready” or “make ready” program, utilities can sometimes arrange and pay for the entire process or a major part of it.

Electrical contractors range from very small businesses to large companies; although the vast majority of firms (95.8 percent) have under 50 employees, over half of employees in the industry work at firms with over fifty employees (See Figure 22). According to an industry survey, EVSE installation was a common activity across all firm sizes (31 percent of companies) but commercial installations (like school bus depots) were most

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229 Occupation classified by the BLS as “49-9051 Electrical Power-Line Installers and Repairers”; industry classified as “NAICS 221122, Electric Power Distribution.”
232 NAICS Sector 23821 - Electrical contractors and other wiring installation contractors.
233 U.S. Census Bureau, Economic Census 2017.
often performed by larger firms. Another study found that for a majority of firms that performed installations, EVSE represented 10-20 percent of business revenues.

**Key occupation: electricians**

The most prominent role at electrical contractors is that of electricians, which make up roughly half of the sector’s workforce. In 2020, there were approximately 465,220 electricians working for electrical contractors, earning a median hourly wage of $26.52. Wages for electricians can be significantly higher in large metropolitan areas; for example, in the New York metropolitan region, the median was $40.48 an hour and in the San Francisco Bay Area it was $51.29.

Electricians are usually required to obtain a high school diploma or equivalent, but the majority take electrical training courses as well. After completing their classroom education, electricians can start working by finding an apprenticeship, which provides on-the-job training as well as educational instruction. Requirements vary by state, but apprentices who have completed 4,000-8,000 hours of electrical work experience can test to become certified as journeyworker electricians, which comes with a higher level of pay and responsibility, including independent work. With additional training and experience, journeymen can become master electricians, which confers the ability to plan and manage electrical projects.

**Impact of school bus electrification**

A recent study estimated the number of jobs created during EVSE installations across several job classifications. The study estimated that each DC fast charger installation would create 3.86 job-days for electricians and 12.23 job-days total. Chargers can be equipped with between one and four connectors, but in practical terms Level 2

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237 BLS, “47-2111 Electricians,” Occupational Employment and Wages, May 2020. The hourly wages for metropolitan areas refer to all electricians, not just those working for electrical contractors; the median for the occupation nationally was 84 cents higher than for those working for electrical contractors.


239 This study relied mostly on data for light-duty chargers; school buses have much higher power requirements, so the figure for DCFC is used; even so, this figure may be conservative.
chargers for ESBs can only use one connector, and DC fast chargers for school buses will often be practically limited to two connectors. Thus, electrifying the U.S.’s entire school bus fleet could create between 3,712 and 7,423 jobs for electricians and between 11,760 and 23,519 jobs total. This figure is for school buses alone; of course, school buses represent only a fraction of the total vehicles on the road that will require charger installations.

As the demand for EVSE installation services grows, it will be important to ensure that the industry provides good, stable jobs. Training is particularly important because it is necessary for safety as well as for career advancement. Installing EVSE requires the knowledge and experience of journeyworker electricians, and also requires some additional specialized training. There are a number of training programs available to help electricians become acquainted with charging technology; the leading industry standard is known as the Electric Vehicle Infrastructure Training Program (EVITP).

The EVITP is a national program administered by a non-profit training and certification organization. It was conceived in 2010 by two locals of the International Brotherhood of Electrical Workers (IBEW), Local 1 in St. Louis and Local 134 in Chicago, and developed collaboratively with auto manufacturers, electric utilities, the National Fire Protection Agency, electrical contractors and inspectors, and several universities. It includes 18-20 hours of training on EVs, charging station types, electric load calculations, and Article 625 of the National Electric Code, which deals with standards for EVSE installation.

Improperly installed EVSE can pose fire and electrical hazards, and the high-power chargers needed for heavy-duty vehicles like school buses may be particularly dangerous. California, the leading state in the installation of electric vehicles, requires EVSE to be installed by a licensed contractor with at least one EVITP-certified electrician for projects funded or approved by the energy agency, the utility regulator, or the Air Resources Board. For high-power projects such as school bus installations, at least a quarter of the electricians on the project must be EVITP certified.

In addition to ensuring safety and proper installation, requiring EVITP provides job quality benefits for electricians. It ensures that training creates a return on investment, maintains high industry standards, and provides new skills and job opportunities for career electricians.

Continued growth in the electrician occupation will also create new opportunities for workers to enter a field with interesting, well-paid work. Workers from all backgrounds should have the ability to successfully pursue electrical careers, and new opportunities for good jobs should be prioritized for workers from disadvantaged communities and workers displaced by the energy transition. Many workers are not aware of the opportunities that exist in the field, so the first step towards promoting inclusion is proactively recruiting displaced workers and workers from underrepresented communities.

240 Chargers with multiple connectors typically split the available current or take turns. It takes a 19 kW Level 2 charger 6.5-8 hours to charge a single 155 kWh bus and would take twice as long to charge two buses. A 50 kW DCFC could charge three such buses in an eight-hour period; however, units with one or two connectors are likely more practical to enable midday charging.

241 Job-years, assuming 40 hours of work 52 weeks a year.


243 California Assembly Bill 841 (2020).

244 Carol Zabin, Putting California on the High Road.

Pre-apprenticeships are invaluable for helping aspiring electricians succeed in an apprenticeship. Although they are not required, they help acquaint workers with the field and prepare them to begin working in the field.246 Often, they include wrap-around services to help underrepresented workers overcome the initial challenges of entering a trade. For example, Mississippi’s Women in Construction program offers childcare to help mothers and other parents enter the trades, and Washington, D.C.’s Building Futures program helps returning citizens obtain the documentation they need for work.247

247 “Leveling the Playing Field,” IBEW.
PART IV: TRANSITIONING TO CLEAN SCHOOL BUSES: POLICY CONSIDERATIONS

The public health, equity, and environmental case for electric school buses is compelling and urgent. Transitioning to electric school buses will immediately benefit the health of students, workers, and communities through improved air quality, and will help pave the way for the electrification of heavy-duty vehicles more broadly, along with significant reductions in air pollution and GHG emissions. Now that the technology is viable, there is strong popular and political interest in implementing policies to accelerate the transition and realize the benefits of student transportation electrification as quickly as possible.

At the same time, electric school buses will have major impacts on those who rely on the student transportation industry—not all of which will necessarily be positive. Without well-designed policies in place, the electrification process could end up reinforcing social, environmental, or economic inequalities. To provide the greatest public benefits and avoid needless harm to communities, policymakers must collaborate with impacted groups when designing electrification programs. This part provides an overview of some of the major issues that policymakers should take into account.

