ACCELERATING ELECTRIC SCHOOL BUS ADOPTION GRID RELIABILITY AND COMMUNITY RESILIENCE

Final Report

On Behalf of Advanced Energy Economy

April 20, 2022

ADVANCED ENERGY ECONOMY

1010 Vermont Ave. NW, Suite 1050, Washington, D.C. 20005
aee.net | powersuite.aee.net | @aeenet

ACKNOWLEDGEMENTS

Supervision and Coordination

Pearl Gray, MPA

Leadership Team

Anika Becker (Manager)

Elise Birde (Deputy Manager)

Editors

Alexa Lorillard

Jordan Shenhar

Contributors

Anna Mahowald

Dengruo Wang

Hadja Fatoumata Doumbouya

Ilina Hristova

John Bivins

Julia Saffer-D'Anna

Ranganath Srinivasan

Yaritza Anguiano

EXECUTIVE SUMMARY

Advanced Energy Economy (AEE)'s mission is to transform public policy to enable rapid growth of advanced energy businesses through education, engagement, and advocacy in over a dozen states. In order to promote this mission, AEE is interested in determining the feasibility of accelerating electric school bus adoption in fast-growing Sun Belt states to help combat the effects of climate change through advancements in renewable energy and community resilience.

This report was prepared by a team of 13 graduate students from Columbia University's School of International and Public Affairs in support of AEE's ongoing work toward accelerating the adoption of electric school buses in Arizona, Florida, and Texas. The report discusses the current landscape surrounding energy markets in these states, analyzes political considerations affecting electric school bus adoption in these three states, and provides recommendations for accelerating the transition to emissions-free school transportation fleets.

While each state, municipality, and school district is unique, this report identifies factors across each which indicate whether electric school bus adoption would be supported and how it should be implemented to best reduce any political, financial, or technological friction.

ii Image Source

TABLE OF CONTENTS

Acknowledgements i

Executive Summary ii

Introduction 1
- Fueling the Problem 1
- Powering Resilient Communities 2
- Why School Buses? 3
- Cost Differential Between Electric and Diesel Buses 3

Federal Policies & Incentives 5

State Policies & Incentives 7
- Arizona 8
- Florida 12
- Texas 15

Vehicle to Grid (v2g) 20
- Technology Overview 20
  - Role of Existing Infrastructure 23
  - Grid Islanding 23

Financing Electric School Buses 24
- Revenue and Partnership Opportunities 24
- Electric School Buses and the Texas Wholesale Energy Market 24
- Electric School Buses in Vertically Integrated Markets 27
- Third-Party Financing 27
- The Challenge of Cost-Benefit Analysis and Quantifying Resilience 28

Criteria for Implementation 29
- Policy Considerations 29
  - Steps for Accelerating Adoption 30
- Infrastructure and Grid Considerations 32
- Physical and Environmental Considerations 32
- School District Considerations 33

CONCLUSION 33

Appendix 35
- Success Stories 35

Table 1 – Key Considerations 39

Figures 1-3 – Electric School Bus Total Costs by State 41

INTRODUCTION

FUELING THE PROBLEM

School buses serve a critical social and economic function by offering families a safe, affordable, and reliable route to school. The school bus fleet across the United States is two-and-a-half times the size of the remaining mass transportation network combined and claims the largest ridership in the country. More than 24 million children travel on 454,000 school buses nationwide each year. As such, there is a significant opportunity to reduce carbon dioxide and other harmful emissions by transitioning school buses to electric alternatives. School buses keep over 17 million cars off the road every year, saving families 62 billion miles of driving and 26 billion gallons of fuel.[1] Switching the school bus fleet to electric alternatives will go further to address emissions in the hard-to-abate transportation sector, and provide ancillary benefits to local communities.

Currently, **95% of school buses in the U.S. run on diesel fuel.**[2] Diesel exhaust contains microscopic particles that penetrate deep into the lung, which can aggravate pre-existing respiratory conditions and have been linked to increased frequency of asthma attacks.[3] The exhaust from diesel fuel is contaminated with more than **40 toxic chemicals**, including benzene, arsenic, and formaldehyde.[4]

The California EPA's Office of Environmental Health Hazard Assessment (OEHHA) determined that long-term exposure to diesel exhaust is correlated with high incidence of cancer compared to other toxic air contaminants.[5] In addition to long-term health effects like cancer, diesel is also linked to short-term, immediate symptoms including irritated eyes, nose, throat and lungs, which can cause coughing, headaches, light-headedness and nausea.[6] Despite the known hazards of diesel exhaust exposure, diesel is one of the most widely used fuels in modern society. It is commonly used for trucking, agricultural equipment and to fuel back-up generators that provide electricity during emergency blackouts.[7]

School buses emit 3,000 tons of these cancer-causing soot particles into the air every year, and an additional 95,000 tons of smog-causing nitrogen oxide compounds per year. As a result, **the 24 million children riding diesel school buses are exposed to 5-15 times more air toxins than their peers** who do not ride school buses.[8] A report by the American Lung Association found that exposure to diesel

---

ii Hawkins, Celeste. "Montgomery CO Approves Nation's Largest Electric School Bus Procurement." *Proterra*, 11 June 2021,https://www.proterra.com/press-release/montgomery-county-approves-largest-electric-school-bus-order/.

1Day, James. "School Buses as the Largest Transit System in the US (recent stats)." *DMV List*, 3 March 2020,https://dmvlist.com/. Accessed 19 April 2022.

[2] "School Buses: Diesel Technology Forum." *Https://Www.dieselforum.org*, https://www.dieselforum.org/.

[3]Sydbom, A., et al. "Health Effects of Diesel Exhaust." *European Respiratory Journal*, vol. 17, no. 4, 2001, pp. 733-746. *ERS Publications*, https://erj.ersjournals.com/content/17/4/733.

[4] Sydbom,et al. "Health Effects of Diesel Exhaust."

[5] Sydbom,et al. "Health Effects of Diesel Exhaust."

[6] Sydbom,et al. "Health Effects of Diesel Exhaust."

[7] Sydbom,et al. "Health Effects of Diesel Exhaust."

[8] Lytle, Rosemary. "Electric School Bus." *Mothers out Front*, 8 April 2021, https://www.mothersoutfront.org/ Accessed 19 April 2022.

exhaust increased the frequency of childhood illness and reduced lung function in children.[9] This is likely because children's developing respiratory systems are more susceptible to fine particle damage than healthy adults. Exacerbating the issue, studies have shown that exhaust from bus tailpipes and engines concentrate inside the bus. [10]

POWERING RESILIENT COMMUNITIES

In addition to reducing exposure to diesel exhaust, EV alternatives provide additional community benefits during power outages. **Vehicle-to-grid (V2G)** enabled fleets can provide generation services in the event of a power outage.

In the U.S., **power outages increased ten-fold** between 1984 and 2012 due to the increased frequency and intensity of extreme weather events.[11] The causes which have led to this historic increase in power outages are both external and central to energy infrastructure. External causes, such as aging electric grids, climate change, and increased demand, are predicted to increase in the future. Central causes, like equipment failure and preventive shutoffs, will also likely increase as the challenges the grid faces from extreme weather events increase in both frequency and intensity. Over 25% of outages between 2000-2016 were caused by electromagnetic events and intentional cyber-physical attacks.[12] The electric grid is an integral part of modern life, which makes it vulnerable to disruption. These attacks present a substantial risk to the electricity grid, and could result in an outage that stretches for months across wide geographies, especially if timed after a natural disaster. Resilience is essential to mitigating against the worst effects of climate change and reducing the vulnerability of electric grids. Power outages can impact health outcomes for those with medical conditions, like asthma and Chronic Obstructive Pulmonary Disease (COPD), that require electricity-dependent medical equipment (DME) and are particularly vulnerable to the effects of power outages. Some of these can be avoided by increasing access to electricity in the event of an outage.

Besides the health impacts of power outages, there are also significant economic losses. NOAA's National Centers for Environmental Information reported that there were **20 climate disasters resulting in economic losses exceeding $1 billion in the U.S. in 2021**.[13] Extreme weather events take a toll on communities and lead to dire outcomes. As the frequency and intensity of these events increase, resilient infrastructure and systems is a crucial component of community development. Each power outage brings a host of economic, social and health challenges that vary depending on the frequency, duration, timing, and geographic range of the outage.

[9] Sydbom,et al. "Health Effects of Diesel Exhaust."
[10] "REDUCE SCHOOL BUS DIESEL POLLUTION TODAY." *Environmental Defense Fund*, https://www.edf.org/sites/default/files/8085_school_bus_brochure.pdf. Accessed 19 April 2022.
[11] Day, James. "School Buses as the Largest Transit System in the US (recent stats)." *DMV List*, 3 March 2020, https://dmvlist.com/. Accessed 19 April 2022.
[12] "School Buses: Diesel Technology Forum." *Https://Www.dieselforum.org*,
n Respiratory Journal, vol. 17, no. 4, 2001, pp. 733-746. *ERS Publications*, https://erj.ersjournals.com/content/17/4/733.
[13] Sydbom,et al. "Health Effects of Diesel Exhaust."
[13] Sydbom,et al. "Health Effects of Diesel Exhaust."

Studies indicate that mitigation measures, population preparedness and prior experience with outages can reduce the negative consequences of an outage event.[14]

Planned resilience can help mitigate inequitable outcomes across co-occurring and vulnerability factors. Key co-occurring factors considering this report include: air pollution, disruption of productivity, displacement & evacuation, and temperature extremes. EV school buses can provide back-up generation that powers community centers and provides displaced individuals with a safe place to go during emergencies. Schools are ideal resilience centers because they are anchor institutions with the facilities to shelter and support community members.

WHY SCHOOL BUSES?

Electric school buses are an ideal power source for resilience for several reasons. **(1)** They have large batteries that can be discharged rapidly to power a community resilience center or when the grid needs help balancing energy supply and demand. **(2)** School buses are idle for most daylight hours and have a consistent daily use schedule that makes them a reliable back-up generation resource. **(3)** School buses are not in use during peak summer demand. Lastly, since children are most vulnerable to the adverse health effects from diesel emissions, electric school buses can significantly reduce exposure to toxic air particles.