ESB MANDATES
State electrification mandates can be highly effective, and often take the form of either fleet rules or manufacturer requirements.\textsuperscript{248} Zero-emissions mandates can set clear expectations for manufacturers, fleets, and utilities, providing

market certainty and making it easier to plan for investments in producing, deploying, and fueling ZEVs. However, without thoughtful planning and close consultation with stakeholders, the risk of unanticipated consequences can be high.

**Manufacturer mandate: Advanced Clean Trucks**

California’s Air Resources Board has led the way on manufacturer requirements through its Advanced Clean Trucks (ACT) regulation, which it adopted in June 2020 after an extensive public deliberation process. The regulation requires that a certain percentage of the heavy-duty road vehicles each manufacturer sells in the state be zero-emission vehicles. These percentages increase each year, from 9 percent of new sales in 2024 to 75 percent of new sales in 2035. It has been estimated that ESBs could achieve total cost of ownership parity with diesel buses between 2025 and 2030, which may mean that ESBs could transition much more quickly than the time frame specified in the ACT rule. However, the regulation will be valuable in helping transition the entire medium and heavy-duty vehicle sector to zero-emission vehicles on a predictable time scale.

Because of the peculiarities of federal environmental law and the state’s unique challenges with air pollution, California has much greater leeway to regulate transportation emissions than any other state. However, it is often permissible for other states to adopt California’s rules. As of March 2022, five states beyond California had adopted ACT: New Jersey, New York, Massachusetts, Oregon, and Washington. Other states are in the process of considering adoption.

**School bus fleet mandates**

New York became the first state to mandate the full transition of its school bus fleet to zero-emissions models on April 8, when it passed its fiscal year 2023 budget. The legislation requires that all new school buses purchased in the state must be zero-emission starting in 2027, and that all school buses on the road would have to be ZEVs by 2035. (The measure includes provisions for districts to seek a waiver if they can’t meet the requirement for technical reasons.) The budget did not include subsidies to help districts pay for ESBs, though it earmarked $500 million that will become available if voters approve a ballot measure in November 2022, the Environmental Bond Act. The state mandate follows on the heels of New York City, which in October 2021 required all school buses to transition to zero-emissions by 2035.

School buses are typically in service for 15 years. In order to comply with the 2035 directive, fleets and districts will have to start transitioning to electric as quickly as possible, and will also have to employ an electrification strategy that involves a combination of early retirements and electric retrofits.

Several questions are worth asking when considering a fleet mandate, including:

- Will school districts and private fleets within the jurisdiction be able to comply while still providing the same level of school bus service as before? In particular, can all of the school bus routes within the state be ready for electric bus service within the prescribed time frame?
- If some current bus routes are too long for ESB ranges, can they be reasonably and fairly rerouted or redistributed?
- Do school districts and the state have a strategy to enable longer-distance ESB trips such as field trips and sporting events? These could include plans for the installation of

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250 California Air Resources Board, Final Regulation Order—Advanced Clean Trucks, submitted January 29, 2021. These percentages would apply to Type C and Type D school buses; requirements for Type A school buses would start at 5 percent in 2024 and increase to 55 percent by 2035.

251 Smith, Electric Trucks and Buses Overview.


253 Rachel Silberstein, “New York Schools Have Five Years.”

of high-power charging stations in public locations and at schools.

• Will districts and fleet operators be able to afford the necessary investments without cutting into educational budgets?

• Will districts have the technical, financial, and logistical assistance they need to procure, install, operate, and maintain an electric bus fleet?

The answers to many of the above questions are not foregone conclusions, and can be altered through local and state policies. The point is that policymakers will have greater success passing and implementing a fleet mandate by first considering these questions and making a plan to provide the resources necessary to support fleets in making the change.

**ESB SUBSIDIES**

Subsidies are both potent and popular. By making ESBs affordable for school districts, they increase the demand needed for OEMs to scale quickly, which can improve the technology while lowering prices. Since subsidies are voluntary, they go to jurisdictions that are prepared to adopt the technology and don’t impose obvious hardships on districts that aren’t ready to switch.

Bipartisan congressional approval of the $5 billion Clean School Bus Program—one of the largest climate investments included in the Infrastructure Investment and Jobs Act (even if only half was exclusively dedicated to ZEV buses)—demonstrates the broad appeal of investing in ESBs. People care about their children's health, and politicians know it. A large bump in state revenues in 2021-22 is opening the window of opportunity even wider for ESB subsidies and other longer-term investments in infrastructure and education.

It is not enough just to allocate money. Thoughtful design of ESB funding programs is essential to their success. As described in earlier sections of this report, deploying ESBs is a new and complex adventure for school districts and fleet operators, and government agencies can play a crucial role ensuring program success, equity, and efficiency. At the same time, ESBs represent big changes for manufacturers and dealers which will disrupt prices, supply chains, bus reliability, and workforces. If done right, investing in ESBs can serve as a powerful step towards reducing greenhouse gas emissions, addressing environmental injustice and creating good, environmentally friendly careers for those who need them most.

**PROMOTING ENVIRONMENTAL JUSTICE**

The transition to electric school buses provides an opportunity for state and federal agencies to reduce the severe racial and economic inequity that exists in the geographic distribution of air pollution sources. Environmental racism is an ubiquitous and thoroughly documented phenomenon. In the United States, companies and public officials are significantly more likely to locate pollution-emitting facilities and infrastructure near lower-income communities and communities of color. Consequently, these communities bear a disproportionate burden of pollution and its harmful health impacts.

There is little reason to doubt that race, ethnicity, and class have a strong influence on where diesel school buses are parked and routed, as well which routes are assigned the oldest, most polluting buses. However, nationwide data on school bus

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routes or depots is not readily available, and so it has been challenging to study the effects of school buses in particular.

New York City activists have mapped the locations of the city’s bus depots, which are located predominantly in lower-income communities of color. The vast majority are located in central and east Brooklyn and in the Bronx.

In the District of Columbia, Mayor Muriel Bowser is pushing to construct a 230-bus depot in Brentwood, a predominantly Black neighborhood in Ward 5, despite objections from the community. The ward is home to almost half of the city’s industrial zoned land, and Brentwood already hosts a garbage truck fleet, a recycling center, construction companies, and auto repair shops. Community residents have sued the city to halt the project.

Although funding for electric school buses is unlikely to reduce disparities in siting bus depots, it can significantly reduce the impact that those depots have on neighborhoods, especially those that are already disproportionately affected by air pollution. Addressing environmental inequity through ESB investments will require intentional decisions to ensure that overburdened communities receive a fair share of ESBs. Otherwise, resources will almost certainly go

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259 NYC Clean School Bus Coalition, School Depot Map, accessed March 2022. The NYC Clean School Bus Coalition is led by the New York League of Conservation voters; JMA is a member of this coalition.


262 Local governments, school districts, and private fleet operators should prioritize equitable school bus depot distribution as well.
where they always go: to wealthier, primarily white
neighborhoods.

The reason for this is that richer neighborhoods
have richer schools with greater staff and financial
resources—both of which are helpful for paying for
and managing the transition to ESBs. Currently,
electric buses are expensive, complicated to
install, and often difficult to procure. New ESB
deployments require close attention and careful
collaboration between dealers/OEMs, utilities,
funders, and fleet operators. In order to deploy
ESBs, a district must have experienced staff
who can pursue funding, coordinate with utilities,
navigate new procurement challenges, and
ensure proper training for drivers and mechanics.
Even more crucially, a district must have a strong
and stable capital budget for transportation to take
advantage of many of the existing ESB subsidies.
Many districts cannot even afford to replace their
aging diesel buses with new ones, and therefore
cannot afford to buy an electric bus even with a
relatively generous subsidy. Unfortunately, such
districts are in the greatest need of replacing their
buses in the first place.

One way to help address this problem is to
provide more generous subsidies. The California
Energy Commission’s approach in its School Bus
Replacement Program was to pay for the entire
cost of a new bus and charging infrastructure for all
applicants. Although covering the full cost of bus
replacements was not cheap, it made the program
much more accessible to districts. Subsidies may
not need to cover the entire cost of the bus. But to
ensure equity, agencies should award adequate
funding to districts with fewer resources. Over the
next couple years, this will mean subsidizing more
than the incremental cost of an electric bus.

Additionally, school bus funding rules can require
that environmental justice communities receive
a greater-than-proportional number of buses.
Ensuring that impacted communities receive
dedicated funding could be a good small step
towards addressing decades of environmental
exploitation in low-income communities and
communities of color.

**MINIMIZING COST**

A federal funding program for ESBs can accelerate
electrification not only through direct subsidies, but
by significantly lowering the price of ESBs in the
market through scale. However, price reductions
could take much longer to realize than necessary,
resulting in wasted public funds and a delayed
transition. Designing the program thoughtfully
can help ensure that costs drop as much as they
should. Best value competition and transparency
at all levels can help bring down prices across the
market, while ensuring vehicle quality, training,
and the creation of good jobs.

California’s experience with ESBs suggests
two powerful tools the government can use to
promote lower prices. The Energy Commission’s
solicitation for the School Bus Replacement
Program in 2018 resulted in lower prices than
the state had previously seen. The program also
required manufacturers to provide information
about the quality of jobs at their factories, which
could be enhanced in future solicitations by
requiring explicit OEM commitments on wages,
benefits, and hiring practices.

Another price reduction strategy could be
to perform careful studies to determine the
appropriate subsidy level for school buses, as
the California Air Resources Board did for its
Hybrid and Zero-Emission Truck and Bus Voucher
Incentive Project (HVIP) program. As discussed
in Part I, the agency solicited detailed information
from each manufacturer, including the cost of
each component, and made a determination
based on all of the information at its disposal.
All buses of the same weight class generally
received the same subsidy in order to avoid giving
an advantage to any manufacturer or creating an
incentive to price buses higher.

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263 Alana Samuels, "Good School, Rich School; Bad School,

264 CEC “Establish Bulk Purchase Pricing for Electric School Buses,”

265 Patrick Chen (air pollution specialist at CARB), conversation with
author, June 28, 2021.
In the case of HVIP, restricting subsidy levels does not appear to have lowered school bus prices. Instead, the restriction may have resulted in fewer school buses being funded, and made it difficult for districts to afford ESBs without securing additional state or federal sources of funding. To result in lower prices, such a program could either set price limits for eligible vehicles or prohibit the use of additional funding sources. This approach is not without risks: districts or OEMs may choose not to participate. Large, market-shaping programs may therefore have more success at limiting prices. As with solicitations, price or subsidy restrictions should factor in the quality of jobs in order to avoid giving an advantage to the OEMs that pay the lowest wages.

CREATING GOOD JOBS AND STRENGTHENING THE SCHOOL BUS WORKFORCE

The benefit of funding programs as large as the federal Clean School Bus Program and the bills under consideration in Colorado, California, and elsewhere is that they have the potential to catalyze a rapid transformation of the national school bus market. While the environmental implications of such a transformation are extremely promising, such a change would also have significant impacts on workers, many of which were discussed in the previous section.

Accounting for and addressing these impacts, while also developing policies to raise employment standards across the school bus industry, will help ensure that the public gets the maximum possible benefit from the proposed nationwide deployment of ESBs. The sections that follow explore such policies.

Training and job protection for school bus operations and maintenance

Electric school buses do not have the same maintenance requirements as traditional diesel or other internal combustion engine buses, a change that threatens the job stability of incumbent school bus operations employees, especially mechanics. When technological change occurs, it is often workers that bear the most negative immediate consequences. However, with the right provisions, ESB funding programs can ensure positive outcomes for school bus drivers, attendants, and mechanics.

One of the largest threats for all three categories of employees is outsourcing. Electrification doesn’t necessarily encourage outsourcing, but some school districts may consider outsourcing as a way to electrify without having to deal with the complexities of charging infrastructure and electricity pricing. At the same time, districts sometimes use outsourcing as a way to cut costs or to attempt to weaken the unions that protect public school bus employees.

Many school districts have contracted with fleet operators for decades, and many of those private operators are unionized and offer high-quality jobs. There are both advantages and disadvantages to contracting out school bus operations. However, if electrification is used as a reason for switching to private contractors, it will only increase the negative disruption on school bus workers’ livelihoods. For that reason, government funding programs should avoid subsidies that have the effect of incentivizing outsourcing student transportation.