COST DIFFERENTIAL BETWEEN ELECTRIC AND DIESEL BUSES

The central challenge preventing municipalities from reaping the benefits of electric school buses is the high upfront purchase price. **Electric buses can cost in the range of $350,000-$400,000 each**, and each bus would require its own Level 2 charger, which could cost another $20,000.[15] That does not include cost estimates for bidirectional chargers or adapters, which vary by source and region but would raise the total price tag even further. Diesel buses, in comparison, cost about $100,000 and do not require any specialized refueling infrastructure. This high upfront cost reduces the effectiveness of available public incentive programs. For example, Florida's Department of Environmental Protection released $5 million in funding to help school districts add electric buses to their transportation fleets. But at current bus prices, the DEP initiative would only fund the purchase of 14 buses, representing less than 0.1% of Florida's total school bus fleet.[16] [17]

That said, there are a number of advantages that electric buses hold over their diesel counterparts that would help narrow the upfront cost disparity:

---

[14]Sydbom, A., et al. "Health Effects of Diesel Exhaust." *Europea*

[15]Wachunas, Joseph. "The Big Deal About NYC's First Electric School Buses Being Diesel Repowers." *School Transportation News*, 8 Jan. 2022, https://stnonline.com/blogs/the-big-deal-about-nycs-first-electric-school-buses-being-diesel-repowers/.

[16]"Clean Buses." *Florida Conservation Voters Education Fund*, https://fcvef.org/portfolio/clean-buses/.

[17] "Pupil Transportation Statistics." *School Bus Fleet*, vol. 66, no. 11, Dec. 2020, pp. 32–33, https://mydigitalpublication.com/publication/?m=65919&i=696373&p=1&ver=html5.

- **Maintenance cost savings:** Electric vehicles (EVs) require significantly less maintenance than gas-powered alternatives.[18] This is because electric motors have fewer moving parts than internal combustion engines, require fewer fluid components, and can use regenerative braking to reduce wear and tear. Blue Bird, a leading manufacturer of both diesel and electric school buses, estimates that the latter option would help owners save about $1,600 in servicing costs per year, corresponding to over $25,000 over the 16-year life of the bus.[19]

- **Fuel cost savings:** Diesel buses only average about 6 MPG, while electric school buses average nearly 25 MPGe.[20] That disparity makes running an electric school bus materially cheaper on an annual basis than running a diesel one, although the exact magnitude depends on the spread between gas prices and power prices as well as the route patterns of each district. Electricity prices also tend to fluctuate less than gas prices, and so some districts or bus operators may place a premium on reducing the volatility of their operating costs on top of any realized savings.

- **Salvage value:** Unlike internal combustion engines, lithium-ion batteries contain valuable minerals that can be resold after the end of their operating life. Based on a 2020 analysis from the National Renewable Energy Lab (NREL), we estimate that an electric school bus could retain up to 20% of its value after its operating life, compared to about 10% for an ICE bus.[21] This disparity alone narrows the cost disparity between electric and diesel buses by $55,000 in nominal terms (as with other savings that accumulate over the bus's lifespan, the net present value would be lower depending on the discount rate used by each bus purchaser. Our model does not include discount rate assumptions due to inconsistencies around how NPV factors into municipal budgeting).

Based on these advantages, we estimate that on average, **electric school buses have already attained nominal cost parity with diesel buses in Texas and Florida,** but remain about 60% more expensive than diesel buses in Arizona (**FIGURES 1-3**). The reason behind the state-level disparity is that as of 2019, Florida employed fewer buses per capita than Arizona or Texas, resulting in higher average annual vehicle miles traveled and, consequently, higher avoided fuel costs.[22] Texas buses also have the opportunity to access revenues available to distribution-level storage resources in the state, as discussed in further detail below.

[18] "Maintenance and Safety of Hybrid and Plug-In Electric Vehicles." *Alternative Fuels Data Center*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, https://afdc.energy.gov/vehicles/electric_maintenance.html#:~:text=EVs%20typically%20require%20less%20maintenance,reduced%20due%20to%20regenerative%20braking.
[19] *Blue Bird Electric School Buses*. Blue Bird, 21 July 2020, https://assets.ctfassets.net/ucu418cgcnau/362sQcGinJzFxVqFh0DBCr/cb2ee507e5c8f646ee133bfdabbccbfb/02_Blue_Bird_Electric_Bus_Presentation_Truck_and_Bus_NOTES_V2.pdf.
[20] *Blue Bird Electric School Buses*. Blue Bird, 21 July 2020.
[21] Johnson, Caley, et al. *Financial Analysis of Battery Electric Transit Buses*. Technical Report, NREL/TP-5400-74832, National Renewable Energy Lab, June 2020, https://afdc.energy.gov/files/u/publication/financial_analysis_be_transit_buses.pdf.
[22] Pupil.

23 Image Source

FEDERAL POLICIES & INCENTIVES

Federal incentives and existing policies make up a significant source of capital to accelerate the transition to electric school buses, although their scope is not sufficient to fully convert America's school bus fleet in the near future. Currently, there are four key federal programs which schools should leverage in order to lower the cost differential between diesel and electric school buses. The four incentives are: **(1)** U.S. Environmental Protection Agency's Clean School Bus Program, **(2)** the 2021 Diesel Emissions Reduction Act (DERA), **(3)** the 2021 American Rescue Plan (ARP), and **(4)** the Volkswagen Clean Air Act Civil Settlement.

The U.S. EPA's Clean School Bus Program has awarded over $73 million to replace more than 3,000 diesel school buses since 2012.[24] Bolstered by the passage of the bipartisan Infrastructure Investment and Jobs Act (2021), the **EPA's Clean School Bus Program25 is set to provide $5 billion over the next five years (2022-2026)** to support the electrification of school bus fleets across the country. Schools must prepare prior to the annually recurring application period, as funds are distributed on a first-come, first-serve basis. These preparations chiefly include the selection of Electronic Business and Government Business points of contact, registration with the System for Award Management, and the creation of a fleet inventory characterizing the quantity, type, make, model, year, etc. available to schools. Additional resources are available through the Clean School Bus Program news or associated online informational seminars. This program is new and no funds have yet been dispersed, but it is expected to **cover up to 100% of the costs** of replacing existing school buses, including vehicles and charging infrastructure.[26]

The DERA program is set to award roughly **$10 million annually to replace 460 old diesel school buses owned by schools** with newer models powered by electricity or other low-emissions fuels.[27] Interested schools must submit applications by email, including bus titles and registration.[28] Schools may submit one application listing up to 10 buses for

[23] "Electric School Buses: Dominion Energy." *Electric School Buses | Dominion Energy*, https://www.dominionenergy.com/our-stories/electric-school-buses.
[24] Sydbom,et al. "Health Effects of Diesel Exhaust."
[25]Clean School Bus Program Funding. EPA. https://www.epa.gov/cleanschoolbus.
[26] McLaughlin, K. Balik, J. (2022). 5 ways US states can get more electric school buses on the road. GreenBiz. https://www.greenbiz.com/article/5-ways-us-states-can-get-more-electric-school-buses-road.
[27] EPA Awards Rebates Totaling $17 Million to Fund School Buses that Reduce Diesel Emissions and Protect Children's Health. EPA. https://www.epa.gov/newsreleases/epa-awards-rebates-totaling-17-million-fund-school-buses-reduce-diesel-emissions-and-0.
[28] School Bus Rebates: Diesel Emissions Reduction Act (DERA). https://www.epa.gov/dera/rebates#:~:text=The%202021%20DE

replacement per 100 school buses in its fleet, and a second application over that level. Applicants are chosen from a lottery with at least one selected from each state or territory. If a school is accepted, they must submit copies of the purchase orders for their replacement buses, documentation of the delivery of their replacement buses, and evidence of scrappage for the old buses. The EPA will relay a rebate payment within a month of receipt. Selected entities purchasing electric or hydrogen-powered buses may receive $65,000 per bus, for a maximum rebate funding amount per application of $300,000.[29] For example, a recent awardee, the Seminole County Public School district in Florida, received $250,000 to fund 10 updated buses. Arizona's Maricopa County is notably utilizing funds from DERA for school bus electrification. In fiscal year 2020 alone, seven municipalities across the county received DERA awards in varying amounts, with the local government advertising the availability and purpose of the funding opportunity within the county.[30] The funding Seminole County Public School in Florida and Maricopa, Arizona have received to date are just two examples of the opportunities offered through DERA that are being realized by entities across the country.

The ARP Electric School Bus Rebate Awards are substantially smaller and more targeted than comparable programs. Having been folded within the American Rescue Plan Act (2021), the initiative promises to **replace 23 old Type C or D diesel vehicles with new electric models**.[31] Totaling $7 million, this program is available exclusively to school districts in underserved communities, including tribal schools. Interested schools must submit applications by email, including bus titles and registration. Applicants are chosen from a lottery with priority given to tribal schools and geographic diversity. If a school is accepted, it must submit copies of the purchase orders for their replacement buses, documentation of the delivery of their replacement buses, and evidence of scrappage for the old buses. The EPA will relay a rebate payment within a month of receipt. Selected applicants that scrap and replace their diesel buses with electric updates are eligible for a rebate of $300,000 per bus, with a maximum of four buses. Schools with a fleet larger than 100 school buses may submit an additional application. Two recent awardees include Bledsoe County in Tennessee, which received some $600,000 to fund two buses, and Orangeburg in South Carolina, which received $1,200,000 to fund four buses.

Lastly, the Volkswagen Clean Air Act Civil Settlement is a large-scale funding opportunity that may prove fruitful for municipalities to seize. Since Volkswagen's systematic cheating of Clean Air Act stipulations was exposed, the company has been required to pay a $1.45 billion settlement promoting the development and adoption of clean transportation

RA%20School%20Bus,to%20EPA's%20cleanest%20emission%20standards.

[29] 2021 American Rescue Plan (ARP) Electric School Bus Rebates. https://www.epa.gov/dera/2021-american-rescue-plan-arp-electric-school-bus-rebates.

[30] "Clean Diesel Program." *Clean Diesel Program | Maricopa County, AZ*, https://www.maricopa.gov/4509/Clean-Diesel-Program.