For school districts looking for assistance in dealing with the complexities of fleet electrification, there are several options that avoid outsourcing. First, many school bus OEMs offer assistance to school districts that wish to electrify, through technical support with grant applications and electrical infrastructure installation. Second, many utilities provide technical and financial help with electrical infrastructure. Such help is often funded by make-ready programs, in which regulators allow investor-owned utilities to include transportation electrification costs as part of their rate base. Finally, there is a burgeoning industry in the provision of charging services.

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267 Sean Hadley (associate director of government affairs at New Jersey Education Association), conversation with author, July 6, 2021.
Instead of contracting out the district’s entire transportation department, schools can hire a company to manage bus charging, the most novel and challenging aspect of ESB deployment.

To help ensure that schools have access to the technical expertise they need to manage the transition to ESBs, funding programs can include extra resources to recipients to help pay for assistance, or empower agencies to create trainings and materials to help all school districts navigate the transition.

A major concern is the risk of mechanic layoffs due to an expected decrease in total maintenance and repair work hours. Although it is impossible to draw definitive conclusions from the relatively small number of ESB deployments so far, the consensus among the school transportation officials interviewed for this report has been that even if their district started purchasing only electric buses, any reduction in work hours would happen more slowly than the expected retirement of school bus mechanics. Some officials expect that work hours would not meaningfully decrease at all, or not until the technology becomes dominant and commonplace.

First and foremost, any funding program should discourage recipients from laying off or transferring workers as part of the ESB transition. When such rules aren’t feasible, an alternative policy is to require funding applicants to submit workforce impact assessments, in which the district evaluates the likely impacts on their workforce, identifies training needs, and makes a plan to retain and upskill their employees.

Training for school bus operations and maintenance. Training is another crucial component of any electric school bus deployment plan. All school bus staff should receive basic training in how the new technology works and differs from older technology. Drivers should additionally learn how to drive the buses safely and efficiently, and in many cases must also learn some basic charging and maintenance skills because drivers often perform such tasks. First responders, especially firefighters, should also learn how to identify electric buses and safely conduct rescue and firefighting operations on them.

Electric school bus training is most intensive for mechanics. In order to even perform basic maintenance operations, mechanics must learn what parts of the bus they can safely work on, and how. However, school bus fleet operators will benefit from providing more extensive training so that mechanics can learn to safely work with high voltages and perform electronic diagnostics. Training will provide major operational benefits to fleet operators. When mechanics have the necessary skills, they can maintain and repair vehicles quickly without sending buses away to a third-party location, which may be across the country, meaning better uptime and less time being serviced.268

There are examples of legislative proposals that have incorporated provisions to address many of these issues for school bus operations and maintenance employees. The federal Clean Commute for Kids Act of 2021, as introduced, included restrictions on layoffs and outsourcing, and would require fleet operators to provide training for their employees. The IIJA’s Clean School Bus Program (CSBP) provides the EPA broad authority to create regulations to administer the program successfully, and the executive order on IIJA implementation requires agencies to ensure that the legislation “improves job opportunities.”269 EPA could respond to that mandate by (1) requiring districts to submit a workforce impact assessment, and (2) requiring school bus procurements to include a provision that the dealer or OEM fully train the district’s workforce to operate and maintain the vehicles.

Training for electricians installing EVSE
Transitioning to electric student transportation will require the investment of billions of dollars, and has the potential to create thousands of jobs. To help ensure the proper installation of school

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268 Joseph Welborn, conversation with author, July 1, 2021.
269 “Executive Order 14052 of November 15, 2021.”
bus EVSE, protect the safety of electricians and school bus operations workers, and maintain high training standards in electrical contracting. Funding agencies and fleet operators can require that charging equipment installations include the participation of journeyworker electricians certified by the Electric Vehicle Infrastructure Training Program (EVITP).

School bus electrification is also an opportunity to create good jobs for those who need them most. Whenever possible, funding agencies and large purchasers should explore the use of incentives or requirements for contractors to proactively hire, train, and retain disadvantaged workers, including through inclusive recruitment and hiring practices and the use of pre-apprenticeship and registered apprenticeship programs.

Creating good jobs throughout the ESB supply chain

As discussed in Part III of this report, the transition to battery electric vehicles will have a major impact on U.S. manufacturing. Without well-designed policies in place, the transition could lead to widespread job losses, lower wages, more dangerous working conditions, and supply chain vulnerabilities. On the other hand, a sound industrial policy could help create a robust, high-road domestic EV supply chain, creating long-lasting careers with opportunities for advancement for people of all backgrounds.

One powerful congressional approach to the issue would be to include explicit preferences for union-built vehicles made in the U.S. in legislation to fund ESBs. In 2021, the proposed Build Back Better Act included higher tax credits for union-built electric cars, and eventually would have applied only to domestically made models. This preference would have helped speed the EV transition while avoiding a race to the bottom in manufacturing with large-scale offshoring, job losses, and falling wages. Only the U.S. Congress can approve union preferences, however, due to federal preemption case law.273

U.S. Jobs Plans for school buses to create good jobs. Another approach that has proven successful even without a union preference is the U.S. Jobs Plan (USJP).271 A USJP is a plan submitted by manufacturers as part of a bid or application process. It includes enforceable commitments of the number of jobs created to produce vehicles along with their promises on wages, benefits, hiring, and training. Agencies score the plans and incorporate these scores into their evaluation of an OEM’s bid. Companies with strong commitments to create jobs with good pay and benefits, hire inclusively, and provide job training receive a higher score and improve their chances of selection.272 Several of the nation’s largest transit agencies, including the New York Metropolitan Transportation Authority (MTA), Los Angeles Metro, the Chicago Transportation Authority, and Amtrak have used the USJP to promote good jobs and inclusive hiring in the production of transit buses and trains.

U.S. Jobs Plans have been included in transit agency procurements valued at billions of dollars, and have been effective at encouraging OEMs to adopt or continue responsible practices. School bus procurements are typically much smaller, but even so, the policy could be adapted for electric school buses in a number of ways, for example:

1. State or federal agencies that provide ESB subsidies could encourage or require manufacturers to provide USJPs in order to be eligible for funding, or can provide higher incentive levels for vehicles that create better jobs and do a better job of hiring, training, and retaining disadvantaged workers.

For programs that use only state or local


271 Also known as the U.S. Employment Plan or USEP.

272 The USJP was developed by experts at Jobs to Move America, the Brookings Institution, the University of Southern California’s Program for Environmental and Regional Equity, and the Political Economy Research Institute, and was approved by the U.S. Department of Transportation for use by transit agencies. For a discussion of how the USJP has been used to promote good jobs in transit bus and train manufacturing see Jobs to Move America’s report on battery electric transit buses, Transforming Transit, Realizing Opportunity by Christy Veeder, July 2019.
funding, it may be possible to also include a geographic preference.

2. States could incorporate USJPs into their process for awarding statewide bulk purchasing contracts.

Depending on state procurement law, fleet operators and school districts could include USJPs as part of a best value procurement process for school buses. This option may be most effective and practical for larger school districts and operators, and could use simplified forms and procedures tailored for smaller procurements.

Other USJP configurations may exist, depending on the specific details of different federal and state funding programs and procurement policies.

In the case of school bus electrification, the USJP can be designed to accomplish three critical goals at the same time. First, as suggested above, the USJP can encourage manufacturers to pay their employees well and provide strong benefits. Second, it can encourage companies to recruit employees from communities that have been traditionally underrepresented in good manufacturing jobs, including returning citizens and women.

Third, the USJP can be used to supplement Buy America, or in place of it when Buy America doesn’t apply. Buy America is a policy under which federal agencies require state and local entities to purchase equipment and materials from domestic sources when spending federal grant dollars. Ideally, Buy America would apply to federally funded school bus purchases, but it is unclear whether this will be the case.

**Retooling and retraining.** Even if investments in ESBs result in the creation of new jobs along the medium- and heavy-duty EV supply chain, it does not guarantee that incumbent workers will be able to enjoy those opportunities. New jobs may require new skills or be located in different states or regions of the country. In the best-case scenario, suppliers will be able to retool their factories and retain their workers so that they can continue in their careers without having to uproot their families and move across the country. Agencies using USJPs can include incentives for OEMs and suppliers to retool their facilities and retrain their employees. More broadly, the federal government can provide funding and incentives to help manufacturers in all sectors to upgrade in place, while securing commitments from companies to train and retain their employees, maintain job quality, and respect the right of workers to organize.273 Such incentives will help ensure that as industries evolve, they don’t leave workers and their families behind, but instead provide an ongoing source of prosperity for families and communities.

**MINERAL SOURCING AND RECYCLING**

Although electrification has the potential to greatly reduce the harmful climate and air quality impacts of vehicles, sourcing the raw materials needed for EV batteries poses unique environmental and social challenges. Lithium and cobalt extraction in particular have harmed communities around the world, though other materials such as copper, nickel, and graphite also have well-documented harmful impacts. With the right policies, these impacts can be mitigated—and they must be, if the electrification of transportation is to truly benefit all people.

At least half of the world’s cobalt is extracted in the Democratic Republic of Congo (DCR). In 2016, Amnesty International reported that up to 40,000 children were working in “artisanal” cobalt mines in Southern Katanga, and that miners faced potential fatal exposure to cobalt dust, tunnel collapses, extremely long hours, and often earned $1-2 a day.274 Cobalt mines can also have severe environmental impacts such as acid mine drainage, which can pollute surface water.275 Amnesty International also found that

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273 UAW Research Department, *Taking the High Road.*
274 *This is What We Die For*: Human Rights Abuses in the Democratic Republic of the Congo Power the Global Trade in Cobalt (London: Amnesty International, 2016).
major consumer electronics and electric vehicle manufacturers had failed to exercise due diligence in sourcing cobalt. Since the release of that report, DRC’s government has promised to eliminate child labor from cobalt mines and many manufacturers have committed to eliminating artisanally mined cobalt from their supply chain or phasing out the use of cobalt altogether. However, it will require continued attention and activism to ensure that cobalt suppliers cease committing human rights abuses.276

Lithium, a critical ingredient in today’s EV batteries, also poses major challenges. There are two main forms of lithium mining: brine and rock extraction. Brine extraction is predominant in Chile, Bolivia, and Argentina—which together are home to over half of the world’s identified lithium resources—and has enormous water requirements, despite occurring in arid regions, causing serious disruption to indigenous people in the Andes who rely on agriculture and livestock for survival.277 American Indian tribes are currently fighting a similar project proposed in Nevada.278 Lithium rock mining can also release harmful air pollutants into the environment and damage miners’ lungs.279

There are several strategies which, taken together, can help minimize damage and ensure the long-term sustainability of lithium battery production. These strategies include the well-known maxim, “reduce, reuse, and recycle,” in addition to a critical fourth component: responsible procurement and better mining laws.

While it would be counterproductive, environmentally and socially, to reduce the number of school buses in use, the need for mineral mining can be reduced through innovations in battery design and chemistry.280 Batteries can also be reused in secondary applications once they can no longer power a school bus, adding several years of useful life to the battery. For example, retired EV batteries could potentially provide large amounts of grid-connected energy storage.281

Eventually, all viable uses of a battery will be exhausted, and it will be necessary to fully retire the battery. Fortunately, it appears that it will be possible to recycle a large portion of the critical minerals from used EV batteries. According to the Institute for Sustainable Futures, it is technologically possible to recover at least 90 percent of a battery’s lithium, cobalt, nickel, and copper.282 The Union of Concerned Scientists has estimated that by as soon as 2035, the U.S. could potentially meet between 30 and 40 percent of the domestic demand for battery metals with recycled materials.283 Even more promising, scientists and engineers are rapidly developing more efficient, cost-effective, and environmentally friendly methods of extracting metals from used batteries.284

Developing a domestic battery cell manufacturing industry would likely increase the economic viability of battery recycling in the United States.285 The reverse is also true. Since both domestic recycling and domestic battery cell manufacturing would provide significant economic and environmental benefits, and since it will be more challenging for one to develop without the other, fomenting both sectors domestically is a fruitful opportunity to implement a comprehensive

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277 Bárbara Jerez Henríquez, Impacto socioambiental de la extracción de litio en las cuencas de los salares altoandinos del Cono Sur (Santiago de Chile: Observatorio de Conflictos Mineros de América Latina, 2018).
279 Rachid Amui, Commodities at a Glance.
280 U.S. Department of Energy, Vehicle Technologies Office’s Research

Industrial policy. The Biden Administration has identified a robust domestic battery supply chain as an environmental and economic priority. Any policy prioritizing a robust domestic battery supply chain should include basic research and development subsidies to improve recycling technology and infrastructure, combined with incentives or mandates on recycling, percent recycled content, chemical content labeling for batteries, and designing batteries for easy recycling.