[31] EPA Awards Rebates Totaling $17 Million to Fund School Buses that Reduce Diesel Emissions and Protect Children's Health. EPA. https://www.epa.gov/.

technology, with a particular focus on nitrogen oxide pollution reduction.[32] This settlement is allocated to individual states based on the extent to which that state was affected by Volkswagen's fraud. These states then administer the funds as they see fit. For example, New York has created transportation electrification programs such as Charge NY, the Drive Clean Rebate, and other municipal rebate programs for consumers.[33] Texas, meanwhile, has set an array of energy modernization goals, including upgrades to Class 4-8 school buses, model 2009 or earlier. Texas' Volkswagen plan considered the replacement of 217 school buses owned by public schools or third parties contracting with public schools at a total estimated cost of $28,258,087 with a maximum funding of 80% of the costs.[34] The engine and original must be scrapped before reimbursement is requested. After submitting a successful application to become a State Beneficiary under the Mitigation Trust Fund, States are eligible for diesel emission reduction project funding over a period of up to 10 years.[35]

In Florida, state authorities plan to invest roughly $8.6 million of the state's total $166 million Volkswagen Mitigation Trust Fund in EVs, but mostly in publicly available charging stations along transit corridors.[36] Arizona's Environmental Mitigation Trust has largely been squandered on newer, marginally cleaner diesel buses.[37] Indeed, much of the funding to date has gone to diesel fuel projects, with notable exceptions.[38] For example, the Beverly public school district in Massachusetts had its first electric bus partially subsidized to the tune of $288,000 from Massachusetts' portion of the settlement.[39]

STATE POLICIES & INCENTIVES

In addition, the federal incentives, states and utility providers play a vital role in achieving cost parity between electric and diesel school buses. In general, electric school buses cost three times as much as diesel alternatives. States and utilities can provide incentives that will enable schools to invest in electric school buses that serve the entire community. In addition to incentives, state policies can accelerate adoption by reducing barriers. Most notably, **favorable state net metering policies can increase the return on investment for electric school buses.** Net metering is the system in which renewable energy generators are connected to a public-utility power grid,

[32] Motavalli, J. (2021). How VW's Diesel Settlement Is Changing Fleets, From Schools to Seaports. New York Times. https://www.nytimes.com/2020/11/05/business/vw-diesel-settlement-states.html.
[33] VW Settlement Information. New York State. https://www.dec.ny.gov/chemical/109784.html.
[34] Volkswagen Environmental Mitigation Trust. Texas Commission on Environmental Quality. (2020). https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg-537.pdf.
[35] "STATE OF FLORIDA BENEFICIARY MITIGATION PLAN." *Florida Department of Environmental Protection*,https://floridadep.gov/. Accessed 19 April 2022.
[36] Florida Taps VW Settlement Funds to Expand EV Infrastructure. Center for Environmental Excellence. https://etapnews.transportation.org/.
[37] Brown, D. (2019). Arizona Receives Failing Grade on VW Settlement Spending Plan. Arizona PRG. https://arizonapirg.org/news/azp/arizona-receives-failing-grade-vw-settlement-spending-plan.
[38] Motavalli, J. (2021). How VW's Diesel Settlement Is Changing Fleets, From Schools to Seaports.
[39] Shemkus, S. (2020). Start-up bets on new model for putting electric school buses on the road. https://energynews.us/2020/11/02/start-up-bets-on-new-model-for-putting-electric-school-buses-on-the-road/

and its surplus power is transferred for use onto the grid. This practice would allow customer generators to offset the cost of power drawn from the utility. **Net metering credits impact the economics of V2G by reducing one of the key levers for cost parity between EV and diesel school buses.** Typically, net metering policies are used to support rooftop solar and wind deployment, but EVs that are connected to the grid can also benefit from netting their electricity bill.

[40] Image Source

Arizona

Arizona is actively expanding its efforts into renewable energy, and is setting more aggressive emissions reductions targets for the coming years. While there are fewer state incentives available in Arizona than there are in other states, Arizona benefits from aggressive goal setting and utility incentives, which serve as opportunities to accelerate the adoption of electric school buses across the state.

Arizona Utility Landscape: The main players in Arizona's energy market are the Arizona Corporation Commission (ACC), the regulatory body tasked with managing the state's electricity network, and three major utilities: Arizona Public Service Company (APS), Tucson Electric Power (TEP), and Salt River Project (SRP). When analyzing opportunities for the adoption of electric school buses in Arizona, it is important to consider and understand the landscapes and backgrounds of each of these utilities to recognize windows of opportunities.

For example, in 2006, ACC expanded its state renewable energy goals to 15% by 2025, and added that 30% of the renewable energy produced in the state must come from distributed energy sources.[41] More recently however, ACC voted against a proposal which would have incorporated a statewide policy of creating 100% carbon-free energy.[42] The regulators who voted against this proposal stated that the statewide policy was unnecessary since many utilities already had similar commitments in place.[43]

While there are a limited number of utilities in Arizona, there are windows of opportunity and advanced goal-setting taking place all across the state. In 2019, SRP committed to shutting

[40] Contributor, ByGuest. "School Bus Electrification: Charging Q&A." *CleanTechnica*, 3 Feb. 2022, https://cleantechnica.com/2022/02/02/school-bus-electrification-charging-qa/.

[41] "Programs." *DSIRE*, https://programs.dsireusa.org/system/program/detail/268.

[42] Randazzo, Ryan. "In Major Reversal, Arizona Utility Regulators Kill 100% Clean-Energy Rules in the State." *The Arizona Republic*, Arizona Republic, 26 Jan. 2022, https://www.azcentral.com/

[43] Wichner, David. "Arizona Regulators Reject New Clean-Energy Rules after Years of Debate." *Arizona Daily Star*, 15 Apr. 2022, https://tucson.com/

down its coal fired power plant in 2027, another in 2025, and 2028. SRP also committed to reducing its carbon emissions by 65% from 2005 levels in 2035 and 90% by 2050.[44] Separately, in 2020, APS committed to shut down all coal generation by 2031. It also committed to 100% of electricity being generated from zero-carbon resources by 2050.[45] Lastly, in 2020, TEP announced that it would retire its coal generation in 2032. TEP also announced its commitment to provide more than 70 percent of its power from renewable sources by 2035.[46] Moreover, local governments made renewable energy commitments which may catalyze the adoption of electric school buses in Arizona in the near future. [47] For instance, Phoenix has a goal of reducing its GHG emissions 80% below 2012 levels by 2050, 30% below 2012 levels by 2025, and achieving carbon neutrality by 2060. Tucson has committed to becoming carbon neutral by 2030. Flagstaff also aims to become carbon neutral by 2030, and is committed to reducing its GHG emissions 80% below 2016 levels by 2050. Scottsdale plans to also be carbon neutral by 2040.

Arizona State Level Policies: Arizona's legislature is currently working on one main state incentive to promote electric buses, a bill called SB124. **SB124 provides a vetted list of approved electric bus providers and in order to utilize national funding for school bus electrification for schools across the state's counties.** SB124 was introduced in the House and was passed, and is currently under review in the state Senate, as of March 2022. SB124 is sponsored by Republican Senator Paul Boyer, and therefore has the potential for bipartisan support.[48]

Arizona Utility Incentives: Arizona has relatively limited state funding options available, but the state's utilities have stepped in to provide additional opportunities to expand electric school bus programs. There are four major programs, described below:

1. **Time-of-Use (TOU) Rates:** Customers in the TEP service area would receive a 5% discount on their bill if they charge their EVs during off-peak periods.

2. **Smart School EV & EE Pilot Program:** This is a TEP pilot that will provide EV chargers and grants for schools for customers.

3. **Take Charge AZ:** An APS pilot program whereby the utility installs and owns Level 2 charging stations in various public location, as well as DCFC along highways.

4. **Home battery program:** The ACC-approved APS pilot program for Demand Side Management incentives customers to connect their batteries to the grid. The pilot provides customers with a one-time $1,250

[44] "Arizona Electric Utilities Voluntarily Commit to 100% Clean Energy." *Sitefinity-2020-Oct*, https://www.azcc.gov/news/2022/01/27/arizona-electric-utilities-voluntarily-commit-to-100-clean-energy.
[45] "Arizona Electric Utilities Voluntarily Commit to 100% Clean Energy."
[46] "Arizona Electric Utilities Voluntarily Commit to 100% Clean Energy."
[47] *Illume Advising, LLC.* https://illumeadvising.com/.
[48] Syed, Zayna. "Groundwater, Electric School Buses Are among the Environmental Issues at the Legislature." AZ Central, 9 Feb. 2022, https://www.azcentral.com/; *SB 1224 - Azleg.gov.* https://www.azleg.gov/legtext/54leg/2R/bills/sb1224p.pdf.

award for a three-year commitment to share up to 80% of the capacity during "events" to the grid. In addition, there is another pilot that gives customers the opportunity to install battery systems and enroll in APS's TOU plus demand rate plan. This plan allows for customers to receive a one-time $500/kW and up to $2,500 per home. A requirement is that customers will discharge their batteries during peak demand.

Another potential program proposed by Arizona PIRG's Education Fund is the Pay as you Save program. This program currently offers customers reduced energy rates when using emissions reducing technologies, and if expanded to electric school buses, could allow school districts to purchase an electric school bus without the immediate financial strain. For instance, a school district would purchase the bus and the utility would cover the difference between a new diesel bus and an electric bus, then the school would pay the utility back over the lifetime of the bus. The difference of costs includes the charging infrastructure, batteries, and the extra cost of the bus itself.[49]

Arizona utilities also offer incentives which target commercial customers. While there is limited evidence that schools have received these particular incentives in the past, there is no exclusion which prohibits school districts from being considered commercial customers of Arizona utilities. Therefore, Electric Vehicle Supply Equipment (EVSE) programs, Commercial electrification rebates, and Commercial Electrification assessment incentives are also incentives potentially available to school districts in Arizona. Such incentives could be alternative solutions to assist in offsetting the cost of purchasing EV equipment, and therefore mitigating the additional costs associated with electric school buses.