Electric vehicle manufacturing will require extensive mineral mining over the next few decades because there are not yet enough EV batteries deployed to support a circular supply chain, in which repurposed and new batteries are mostly fabricated from the materials of depleted ones. In the U.S., mining laws provide few environmental controls and are notoriously deficient in protecting the environment. Nor do they include meaningful provisions to protect impacted communities. Reforming our mining standards, with greater protections for Department of Interior-managed ventures, would help ensure more responsible mineral recovery. For imported metals, consumers and policymakers can also insist that manufacturers only purchase responsibly mined or recycled minerals. To identify and monitor responsible minerals, there are now widely recognized certifications to measure adherence to sound labor, environmental, and community practices, most prominently those developed by the Initiative for Responsible Mining Assurance (IRMA).

The federal government, states, and school districts can all help to ensure that the batteries used in ESBs create high-quality jobs while minimizing negative social and environmental impacts. Through legislation, the federal government can require safe, environmentally and socially responsible mining practices in the U.S. Entities purchasing or funding ESBs can insist that batteries being used in their buses are (1) manufactured by workers with high-quality jobs and (2) include responsibly-sourced minerals from materials recycled in factories with strong labor, safety, and environmental standards, or mines receiving the highest levels of IRMA certification.

### FAIR AND EQUITABLE ACCESS TO STUDENT TRANSPORTATION

Many students in the U.S. do not have access to school transportation at all. Lack of access to a free, safe ride to school may have significant equity and environmental impacts. Taking the bus has been associated with fewer absences and lower likelihood of chronic absenteeism among kindergarteners. And national transportation statistics suggest that school buses are by far the safest way to get to school. Low-income families are much more likely to not own a car, or may have fewer cars than they need to manage family logistics. Parents in these families may be more likely to have work schedules which make it difficult for them to bring their children to school, even if they do have access to a car. Nationwide, 60 percent of students in low-income families take a bus, versus 45 percent of students from non low-income families.

The federal government only requires states or districts to provide transportation to homeless

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292 For example, in 2001, families earning under $25,000 per year were nine times as likely as other families to not have a car. U.S. Depart-ment of Transportation, “Household, Individual, and Vehicle Character-istics,” Bureau of Transportation Statistics, December 21, 2011.


Driving the Future: How to Electrify our School Buses and Center Kids, Communities, and Workers in the Transition

students and students with disabilities. While some states require districts to provide rides based on age and distance from the school, in many cases these programs ignore large swaths of the student population. In California, for example, districts do not need to provide student transportation at all beyond federal requirements. The Los Angeles Unified School district transports about 28,000 students each day, representing less than 5 percent of its students, compared to over half of students who ride the bus nationally. Statewide, only 12 percent of students ride school buses, while over half travel to school in private cars.

Further research is needed to fully understand the intersection of student transportation access and school bus electrification. However, whenever possible, states should consider how they can expand and improve transportation access for kids while also investing in a clean school bus fleet.

Global market for used school buses

Policymakers and environmental advocates have expressed interest and concern over the fate of old school buses when they are retired. In order to maximize the environmental impact of school bus electrification, several U.S. funding programs require the immediate destruction of diesel engines (e.g. DERA and the VW Fund). However, it is possible that in some cases, districts may dispose of buses that, despite being used, are more environmentally friendly than currently existing alternatives for users without access to ESBs. Additional research is needed to fully understand the market and policy implications for used school buses.

The school districts interviewed for this report mentioned a variety of methods of disposing of old buses: having the buses auctioned off, recycling buses, or trading them in at the dealer. Among districts that had their buses auctioned off, transportation directors were not able to provide extensive information about where buses ended up, but believed they were mostly purchased by non-school users such as churches or community groups, or else were sent to be used for public transportation in Latin America.

The United Nations Environment Programme released a report in October 2020 on the global trade in used light duty vehicles, which found that many lower-income countries had few or no regulations on the quality or safety of imported used vehicles, but also that in some cases, imported used vehicles had higher environmental standards than domestically manufactured new vehicles. The report recommends developing global or regional regulations on imported and domestic vehicles alike, and that both exporting and importing countries take responsibility to improve the quality of globally traded used vehicles. The program is currently researching the global trade in used heavy duty vehicles including school buses.

SUMMARY OF RECOMMENDATIONS

Based on the above discussion, this report recommends the use of state and federal subsidies as a central strategy to accelerate the transition to electric school buses. The federal government has committed billions of dollars to the ESB transition, and some states, especially California, have committed significant additional sums. Further investment is likely warranted. All government subsidies, current and future, for electric school buses should adhere to the following principles:

1. **Promote environmental justice**
   Prioritize funding for disadvantaged communities. The transition to electric school buses provides an opportunity for state and federal agencies to reduce the severe racial and economic inequality that exists in the

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294 These requirements are based on the Individuals with Disabilities Education Act and the McKinney-Vento Education of Homeless Children and Youth Assistance Act. For a background on these regulations, see Phillip Burgoyne-Allen and Jennifer O’Neal Schiess, *Miles to Go: Bringing School Transportation into the 21st Century* (Boston: Bellwether Education Partners, 2017).

295 Burgoyne-Allen, *Miles to Go*.


geographic distribution of air pollution sources such as school bus depots. Funding programs should create explicit, well-defined, and accountable preferences for disadvantaged communities.

Fleets serving disadvantaged communities should not only be first in line, but they should also receive deeper subsidies. Over the next several years, this will mean awarding subsidies greater than the incremental cost between diesel and electric, at a minimum, plus infrastructure costs and technical assistance. Agencies should engage communities directly to ensure that funding programs are meeting their needs.

2. **Promote good jobs for school bus drivers, attendants, and operators**

**Workforce impact assessments.** Funding applications should include workforce impact assessments, in which fleet operators evaluate the expected impact of ESBs on school bus drivers, attendants, and technicians, and provide their plan to ensure that workers retain their positions, receive the training they need, and maintain wage and benefit levels.

**Procure for training.** When purchasing ESBs, a best practice is to require the OEM or dealer to thoroughly train drivers and mechanics in the skills they need to continue operating, maintaining, and repairing school buses. Government subsidies for ESBs should also provide funds for employee training.

3. **Promote good jobs for manufacturing workers in the school bus supply chain**

**Incorporate the U.S. Jobs Plan (USJP) in funding streams and solicitations.** ESB funding programs should promote the development of a high-road ESB supply chain. One of the best ways to do this is through the U.S. Jobs Plan. With a USJP, manufacturers make enforceable commitments on the creation of good jobs and the use of equitable hiring and training practices.

Depending on the design of the program, the USJP can be used to provide greater subsidies for vehicles that create better jobs and hire more inclusively, establish job quality criteria for program eligibility, or as a factor in statewide or local purchasing solicitations.

**Adopt Buy America provisions, where possible.** While the USJP includes incentives for domestic manufacturing, Buy America has additional requirements that can help ensure that public investments in ESB technology support the development of a domestic supply chain for ESBs.

4. **Ensure safe and proper installation of charging infrastructure**

**Require the participation of electricians trained using the Electric Vehicle Infrastructure Training Program (EVITP).** ESB funding programs that subsidize electrical infrastructure installation should require that EVITP-trained journeyworker electricians participate in the installation. Requiring EVITP will help guarantee safety, high training standards, and proper installation of school bus EVSE.

**Require prevailing wages.** Whenever possible, funding agencies, school districts, and fleet operators should require the payment of prevailing wages when they procure electrical contracting services to install school bus charging equipment.

5. **Promote equitable employment practices**

**Incorporate the USJP for school bus investments.** For manufacturing workplaces, the USJP includes incentives for OEMs and suppliers to develop concrete, enforceable plans to recruit, hire, train, and promote inclusively, ensuring the equitable participation of workers from disadvantaged communities. A simplified version of the USJP could also be adapted for the procurement of electrical contracting services, giving priority to contractors that create good jobs and hire and promote inclusively.
Encourage the use of inclusive and well-designed apprenticeship and pre-apprenticeship programs. Agencies can support and promote the use of apprenticeship and pre-apprenticeship programs that equitably recruit workers from underrepresented communities, workers with barriers to employment, or workers displaced by COVID-19 or from the transition to clean energy and zero-emissions transportation, providing workers a chance to learn on the job.

6. **Promote recycling and responsible mining**

Although electrification has the potential to greatly reduce the harmful climate and air quality impacts of vehicles, sourcing the raw materials needed for EV batteries poses unique environmental and social challenges. ESB funding programs should investigate the use of incentives for school bus manufacturers and their suppliers to recycle their vehicles at end of life and use recycled or responsibly mined materials. Funding programs and procurements can also include best practices such as labeling batteries with their chemical components.

7. **Facilitate ESB adoption and technology improvements though data collection, information sharing, and transparency**

Agencies should take the opportunity to facilitate collective learning between districts, school bus fleet operators, OEMs, dealers, government, and the public. By collecting and publicly sharing data on government-funded ESB deployments, agencies can help develop best practices for dealers and fleets, ensure transparency, and promote the technology improvements.

8. **Incentivize lower school bus prices**

Use statewide centralized procurements to encourage competition. Conduct statewide best-value procurements to determine which buses will be eligible for subsidies. Agencies can evaluate bidders on cost, quality, and service, while also including criteria on environmental impact and the creation of good jobs. The USJP is a valuable tool for such procurements. In order to provide flexibility for school districts while still creating a strong incentive to compete, agencies may consider making two or three awards in each category of school bus.

9. **Invest in electrical infrastructure**

Agencies should work with utilities and regulators to actively plan the transition to ESBs. School bus lots across the country will need major power upgrades.

In order to serve students on longer field trips, ESBs will need access to high-power public charging stations. Therefore, governments should help ensure the development of a robust network of public charging stations across the nation, including high-power charging stations with at least 50 kW, or preferably higher, so that buses can recharge quickly on the road.
alternating current (AC). A flow of electricity which rapidly changes direction—120 times per second in the U.S. grid, or a frequency of 60 Hertz. Most electricity in the U.S. is generated, transmitted, distributed, and used in AC in large part because it is easy to change the voltage of AC electricity. When electricity is generated, power companies vastly increase the voltage of the power using transformers up to 138-765 kV, allowing much more efficient transmission. Transformers are then used to step down the voltage of electricity as low as 120 or 240 V for home customers.

amp (A). See volt.

behind the meter. Refers to power use, generation, or infrastructure on the customer’s side of the electric meter. The electric meter is what measures the flow of power from the grid to the customer in order to determine pricing.

chassis. The load-bearing frame of a school bus. Some, but not all, school bus OEMs manufacture their own chassis.

conduit. Tubes that contain electrical wires; the tube is used to protect the wire.

direct current (DC). A flow of electricity in one direction. Batteries, including school bus batteries, create current by allowing electric charge to flow from one half-cell to another as part of a chemical reaction, resulting in a unidirectional current.

direct current fast charging (DCFC). See electric vehicle supply equipment.

distribution, of electricity. See transmission.

electrical panel. Device that distributes the customer’s power from the grid to all of the customer’s power circuits.

electric vehicle supply equipment (EVSE). Charging equipment which controls the supply of electricity to charge an EV. Level 2 chargers supply AC power to the bus which an onboard rectifier converts into direct current, and typically have a maximum power of 19.2 kW. Level 3 chargers or DC fast chargers (DCFC) include the rectifier inside the EVSE, commonly delivering power at 50 kW or 60 kW or higher and charging the bus 2-3 times as quickly.

energy, electric. Electric energy is measured in kilowatt-hours (kWh), and refers to the total work over time that could be done by that electricity (analogous to gallons of gas in a car). A 60 W light bulb will consume 60 watt-hours (Wh) of energy in one hour, or 0.06 kWh. A typical Type C ESB battery system can have a capacity around 155 kWh, which is enough energy to light a 60 W bulb for 2,583 hours.

high-road. Refers to employment strategies in which “employees and the skills that they possess are viewed as an integral part of a business’s competitive advantage”; compared to low-road strategies, in which “labor is considered a commodity and workers are seen as a cost to be minimized.”

inverter. Device that converts DC power to AC power. Rectifiers do the opposite, converting AC power to DC power.

investor-owned utility (IOU). See transmission.

kilowatt-hour (kWh). See energy.

level 2 / level 3 charging. See electric vehicle supply equipment.

managed charging. Technology that automates the process of EV charging while controlling the time and power of charging to minimize costs. Some refer to this as smart charging; others make a distinction between the two.

municipal utility (muni). See transmission.

original equipment manufacturer (OEM). In automotive manufacturing, the OEM is the company that performs final assembly of a vehicle. In school bus manufacturing, OEMs also typically produce the body.