The EVSE program is offered by multiple utilities in Arizona, including TEP, and SRP. The price of the rebate varies across each utility, with **TEP offering rebates to residential customers that covers up to 75% of the cost of EVSE installation** with a maximum rebate award of $500 for a two-way charger. The SRP incentive program offers a rebate of $1,500 per port for commercial customers which install networked Level 2 equipment. These programs do not explicitly exclude school districts as commercial customers.[50]

SRP also offers commercial electrification rebates wherein commercial customers are rebated for the purchase or lease of electric forklifts, electric truck refrigeration units (TRUs) charging infrastructure, truck charging bays, EVSE, and custom electrification projects.[51]

Additionally, SRP offers commercial electrification assessment incentives, which offers funding to trained vendors who study electrification opportunities for commercial non-road equipment through the Electric Qualified Service Provider Assessment (eQSP) Program and on-road electrification opportunities for fleets under the Fleet

[49] *Accelerating the Transition to Electric Buses.* https://masspirg.org/sites/pirg/files/reports/MA_EL%20buses%202021%20scrn.pdf.

[50] "Arizona Laws and Incentives." *Alternative Fuels Data Center: Arizona Laws and Incentives*, https://afdc.energy.gov/laws/all?state=AZ.

[51] "Arizona Laws and Incentives."

Advisory Services (FAS) Program. Maximum funding amounts for each study through the eQSP and FAS Program are $10,000 and $20,000, respectively.[52]

Barriers to Adoption in Arizona: While Arizona does have some mechanisms currently available to help accelerate electric school bus adoption, some important barriers remain in place. APS and TEP in particular face issues when working with state and local governments on EV/Transportation goals, namely: lack of collaboration and education and outreach to communities, insufficient existing charging infrastructure and the cost of potential development, grid planning and capacity needs, and electricity rate design development.

In addition to APS and TEP specific barriers, **Arizona as a whole does not have net metering.** Net metering has been largely phased out in the state of Arizona following a 2016 decision by ACC. Instead, Arizona now has a net billing structure. Net billing is the practice where a utility sees how much electricity was produced and will compare that to consumption during a given period of time. Under net billing, any excess energy not consumed will be credited back to the generator at the excess generation rate. Therefore, **customers served by utilities such as APS and TEP are credited with an "export rate"** lower than that which was offered through net metering.

Another challenge in Arizona is that the highly regulated structure of the state's electricity markets. For instance, ACC is an extremely powerful entity in the state, which has not prioritized renewable energy initiatives in the recent past. Additionally, ACC is a highly political entity which requires the feedback of its stakeholders in order to implement new initiatives, which may delay more novel programs such as those which promote new energies (i.e. EVs). Therefore, the Arizona market seemingly has not promoted initiatives such as the adoption of EVs on as large a scale as other states. It is noteworthy that Arizona's Governor, Doug Ducey, abolished Arizona's energy office in 2015, which eliminates any state environmental initiatives that existed before 2015, and has not implemented newer ones.[53]

[54] Image Source

[52] "Arizona Laws and Incentives."
[53] Randazzo, Ryan. "Arizona Shutters Energy Program; Remaining Workers Fired." *The Arizona Republic*, The Arizona Republic, 3 Nov. 2015, https://www.azcentral.com/.

[54] Kane, Mark. "First Student Orders 260 Lion Electric School Buses." *InsideEVs*, InsideEVs, 22 May 2021, https://insideevs.com/news/508387/first-student-lion-electric-buses/.

Florida

A joint report published by Environment Texas, TexPIRG and Frontier Group found that electrifying Florida's entire fleet of school buses would provide 1,838 MWh of power capacity, which is enough to power an average of 34,374 homes for a day.[55] While an entire fleet of electric school buses and complementary V2G infrastructure would have an significant impact on the grid's capacity, **even a scaled implementation would provide significant resilience benefits** by reducing reliance on hazardous diesel and other fossil fuel generators and powering additional community centers during outages. Florida is prone to extreme weather events that can result in power outages. Tropical cyclones, thunderstorms, tornadoes and flood events are all predicted to increase in both frequency and intensity as the effects of climate change continue to wreak havoc on the state's biosphere. In response to growing need for resilience and disaster preparedness, Florida recently allocated $500 million for the Resilience Florida Grant Program to make communities more resilient to sea level rise, intensified storms and flooding.[56]

Florida Utility Landscape: There are five IOU's that serve over 8 million residential, commercial and industrial customers in Florida. The largest is Florida Power and Light Company (FPL) with roughly 70% of the market share, or 5.6 million customers. Large IOUs can partner with school districts to pilot and deploy electric school buses across the state. In 2019, FPL announced a partnership with West Palm Beach to pilot five electric school buses. The West Palm Beach pilot demonstrates how **IOUs can benefit from subsidizing EV school buses by leveraging the buses battery to service peak demand.**[57] FPL owns and maintains the charging stations and the batteries in the EV, while the city owns the buses. FPL financed two-thirds of the $1.5 million program budget in order to maintain partial ownership of the project. Public-Private Partnerships (PPP) exemplify how private industry can close the funding gap between diesel and electric school buses, while improving their business' service through additional resilience and ancillary services.

The other major IOU in Florida is Duke Energy. Duke Energy is the second largest utility with 1.7 million customers. Similar to FPL, Duke Energy sees an opportunity to expand EV market penetration and charging infrastructure. Duke Energy proposed a $76 million dollar EV infrastructure project in North Carolina that included $18 million for electric school buses.[58] Analysts at Atlas Public Policy's Southern Alliance for Clean Energy indicated that similar investments in Florida would likely increase

[55] Horrox, James, et al. "Electric School Buses and the Grid." *Environment Texas*, TexPIRG, 2022, https://environmenttexas.org/. Accessed 19 April 2022.
[56] "Governor Ron DeSantis Announces Budget Proposals for Everglades Restoration, the Protection of Water Resources, and the Resilient Florida Program." *Florida Governor Ron DeSantis*, 16 November 2021, https://www.flgov.com/. Accessed 19 April 2022.
[57] Doris, Tony. "City getting electric school buses that recharge FPL grid at peak times." *Palm Beach Post*, 31 July 2019, https://www.palmbeachpost.com/. Accessed 19 April 2022.
[58] "Transportation Electrification in Florida." *Southern Alliance for Clean Energy*, https://cleanenergy.org/wp-content/uploads/. Accessed 19 April 2022.

adoption of EV school buses and achieve savings for ratepayers.[59]

Tampa Electric Company, Gulf Power Company and Florida Public Utilities Corporation each have fewer than one million customers and more regional presences. Similarly, there are 35 municipally owned electric companies that aim to address individual municipalities' needs for cost effective and reliable energy. Florida's municipally owned electric companies' rates and revenues are regulated by their city commissions, which may present a challenge if school districts or utilities seek to monetize school bus fleet batteries. As of April 2022, 33 of the 35 municipally owned electric companies, representing 1.5 million customers, are members of the Florida Municipal Electric Association (FMEA).[60] One municipally owned utility company, the Jacksonville Electric Authority, is currently offering **a rebate of up to $17,000 for the purchase and lease of electric school buses and related equipment**. The rebate is available to EVs and EVSEs installed between October 1, 2019 and September 30, 2025.[61]

In addition to the municipal and IOU utility companies operating in Florida, there are 18 rural electric cooperatives serving 2.4 million customers.[62] The rates and revenues of rural electric co-ops are regulated by their elected cooperative officers. The fragmented landscape of rural electric cooperatives presents a challenge to scaling EV school bus deployment across the state, but the National Rural Electric Cooperative Association (NRECA) could prove to be an ally. NRECA played an instrumental role in electrifying rural America 75 years ago, and it is now looking to electrify vehicles and homes. Two of their member co-ops partnered in 2017 to bring an electric school bus to the Independent School District 194 in Lakeville, Minnesota.[63] In another example, a Missouri electric co-op helped lobby state legislators to utilize funds from the Volkswagen settlement and their partnership school to apply for the requisite grants.[64] A similar approach could be taken in Florida to facilitate the distribution of a portion of the $166 million funding from the Volkswagen settlement.

Florida State Level Policies: Florida offers state incentives that can be used to support the acceleration of EV school bus adoption. Florida's Diesel Emissions Mitigation Program (DEMP) uses funds made available from the Volkswagen settlement's ZEV Investment and the EPA's Diesel Emissions Reduction Act (DERA) state grants program.

Florida submitted its Beneficiary Mitigation Plan in October 2019, which details how the Florida EPA department will use the funds to develop EV infrastructure across the state. The report indicated that **voters most interested in investing the funds in projects that would**

[59] "Transportation Electrification in Florida."
[60] "Municipal Members." *Florida Municipal Electric Association*, https://www.flpublicpower.com/. Accessed 19 April 2022.
[61] *JEA Electrification Rebate Program*, https://erp.programprocessing.com/. Accessed 19 April 2022.
[62] "Members." *Electric Cooperatives*, https://feca.com/members/. Accessed 19 April 2022.
[63] Kahn, Michael W. "The Big Yellow, All-Electric School Bus - America's Electric Cooperatives." *National Rural Electric Cooperative Association*, 6 July 2017, https://www.electric.coop/. Accessed 19 April 2022.
[64] Kahn, "The Big Yellow, All-Electric School Bus - America's Electric Cooperatives."

improve school, shuttle, and transit buses. Both government owned and privately owned school buses that have 2009 engine model years or older class 4-8 buses are eligible for funds.

In November 2020, the Florida Department of Environmental Protection announced a Notice of Funding Availability (NOFA) for $57 million to purchase Type C or Type D electric buses to replace eligible Type C or Type D diesel buses.[65] While this plan does not explicitly address the acceleration of electric school bus adoption, it provides an **indication of the state's readiness to invest in grid modernization** and supporting EV infrastructure.

Florida utilities joined the National Electric Highway Coalition (NEHC)'s commitment to building an infrastructure of DC fast charging stations from the Atlantic to the Pacific.[66] Members aim to ensure efficient and effective fast charging deployment plans that support long-distance EV travel. This commitment further indicates Florida utilities' readiness to invest in essential infrastructure to modernize the grid and support the growth of electric transportation. **NEHC's members have invested more than $3.4 billion to deploy charging infrastructure and accelerate electric transportation.**[67] This demonstrates the considerable funding utilities are willing and able to invest in electric infrastructure, and how school districts can leverage this momentum to accelerate the adoption of electric school buses.