city and the surrounding area. A public company that provides student transportation services, typically contracted by a school district, joint power authority, or other public body responsible for providing K-12 student transportation. Student transportation services typically include management of the fleet, operation and maintenance of the buses, and provision of support services. Private fleet operators often own the buses, but not always.

rate base. See transmission.

rectifier. See inverter.

school district. Used broadly in this report to refer to local governmental authorities responsible for administering K-12 educational programs; can include school districts, joint power authorities, states, or other entities.

total cost of ownership (TOC). The purchase price plus the costs of operating a vehicle over its lifetime, which typically includes the present value of the cost of fueling, maintaining, insuring and repairing the vehicle. TOC gives a more accurate accounting of the lifetime costs of owning a vehicle, and is useful for deciding between vehicle technologies. Present value discounts future savings to account for the time value of money or the costs of borrowing. TOC calculations include any subsidies received, may or may not include the cost of fueling infrastructure, and typically do not include the cost of driving the vehicle, which doesn’t significantly vary between school bus fuel types.

transmission. Long-distance transportation of electrical power from the site of generation. Distribution is the delivery of power from transmission facilities to consumers. Together, transmission and distribution networks make up the grid. See Figure 24 for a basic model of the electric grid. Most electricity used in the United States is distributed by for-profit companies known as investor-owned utilities (IOU), though there are some publicly owned municipal utilities. Most states have public utility commissions which set rules for IOUs as regulated monopolies. Electric rates for IOUs are established in public proceedings called rate cases, and published in documents known as tariffs. IOUs are permitted to earn a certain percent profit according to the value of their approved electrical infrastructure; the value of such approved property is the rate base. Depending on state regulations, IOUs may, or may not, be permitted to own generation facilities.

uptime. The percentage of time a fleet vehicle is available for service; downtime is the percentage of time vehicles are unavailable for use because of being in the shop for repair or maintenance.

vehicle grid integration (VGI) refers to technology which allows the utility or grid operator to communicate with grid-connected devices, such as ESBs. Grid-integrated devices use software to determine how to respond to grid signals. For example, in demand response programs, utilities could send instructions to devices that if they reduce their usage during a certain period of heavy usage, they can earn or save money. The ability of devices to automatically control charging times is known as V1G. When devices can also discharge electricity to the grid, it is known as vehicle-to-grid (V2G).


vehicle-to-grid (V2G) refers to technology which allows communication between the grid and a
connected device, such as an ESB, where devices have both the ability to automatically control their charging behavior and to discharge power back to the grid. V2G allows electrical storage devices, including vehicle batteries, to serve as grid storage, which can help even out peaks and valleys in grid electricity usage. Alternatively, devices can connect with building power systems to offset building electrical usage, which is known as vehicle-to-building (V2B).

**volt (V).** Volts and **amps** are less commonly used when discussing ESBs. Volts measure electromotive force (analogous to water pressure in a pipe) and amps measure current, which is the quantity of moving charge (analogous to the amount of water flowing through a pipe per second). Power (in watts) is the product of volts and amps. Keeping with the water analogy, the power of a shower depends both on the quantity of water coming through the pipe per second and the pressure that water is under. A standard household outlet in the U.S. provides 15 amps of alternating current at 120 volts. A Blue Bird electric Type C battery runs at a nominal voltage of 620 volts and maximum power of 232 kW, which would imply a maximum current of 351 amps.391

**watt.** See **power.**

# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AC</td>
<td>alternating current</td>
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<tr>
<td>BLS</td>
<td>Bureau of Labor Statistics</td>
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<tr>
<td>CAISO</td>
<td>California Independent System Operator</td>
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<td>CARB</td>
<td>California Air Resources Board</td>
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<tr>
<td>CDL</td>
<td>commercial driver’s license</td>
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<td>CEC</td>
<td>California Energy Commission</td>
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<td>CPUC</td>
<td>California Public Utilities Commission</td>
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<td>CSBP</td>
<td>Clean School Bus Program</td>
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<td>DC</td>
<td>direct current</td>
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<tr>
<td>DCFC</td>
<td>direct current fast charging</td>
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<tr>
<td>DERA</td>
<td>Diesel Emissions Reduction Act</td>
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<tr>
<td>EPA</td>
<td>U.S. Environmental Protection Agency</td>
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<tr>
<td>ESB</td>
<td>electric school bus</td>
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<td>EV</td>
<td>electric vehicle</td>
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<td>EVITP</td>
<td>Electric Vehicle Infrastructure Training Program</td>
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<td>EVSE</td>
<td>electric vehicle supply equipment</td>
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<tr>
<td>HVIP</td>
<td>Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project</td>
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<td>IBEW</td>
<td>International Brotherhood of Electrical Workers</td>
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<tr>
<td>ICE</td>
<td>internal combustion engine</td>
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<tr>
<td>IIJA</td>
<td>Infrastructure Investment and Jobs Act of 2021</td>
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<tr>
<td>IOU</td>
<td>investor-owned utility</td>
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<tr>
<td>IRMA</td>
<td>Initiative for Responsible Mining Assurance</td>
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<td>JMA</td>
<td>Jobs to Move America</td>
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<tr>
<td>kW</td>
<td>kilowatt</td>
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<tr>
<td>kWh</td>
<td>kilowatt-hour</td>
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<tr>
<td>MHDV</td>
<td>medium- and heavy-duty vehicle</td>
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<tr>
<td>NYISO</td>
<td>New York Independent System Operator</td>
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<tr>
<td>OEM</td>
<td>original equipment manufacturer</td>
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<tr>
<td>OGS</td>
<td>(New York) Office of General Services</td>
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<tr>
<td>TOC</td>
<td>total cost of ownership</td>
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<tr>
<td>TOU</td>
<td>time of use</td>
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<tr>
<td>UAW</td>
<td>United Auto Workers</td>
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<tr>
<td>USJP</td>
<td>U.S. Jobs Plan</td>
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<tr>
<td>V2B</td>
<td>vehicle-to-building</td>
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<tr>
<td>V2G</td>
<td>vehicle-to-grid</td>
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<tr>
<td>VGI</td>
<td>vehicle-grid-integration</td>
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<tr>
<td>ZEV</td>
<td>zero-emission vehicle</td>
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Jobs to Move America is a strategic policy center that works to transform public spending and corporate behavior using a comprehensive approach that is rooted in racial and economic justice and community organizing. We seek to advance a fair and prosperous economy with good jobs and healthier communities for all. Learn more and join our mailing list at jobstomoveamerica.org.