Florida Utility Incentives: As of Spring 2022, there are **no utility incentives that would support funding the acceleration of EV school bus adoption in Florida**. The outlook for future incentive programs is bleak. The current Agriculture Commissioner, Nikki Fried, has announced an effort to set a 100% renewable energy goal by 2050.[68] Increased renewable generation benefits the value proposition offered by battery storage, and catalyzes investment in V2G technology in the future. In the near term, Florida utilities are not incentivizing electric school bus adoption.

Barriers to Adoption in Florida: Renewable energy generation is currently just 5% of Florida's power mix. The state does not have a renewable energy commitment. A key tenet of EV school buses' V2G application is that they can serve as a distribution resource to the grid. **Storage capacity is valuable to utilities using intermittent generation sources**, like solar and wind, but offers a smaller value proposition to utilities relying on dispatchable fossil fuel assets.

Motor fuel taxes account for the single largest source of funding for roadway infrastructure in Florida. Accelerated EV adoption could result in a budget deficit, which would leave the state

---

[65] "DEMP - Volkswagen Settlement and DERA." *Florida Department of Environmental Protection*, 25 February 2022, https://floridadep.gov/Accessed 19 April 2022.

[66] "Alternative Fuels Data Center: Electric Vehicle (EV) Infrastructure Support." *Alternative Fuels Data Center*, https://afdc.energy.gov/laws/12774. Accessed 19 April 2022.

[67] "Alternative Fuels Data Center: Electric Vehicle (EV) Infrastructure Support."

[68] Harris, Alex. "Florida to set goals for 100% renewable energy by 2050. But will it actually happen?" *WUSF News*, 12 February 2022, https://wusfnews.wusf.usf.edu/environment/2022-02-12/florida-to-set-goals-for-100-renewable-energy-by-2050-but-will-it-actually-happen. Accessed 20 April 2022.

in search of additional revenue sources.[69] Florida's **dependence on motor fuel taxes** to fund essential infrastructure could result in delayed implementation of key policies that would support EV growth and related infrastructure. Net metering and interconnection policies are particularly vulnerable because cost savings are a key driver of cost parity because EVs and internal combustion engines (ICEs).

In March 2022, the Florida Senate passed a bill 24-15 that will alter net metering requirements.[70] Distributed energy advocates have criticized the bill arguing that it will gut rooftop solar incentives by reducing the credit, and therefore return on investment for customers. The bill has passed the House of Representatives, and is on its way to Governor DeSantis.

[71] Image Source

Texas

Texas is uniquely situated to benefit from distributed energy resources. The proliferation of DER technologies in Texas is currently hampered by complicated ERCOT rules and unrealized benefits and financing options associated with the adoption of electric school buses.

Texas Utilities: Texas's utilities are broken up by power generation, transmission, and distribution/retail sales. Generation companies own and operate power plants, retail electric providers package the power with transmission and delivery services for sale to retail customers (not permitted to own power plants, but can be affiliated with a generation company), and transmission and distribution service providers (TDSP) provide the actual delivery of electricity (poles, wires, and meters). Each of these utilities is regulated by the Public Utility Commission of Texas (PUC), and PUC sets the rates of transmission and distribution services, establishes reliability and safety standards, and ensures that all customers and REPs are treated the same.

Texas State-Level Policies: Texas' state-specific initiatives include two main programs: **(1)** the Texas Clean Fleet Program and **(2)** the Government Alternative Fuel Fleet (GAFF). There are also Texas state-specific initiatives offered by local utilities including Austin Energy's Workplace Charging Rebate, while other initiatives are geared toward residential savings. The Workplace Charging Rebate offers rebates to commercial customers of Austin

[69] "Transportation Electrification in Florida."
[70] Gheorghiu, Iulia. "Florida passes net metering bill that will gut rooftop solar, advocates say, as they call for a veto." *Utility Dive*, 8 March 2022, https://www.utilitydive.com/news/florida-passes-net-metering-bill-that-will-gut-rooftop-solar-advocates-say/620000/. Accessed 20 April 2022.

[71] "The Lion Electric Co.: Electric School Bus." *The Lion Electric Co. | Electric School Bus*, https://thelionelectric.com/en/products/electric.

Energy to install electric charging stations. Austin Energy offers a rebate of up to $4,000, or 50%, of the cost to install an approved Level 2 (240 V) charging station and/or Level 1 (120V) outlet, while also providing additional rebates of up to $10,000 to customers installing a DC Fast Charger.[72] These available rebates can offset the cost of EV equipment installation in Texas, and by providing more available charging infrastructure, can more readily ease the transition for the city of Austin to go electric. While utility rebates in the state are primarily targeting personal EV owners, **the fact that utilities offer such discounts shows that electric bus incentives could be pioneered through preexisting institutional pathways**. There is the potential that because utilities offer residential rebates, these programs could expand to the commercial and municipal levels.

The Texas Clean Fleet Program is a competitive grant initiative offering to **reimburse 80% of the eligible incremental costs** of replacing old diesel light- or heavy-duty fleet vehicles with alternative fuel or hybrid models. Associated charging infrastructure is also eligible. Entities which operate at least 75 vehicles can request support in replacing, at minimum, 10 of those. The program evaluates the cost effectiveness of projects by the cost per ton of NOx reduced and **requires a reduction in NOx emissions of at least 25%.** Vehicles also must be used within the district for which they're purchased at least 25% of the time and within Texas at least 75% of the time. Schools are largely responsible for working through the necessary NOx reduction calculations, as well as assessing the applicable emissions standard, though the Texas Council on Environmental Quality (TCEQ) provides supplementary resources online. After receiving funds through a contract with TCEQ, recipient schools are obligated to ensure the destruction of the engine being replaced. In 2021, five entities were granted funding, including the San Antonio Independent School District, the Alvin Independent School District, and the Hays Consolidated Independent School District. These schools collectively received more than $2 million to replace 33 vehicles with liquified petroleum gas models. Only one entity, the Capital Metropolitan Transportation Authority, was granted funding for an electrification project.[73]

The GAFF Grant Program is designed to accelerate electric and hybrid fleet transitions for state agencies and political subdivisions, including municipalities and school districts, with at least 15 motor vehicles. Class 7-8 vehicles, such as school buses, are eligible for a predetermined grant amount of $70,000 for purchase or replacement, and while associated charging infrastructure is eligible, no more than 10% of total requested grant funds may be applied for this purpose. The program is especially designed to replace vehicles which are owned and operated by the entity in question, but commercial school transit providers are explicitly accepted. Applicants are selected based on criteria including entity type (state agencies are advantaged over

[72] "Workplace Charging." *Austin Energy*, https://austinenergy.com/ae/green-power/plug-in-austin/workplace-charging.

[73] "TERP Grant Programs." *Texas Commission on Environmental Quality*, https://www.tceq.texas.gov/airquality/terp/programs.

political subdivisions or school transit providers), project area (grants are available statewide but prioritized for areas of non-attainment), emissions reduction (Class 7-8 vehicles are privileged over smaller vehicles), and the necessity of refueling infrastructure (benefiting projects which need chargers). After receiving funds through a contract with TCEQ, recipient schools are obligated to ensure the destruction of the engine being replaced. In 2021, 24 entities, including cities, police departments, and school districts, requested over $13 million in funding. However, only one entity, the Cypress-Fairbanks Independent School District in the Houston area, was selected, receiving more than $6 million to replace 81 vehicles with liquified petroleum gas models.[74]

Barriers to Adoption in Texas: While Texas appears to have the greatest breadth of DER support among our subject states, state-wide financial support for DER development is still limited and structurally insufficient. Additional challenges include a lack of transparent distribution grid planning processes, such as policies relating to the interconnection application and reworking process.[75] The ERCOT market was designed to minimize system costs and incentivize new transmission infrastructure via socialized costs, two goals that can make it **challenging to integrate relatively high-cost distribution-level resources that benefit the grid's overall resilience**.[76] [77] The interconnection process for larger generators to the transmission network is handled by ERCOT directly and uniformly, but distributed generation is interconnected by each distribution utility with its own process. While ERCOT allows installed capacity, including export capacity, less than or equal to one megawatt, distributed generation is interconnected by each distribution utility with its own process, and the patchwork of processes and requirements from local utilities can be both onerous and opaque. [78] [79] The application may include accessing permissions from property owners (likely not a challenge for schools), cost assessment, anticipated energy consumption assessment, and the establishment of a new customer account with associated credit evaluation.[80]

A report from the American Council for an Energy-Efficient Economy (ACEEE) from February 2021 rated Texas' progress in transportation electrification planning and goal setting as 0 out of 17 points[81]. While Texas was among the only states to adopt EV school bus deployment requirements via the Texas' Clean

[74] "TERP Grant Programs."
[75] Hall, J. Jewell, M. Ryan, S. (2020). Encouraging the Development of Distributed Energy Resources in Texas. Environmental Defense Fund. https://www.edf.org/sites/
[76] Distributed Energy Resources. The South-central Partnership for Energy Efficiency as a Resource. https://eepartnership.org/
[77] Neeley, J. (2020). How to Make Distributed Energy Resources Work for Texas. R Street. https://www.rstreet.org/2020/
[78] 2020. Distributed Generation. ERCOT. https://www.ercot.com/services/rq/re/dgresource.
[79] Distributed Energy Resources. The South-central Partnership for Energy Efficiency as a Resource. https://eepartnership.org/program-areas/policy/ee-as-a-resource/.
[80] Recommended Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Houston Area. City of Houston. https://www.houstontx.gov/fleet/ev/evdeploymentguidelines.pdf. Date Accessed: 2/21/2022.
[81] Howard, B. Vaidyanathan, S. Cohn, C. Henner, N. Jennings, B. (2021). The State Transportation Electrification scorecard. ACEEE. https://www.aceee.org/sites/default/files/pdfs/t2101.pdf.

School Bus program, it has yet to develop comprehensive EV and EV charging infrastructure plans, utility EV charging infrastructure goals, transportation-sector GHG reduction targets, heavy-duty EV adoption goals or mandates, or transit agency bus procurement goals. In another article from last November, the lead author of this same ACEEE report stated that despite progress in the city of Austin, the Texas state government has no "overall roadmap" in place for the development of EV infrastructure, contributing to its overall ranking on the scorecard of 27 out of 29. An Environment Texas report from 2021 further noted that Houston has developed an EV Roadmap including an EV sales target of 30% by 2030 along with a plan for achieving this target.

Regulatory gaps also include clarity regarding outage coordination.[82] Texas has not streamlined remote monitoring or management of distributed energy resources or denoted the responsibility of such parties during a grid failure. ERCOT has prioritized the promotion of visibility between distributed energy resources and the ERCOT transmission system. This is especially relevant to community resilience.

Finally, integrated utilities outside of ERCOT and distribution utilities within the ERCOT competitive market have a track record of discouraging clean DERs by imposing on customers excessive charges and fees, or cumbersome rate structures. Even when utilities aren't overtly hostile, they're often hesitant to contract with third parties who own DER assets.[83] The Pecan Street/Austin SHINES collaborative may open new possibilities by demonstrating V2G value on a utility scale.

Texas lacks a centralized net metering policy, but most utilities have some kind of net metering rate, whether it's set equal to retail kWh prices, the wholesale price, or a feed-in tariff below the retail kWh price.

Texas lawmakers are also now considering an annual charge to electric car owners representing some $200-$250 at minimum, with an additional $190 fee for drivers exceeding 9,000 miles in a given year, to compensate for slack in the gasoline tax[84].

Success for Electric School Buses in Texas:

While there are barriers to the adoption of electric school buses in Texas, there are pockets of success across the state which prove that the adoption of electric school buses is not only possible, but welcomed and beneficial. These success examples include Austin, Dallas, Port Arthur, and North Central Texas.

- **Austin, Texas** has passed an initiative for electric buses, and Austin's transit agency Capital Metro expanded its bus lines with an all-electric fleet after residents passed a ballot initiative to fund the transition in 2020.
- **Dallas, Texas** has adopted electric buses, with Dallas's transit agency (DART)

[82] Cohn, L. (2019). Texas Customers Could Save $5.47 Billion with DERs, but Regulations Must Change.
[83] Hall, J. Jewell, M. Ryan, S. (2020). Encouraging the Development of Distributed Energy Resources in Texas.

[84] Loveday, S. (2022). Texas EV Drivers May Get $200-$400 Fee To Replace Gas Tax. Inside EVs. https://insideevs.com/news/568956/texas-ev-fee-potential/

purchasing seven fully electric buses. It is estimated that the seven electric buses will reduce carbon dioxide emissions by nearly 244,000 pounds a year.

- **Port Arthur, Texas** moves toward clean buses: Port Arthur will have 10 fully electric buses by early 2021.

- **North Central Texas** offers a clean school bus program through the North Central Texas Council of Governments. This program provides grant funding for school districts in the Dallas-Fort Worth area. This initiative is hosted by Dallas-Fort Worth Clean Cities Coalition and provides education and funding programs across school districts in the county.[85]

A commonality between the success stories listed above is Texas's Electric School Bus Program which is funded under the **Texas Emissions Reduction Plan (TERP).** This state initiative is a bipartisan infrastructure law, and has garnered support from environmental advocacy groups across the state including Moms Clean Air Force. Overall, this law has represented a point of bipartisan agreement around environmental action in the state. Combined with federal funding, this program is currently open to all Texas' school districts on a first-come, first-served basis, **offering approximately $13 million to reimburse school districts which upgrade older diesel school buses with electric models**.[86]

While policy and financial incentives are integral components to the success of adoption of electric school buses across the country, existing grid and infrastructure components are equally necessary to accelerate the adoption of electric school buses. The intermittent nature of renewable resources is a unique challenge when it comes to accelerating adoption of electric school buses, but is a necessary barrier to overcome. Once it is established that infrastructure exists and local energy grids are equipped to handle the energy provided by electric school bus batteries, policy and financial considerations become easier to overcome logistically, and the idea of adopting electric school buses becomes more realistic.

[87]Image source

[85] "North Central Texas Clean School Bus Program." *North Central Texas Council of Governments - North Central Texas Clean School Bus Program*, https://www.nctcog.org/trans/quality/air/for-fleets/clean-school-bus-program.
[86] "TERP Grant Programs." *Texas Commission on Environmental Quality*, https://www.tceq.texas.gov/airquality/terp/programs.

[87] "Beverly Massachusetts Electric School Buses Make V2G Energy Transfer History." *Thomas Built Buses*, 19 Nov. 2021, https://thomasbuiltbuses.com/resources/articles/beverly-massachusetts-electric-school-buses-make-v2g-energy-transfer-history/.

VEHICLE TO GRID (V2G)

Technology Overview

Demand for electricity rises and falls in predictable patterns throughout the day. Accompanying these predictable demand curves is unpredictable generation from renewable sources. Since wind and solar resources are intermittent and inconsistent by nature, they produce differing volumes of energy at any given time. As more renewable resources are added to the grid, this intermittency complicates the grid operator's ability to match supply and demand, unless efforts are made to capture and store the intermittent energy.[88] Furthering this issue, peak electricity demand is usually in the morning and the early evening, when solar generation is limited. **One potential solution to the mismatch between demand and generation is the application of vehicle-to-grid (V2G) technology**.

Vehicle-to-grid allows the battery of an EV to be used as a source of power for the grid. With this technology, the grid is flexible in its ability to consistently match supply of energy with demand for energy. EVs with V2G capability can charge the surplus of renewable energy resources during periods of peak production and off-peak demand. This energy can then be sent back to the network as renewable energy generation falls and demand rises in the evening.[89] Further, a surge in renewable energy, such as strong winds or irregular irradiative activity, may overwhelm existing energy storage systems and require grid operators to curtail, or throw out, excess clean power. The **additional capacity afforded by grid-connected EV batteries can improve the efficacy of renewable energy capture**, speeding the transition towards zero-emissions technologies.[90] [91]

Batteries also allow for a greater degree of control in the distribution of power, allowing utilities to simultaneously shave peaks and fill valleys of demand, reducing the grids reliance of expensive "Peaker" power.[92][93] In order to take advantage of the benefits of V2G technology, bidirectional charging, the ability to charge and discharge a vehicle battery from and to the grid, must be installed. **Bidirectional charging stations "push and pull" energy from vehicles based on the demands of entities connected to the grid**, leaving EVs as both a load and a source of energy to the grid.[94]

[88] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*: Ev Connect. EV Connect. Retrieved March 31, 2022, from: https://www.evconnect.com/blog/what-is-vehicle-to-grid-for-electric-vehicles.

[89] Mehrjerdi, H., & Rakhshani, E. (2019). Vehicle-to-grid technology for cost reduction and uncertainty management integrated with solar power. *Journal of Cleaner Production*, *229*, 463-469.

[90] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*: Ev Connect. EV Connect. Retrieved March 31, 2022, from: https://www.evconnect.com/blog/what-is-vehicle-to-grid-for-electric-vehicles

[91] Wenzel, E. Valarino, Philip. (2019). Vehicle to Grid (V2G) Technology. IEEE. Retrieved February 22, 2022 from https://innovationatwork.ieee.org/vehicle-to-grid-v2g-technology/.

[92] "Peakers" are plants run to meet peak demand. Power generated at these plants is more expensive due to the economics of variable energy generation.

[93] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*: Ev Connect. EV Connect. Retrieved March 31, 2022, from: https://www.evconnect.com/blog/what-is-vehicle-to-grid-for-electric-vehicles

[94] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*: Ev Connect. EV Connect. Retrieved March 31,

Bidirectional charging, as a technology, also allows for the provision of ancillary services to the grid, including the regulation of frequency and voltage. Thus, appropriately designed vehicle-to-grid systems can charge and discharge electricity more efficiently and cost-effectively than large generators, once the costs of extensive transmission and distribution infrastructure such generators would require are taken into account, without causing the same stability control issues associated with integrating utility-scale renewables.[95] In other words, **V2G may help power companies to defer investments in other costly grid infrastructure**.[96]

Batteries from EVs with V2G technology not only offer the ability to meet fluctuating demand, but can also play an important role during periods of imbalance or uncertain grid conditions. In essence, EV batteries can serve as reserves. Energy can be drawn from the vehicles themselves and injected into the local distribution grid during unexpected outages or periods of low voltage.[97] For example, the battery of a Ford F-150 Lighting could meet the electrical needs of the average American household for more than three days.[98] A fleet of even larger batteries could keep the lights on in a community resilience center capable of islanding.

Vehicle to grid charging has the additional benefit of cost stability. The complex interactions of supply and demand typically drive price volatility for utilities. The adoption of vehicle-to-grid capability has been shown to bolster reductions in the peak-valley demand differential already associated with the use of EVs.[99] As a result, a case study found that **a single vehicle to grid charger could save the company which installed it as much as $1,900** annually in utility bills.[100] The Colorado Energy Office has estimated that with a V2G system, each EV would create $600 over its lifetime in benefits to utility ratepayers.[101] V2G technology also mitigates the costs of transporting traditional fuel sources, and it cuts back on the price arbitrage of conventional energy sources.[102]

In applying this technology to AEE's effort for electric school buses, it is important to understand why bus fleets are an ideal venue through which these benefits can be realized. While individual V2G use with private vehicles is unpredictable, buses have consistent

---

2022, from: https://www.evconnect.com/blog/what-is-vehicle-to-grid-for-electric-vehicles

[95] Habib, S. Kamran, M. Rashid, U. (2015). Impact analysis of vehicle-to-grid technology and charging strategies of electric vehicles on distribution networks – A review. Journal of Power Sources. Volume 277, 1 March 2015, Pages 205-214. https://www.sciencedirect.com/science/article/pii/S0378775314020370?via%3Dihub.

[96] Wu, W. Lin, B. (2021). Benefits of electric vehicles integrating into power grid. Energy. https://www.sciencedirect.com/science/article/pii/S0360544221003571?via%3Dihub.

[97] Habib, S. Kamran, M. Rashid, U. (2015). Impact analysis of vehicle-to-grid technology and charging strategies of electric vehicles on distribution networks – A review.

[98] Dyson, M. Matson, J. Mullaney, D. (2021). Can Electric Pickup Trucks Save the Grid in Texas? RMI. Retrieved March 2, 2022 from https://rmi.org/can-electric-pickup-trucks-save-the-grid-in-texas/.

[99] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*

[100] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*

[101] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*

[102] EV Connect. (2021, December 20). *What is vehicle-to-grid for electric vehicles?*

patterns of use that can be coordinated for carefully-timed battery-energy extraction to relieve pressure on grid networks. This technology has not yet been deployed on a sufficiently broad scale to adequately assess the magnitude of projected benefits, but we can expect some clarity as demonstration projects materialize in the coming years. For example, Dominion Energy in Virginia plans to electrify 1,500 buses by 2025, offering enough excess storage and supply capacity to power more than 15,000 homes for much of the day.[103] This cost stabilization is particularly important given the **volatility in oil prices** over the last year. In mid-April 2022, diesel fuel costs averaged $4.731 in TX, $5.030 in FL and $5.020 in AZ, **making the electric fleet vehicle look like an even more attractive option**.

With that said, there are certainly challenges to V2G technology as it relates to school bus fleets. First and foremost, peak demand in most states is between 4pm and 9pm, meaning the batteries would be of greatest value as a back-up resource during those times. However, assuming most school buses run between 3pm and 5pm, they are likely at their lowest charge of the day when peak demand is taking place, making the proposition of shaving peak demand with these batteries one that is difficult to realize. Second, wear and tear on batteries as they are charged and discharged for grid services can affect their operating capabilities. There are also specific concerns around battery safety in extreme heat, which could affect buses in all three states evaluated here but most acutely in Arizona. If batteries are mishandled or manufactured incorrectly, high temperatures can lead to thermal runaway, a positive feedback loop chemical reaction that leads the battery to produce more heat, one of the main safety risks associated with lithium-ion batteries.[104] Exposure to extremely high temperatures can also cause cathode electrolyte oxidation, resulting in the loss of battery capacity, or can increase the battery's internal resistance, which results in a loss of power and lead to evaporation and corrosion in the cell, as well as a potential for overcharging. Specifically, at 113 degrees Fahrenheit, one study found that battery degradation was twice the rate of degradation at 77 degrees.[105]

Potential solutions to address the temperature sensitivity of batteries includes material selection, cell and module design and balance of the system life.[106] As for material selection, battery manufacturers need to develop non-flammable electrolytes, add fire retardants to the battery, develop coating for cathodes and anodes and implement heat resistant layers within the battery. In terms of cell and module design, cells could be better designed to handle uniform heat distribution to lengthen

[103] Wright, N. (2020). Is Vehicle-to-Grid Technology the Key to Accelerating the Clean Energy Revolution? Power Magazine. Retrieved February 2, 2022 from https://www.powermag.com/is-vehicle-to-grid-technology-the-key-to-accelerating-the-clean-energy-revolution/.

[104] Dragonfly Energy. (2021, April 21). What Is Thermal Runaway In Batteries? Retrieved March 30th, 2022 from https://dragonflyenergy.com/thermal-runaway/.

[105] Prine-Robie, Michael. (September 2020). How Does Temperature Affect Battery Performance? Retrieved March 18th, 2022 from https://www.cedgreentech.com/article/how-does-temperature-affect-battery-performance.

[106] Pesaran, A., Santhanagopalan, S., & Kim, G. H. (2013). *Addressing the impact of temperature extremes on large format li-ion batteries for vehicle applications (presentation)* (No. NREL/PR-5400-58145). National Renewable Energy Lab. (NREL), Golden, CO (United States), https://www.nrel.gov/docs/fy13osti/58145.pdf.

the life of the battery. Lastly, balancing the system of the battery is important. Manufacturers should incorporate battery thermal management systems such as a standby or pre-conditioning cooling and heating capacity. There should also be more advanced sensing and perhaps even refrigeration cooling systems with insulation.

Other challenges of vehicle-to-grid technology include the expense of sine-wave inverters and electrical code transfer switches which are necessary for the charging infrastructure for buses, the necessary investment in retraining and reskilling bus drivers and fleet operators, and the deep challenges of grid interconnection.[107]

ROLE OF EXISTING INFRASTRUCTURE

The existence of charging networks for EVs affects implementation of electric school buses in different areas. For example, areas with established charging infrastructure are more likely to support investment in V2G technology. Charging networks facilitate the transition to V2G technology because consumers and residents know what to expect in further adaptations for electric bus integration.

The plug-in EV system is constructed primarily by constructing and adding inverter generators to charging stations. The inverter allows itself to draw power from the car's main pack lithium battery and store the excess energy. Energy is stored by transferring the electricity through overhead or underground cables, wires, and substations. Inverter generators electronically throttle power converting mechanisms within vehicles up and down to meet the station's charging requirements rather than continuously streaming the full engine tilt.[108] The nuances of the technology are complex; however, construction agencies are equipped to annex inverter generators to traditional charging stations. **It is far easier to transition to V2G technology if there is already an existing charging network**. Expanding the capabilities of charging stations is a more straightforward process than creating new stations entirely.[109] If there is a structural foundation already accommodating charging stations, adding the system to the grid is conducted merely by adding an inverter and connecting the system to transmission lines.

GRID ISLANDING

Grid islanding is one of the most essential steps in ensuring that the adoption of electric school buses will provide the resilience benefits it boasts. **For a power system to be resilient, it must be capable of islanding**, meaning it can operate independently from the grid during outages. Grid islanding can be installed with just a bit of additional hardware, including transfer switches, critical load panels, and appropriate controls. These systems can act as self-sufficient microgrids, generating energy

[107] Templeton, Brad. (2021, July 15). Electric Yellow Schoolbus Will Try To Make Vehicle To Grid Power Work. Retrieved April 4th, 2022 from https://www.forbes.com/sites/bradtempleton/2021/07/15/electric-yellow-schoolbus-will-try-to-make-vehicle-to-grid-power-work/?sh=465a5a3c675a.

[108] *Vehicle to grid - save money on electric car charging*. Flexi. (2021, May 12). Retrieved March 31, 2022, from https://www.flexi-orb.com/electric-vehicles/vehicle-to-grid/.

[109] *Vehicle to grid - save money on electric car charging.*

and powering critical loads until utility services are restored during an outage. For example, a major cause of grid disturbance is an imbalance in generation and load. Mismatch between the two results in changes in frequency from the 50 Hz (assuming Grid voltage to be 50 Hz during normal condition). If the load on the grid increases, the frequency decreases while in case of a decrease in load, the frequency will increase. With the ability to island, microgrids can supply power to restore the overall grid system to the correct frequency.

[110] Image Source

FINANCING ELECTRIC SCHOOL BUSES

REVENUE AND PARTNERSHIP OPPORTUNITIES

Promises of future savings alone may not be enough for school districts to justify the upfront cost of electric school bus procurement. But as discussed above, utilities or energy service providers can often use school bus fleets to manage fluctuations in power supply and electricity cost, and in deregulated markets such as Texas, school bus operators can sell these benefits to the grid directly. In Texas, Florida, and Arizona, **opportunities are available for bus operators to earn revenues off of the grid-level benefits that electric buses can provide**, or to partner with utilities to fund the upfront cost of electric bus procurement, although the nature of these opportunities can vary based on each state's electricity market regulations.

ELECTRIC SCHOOL BUSES AND THE TEXAS WHOLESALE ENERGY MARKET:

Texas is unique among the states evaluated for this study in that it has a deregulated electricity market administered by the Electric Reliability Council of Texas, a nonprofit independent system operator. This means that ownership of generation, transmission, and distribution assets is separated, and that electricity generated in the state is traded as a commodity on a wholesale market, with prices fluctuating based on supply and demand subject to ERCOT's oversight and regulation. On the back end, consumers in most of the state are free to choose from several retail providers, whose rates usually reflect the average wholesale price over a billing period plus adders for the cost of transmission, distribution, and system maintenance. However, there are a few cities - most notably Austin and San Antonio - that are

[110] Kopanko, Whitney. "Top 5 Safety Considerations for Fleets Going Electric." *Sonny Merryman Inc.*, 14 Apr. 2022.

exempt from retail competition regulations and are instead served by one dominant distribution utility.

In theory, Texas's deregulated electricity network should allow school buses to earn additional revenues through participating in two markets managed by ERCOT:

1. **Wholesale energy market:** As participants in ERCOT's wholesale energy market, electric school buses could charge up overnight when power is cheapest and sell electricity back to the grid during the evening and summer hours when prices are higher, a process known as *energy arbitrage*. Given that school buses are usually idle during these times, arbitrage could help offset the high upfront cost of electric school bus procurement with no effect on bus route operations.

2. **Ancillary services market:** This market consists of incentive payments that ERCOT issues to any grid resources that can help moderate or counteract fluctuations in frequency caused by temporary mismatches between the supply and demand of electricity at a given time. Batteries are an excellent ancillary services resource: they ramp up and down quickly, can either absorb power from the grid or discharge power to it as needed, and lack the intermittency challenges of wind and solar generation.

However, there are a number of financial and logistical barriers that currently make these opportunities implausible for school bus operators to access on their own. On the arbitrage side, **one key challenge is that profiting off energy arbitrage requires a level of technical expertise that school bus operators may not possess**, and a level of financial risk that may not be appropriate for a provider of a critical public service to absorb. Navigating market entry for traders in ERCOT is a complex process that requires applicants to demonstrate credit quality and/or issue security deposits, to ensure that energy resources do not encounter financial difficulties that would prevent them from performing as anticipated.[111] Perhaps owing to these barriers, no operator of electric bus fleets has successfully registered as an ERCOT market participant as of publication. And even if an aggregator of electric buses could meet the financial and technical criteria required to participate in wholesale markets, they would need adequate staffing and expertise in commodity trading, hedging strategies, insurance, and state and federal securities regulations to do so effectively. Any bus operator attempting to trade wholesale electricity without this infrastructure in place could easily become insolvent during a crisis event, jeopardizing school transit for thousands of children and eliminating the bus's value as a community resilience asset. There is precedent for this type of failure: a company called Griddy, which allowed subscribers to bypass retail electric providers and purchase electricity directly from the wholesale market, was forced to cease operations in 2021 after Winter Storm Uri caused power prices to spike up to $9,000/MWh for almost five days straight, leaving many ordinary Texans saddled with

[111] "Credit." *ERCOT*, https://www.ercot.com/services/rq/credit.

monthly power bills above $10,000 and Griddy itself unable to meet its credit obligations to ERCOT.[112]

On top of these operational challenges, ERCOT market rules are not currently designed to accommodate bidirectional flow from distribution-level resources, which limits the economic case for both arbitrage and ancillary services in the near term. In most circumstances, electric school buses would pay a *retail* rate while charging, which means that even if they were able to sell power back to the grid at the wholesale rate, they'd likely be operating at a loss after factoring in the transmission, distribution, and ancillary service charges built into the retail price.[113] And if a bus were attempting to participate in the ancillary services market while also selling energy on the wholesale market, it would run the risk of not having enough capacity available to provide ancillary services when called upon, leading to severe nonperformance penalties. ERCOT is currently discussing rules changes that may address some of these challenges for distribution-level batteries, but that process is in the early stages and could take several years to complete.[114] In the interim, ancillary service prices in ERCOT are expected to decline as the number of energy storage projects in Texas expands.[115] By the time the new ERCOT regulations are complete, there will be more batteries on the grid to provide the same grid management functions, meaning that school buses may struggle to earn a sufficient payout to justify the costs of participating in the ancillary services market.

Despite the barriers to ERCOT market participation, there are still promising revenue opportunities that electric school buses in Texas can access, mostly via partnerships with retail electric providers or distribution utilities. **One such opportunity would be a payment for avoided costs built into the utility's rate base.** If a distribution utility could demonstrate that using electric buses as a storage resource would preempt the need to install expensive new substations or power lines, they would be able to include the cost of purchasing such buses in their retail rate and distribute the cost evenly to consumers, subject to approval from the Public Utility Commission of Texas. Based on a report from the Texas Advanced Energy Business Alliance quantifying the avoided-cost value of distributed resources more broadly, we estimate that each electric school bus could be worth **over $12,000 per year in avoided costs alone, translating to over $193,000 in potential savings over the lifespan of the bus**.[116] An arrangement with a distribution utility that passed through some portion of these grid management benefits to a bus owner or operator could further offset the

[112] Steffy, Loren. "Griddy Argues It Was, in Fact, a Champion of Consumers." *Texas Monthly*, June 2021, https://www.texasmonthly.com/news-politics/griddy-argues-it-championed-consumers/.
[113] Reedy, Steve. *SIPA - CIM View Consulting Interview on ERCOT Market Participant Rules for DERs*. 8 Apr. 2021.
[114] Reedy, Steve.
[115] Chang, Judy, et al. *The Value of Distributed Electricity Storage in Texas*. Brattle Group, Mar. 2015, https://www.brattle.com/wp-content/uploads/2017/10/7924_the_value_of_distributed_electricity_storage_in_texas_-_proposed_policy_for_enabling_grid-integrated_storage_investments_full_technical_report.pdf.
[116] Demand Side Analytics. *The Value of Integrating Distributed Energy Resources in Texas*. Texas Advanced Energy Business Alliance, https://www.texasadvancedenergy.org/hubfs/TAEBA%20(2019)/Valuing%20DERs%20in%20ERCOT%20final.11.13.19.pdf.

upfront cost disparity between diesel and electric buses.[117] **Alternatively, a distribution utility could directly subsidize the purchase of electric buses for use as a grid management resource**. A similar arrangement between developer AEP and transmission operator ETT helped fund the installation of a battery storage system in the remote community of Presidio, located near Big Bend National Park approximately 250 miles southeast of El Paso, in 2010.[118]

Another advantage of electric school buses that could particularly benefit retail electric providers is coincident peak shaving. This is because of the way that ERCOT decides what share of its annual systemwide transmission and distribution costs to allocate to any particular distribution utility: by assessing each utility's share of the total system load during the 15-minute intervals in June, July, August, and September when systemwide demand is highest. These intervals are known as the four coincident peaks (4CP). Because school buses are often idle during these months, there is a huge incentive for retail providers to discharge them when they anticipate a 4CP interval approaching, reducing their cost burden for the entire year. This incentive is especially strong in regions that are exempt from retail competition, like Austin and San Antonio, where the local distribution utility is also the dominant retail provider – in the rest of the state, distribution utilities can simply pass their 4CP costs onto the third-party retail providers who use their network, and the retail providers will pass the costs to consumers.

ELECTRIC SCHOOL BUSES IN VERTICALLY INTEGRATED MARKETS

Unlike Texas, Florida and Arizona both have regulated electricity markets, with a small number of dominant utilities owning and operating generation, transmission, and distribution assets with oversight by the Florida Public Service Commission and Arizona Corporation Commission, respectively. Neither state has an independent system operator like ERCOT that can operate liquid power markets, and so there are no opportunities for buses to earn additional revenues from wholesale trading or ancillary services. That said, the utilities active in these states still need to manage electricity demand and regulate the frequency at which power flows through the grid. As such, they could stand to **benefit from partnering with school districts or bus operators to procure electric buses for use as demand management resources**. Dominion Energy, a large utility operating in the partly-deregulated Virginia market, has piloted this approach, covering the incremental cost of 50 electric buses throughout the state in order to reduce volatility in power demand throughout the day when the buses are not running routes.

THIRD-PARTY FINANCING

[117] The financial model appended to this report assumes that avoided cost compensation would equal 80 percent of avoided costs, in compliance with ERCOT production cost savings requirements for transmission planning filings.

[118] *Presidio NAS® Battery Project Facts at a Glance*. Electric Transmission Texas, 5 Apr. 2010, http://www.ettexas.com/Content/documents/NaSBatteryOverview.pdf.

If long-term savings, DER revenues, and utility partnerships are still insufficient to cover the initial price gap between diesel and electric buses, **districts can turn to the debt markets to help their acquisition efforts**. The best-established approach for this type of financing would be to issue municipal bonds, particularly if the school district or municipal government has a high enough credit rating to support a low-interest offering. Large cities in Texas have used this approach to fund transportation infrastructure in the past, with Dallas adding seven electric buses to its rapid transit fleet in 2016 via a municipal bond issuance.[119] In the longer term, **green banks may be able to provide competitive financing solutions for electric school buses**. For instance, the New York Green Bank plans to get involved in the sector after the state announced plans to phase out diesel school buses by 2035 and ban new diesel bus procurement after 2027.[120] [121] However, there are no green banks currently active or slated to commence operations in Texas, Florida, or Arizona that can provide similar solutions for the foreseeable future.

THE CHALLENGE OF COST-BENEFIT ANALYSIS AND QUANTIFYING RESILIENCE

One of the biggest challenges communities face in investing in resilience measures is conducting a cost-benefit analysis. To value resilience, one must place value on hypothetical damage to the economy, infrastructure, homes and individual health. Despite this challenge, researchers have worked to estimate the value of resilience using a variety of quantifiable metrics.

The value of resilience should reflect the lost output and wages, spoiled inventory such as food waste caused by a lack of refrigeration, delayed production, inconvenience, and damages to the electric grid. [122] A study by NREL, estimated that **power outages result in $172/kWh losses for families and $15.64/kWh for commercial customers.**[123] Factoring this metric into cost-benefit analysis for resilience benefits can dramatically increase the net present value (NPV) of electric school bus acquisition. Standardizing metrics and methods for estimating resilience benefits will be essential to creating a compelling investment thesis for innovative projects, and comparisons across resilience projects.

[119] Casale, Matt, and Brendan Mahoney. *Paying for Electric Buses: Financing Tools for Cities and Agencies to Ditch Diesel*. U.S. PIRG Education Fund, Fall 2018, https://uspirg.org/sites/pirg/files/reports/National%20-%20Paying%20for%20Electric%20Buses.pdf.

[120] Spielberg, Brett. "NY's Electric School Bus Push: What to Know." *New York League of Conservation Voters*, 25 Mar. 2022, https://nylcv.org/news/nys-electric-school-bus-push-what-to-know/.

[121] Carruthers, Alexandra. *SIPA-New York Green Bank Interview on Electric School Bus Financing*. 5 Apr. 2022.

[122] "Valuing the Resilience Provided by Solar and Battery Energy Storage Systems." *Department of Energy*, https://www.energy.gov/sites/prod/files/2018/03/f49/Valuing-Resilience.pdf. Accessed 19 April 2022.

[123] "Valuing the Resilience Provided by Solar and Battery Energy Storage Systems." *Department of Energy.*

[124] Image Source

CRITERIA FOR IMPLEMENTATION

Each school district, municipality, and state is unique, and therefore it is nearly impossible to make a blanket recommendation for actionable steps to accelerate the adoption of EVs across all levels. Instead, it is imperative to consider key criteria in order to identify the school districts, municipalities or states which are most inclined to begin the process to adopt the use of electric school buses. To identify such opportunities, this report suggests **a framework to understand policy, infrastructure/grid, physical and environmental, school district, and financial considerations.** **(TABLE 1)** If an opportunity school district, municipality or state possesses these characteristics, it is likely that the road to adopting electric school buses will be met with the least friction.

[124] "Your Full Service Bus Dealer." *Sonny Merryman Inc.*, 21 Mar. 2022, https://sonnymerryman.com/#.

Policy Considerations

The policy considerations which factor into a school district, municipality, or state adopting electric school buses boil down into five indicators. First, one must assess what incentives are available to an entity at the state, federal or utility level. These funding opportunities are necessary in order to reduce the costs associated with purchasing electric school buses, which oftentimes is considered a barrier to obtaining such assets. Next, it is helpful to consider municipalities which have goals, comprehensive strategies and mandates surrounding renewable energy generation and usage and climate resilience. To date, the success stories which exist are often attributed to a municipality having renewable or climate resilience goals and strategies, and the adoption of EVs is used to help reach these goals. The existence of such goals and strategies may also serve as an indication of acceptance within a community, representing a more easily penetrable market for electric school buses. Third, one must consider the administrative capacity of schools and municipalities. It is difficult and time consuming to identify, pursue and apply for local and federal funding opportunities. Such work requires full-time dedication focused solely on applying for grants and such, and therefore it is important to target school districts and municipalities which have the bandwidth and patience for such work. Fourth, one must consider policy barriers when identifying school districts, municipalities, and states which might adopt electric school buses. The most widespread and noteworthy barriers include net metering and interconnection rules. And lastly, it is important to consider a school district's, municipality's, or state's orientation toward partnership arrangements. To do so, one must consider historical or current partnerships and what their focus was and which organizations did that actor choose to partner with. Past and present partnerships are an important indicator of a school district, municipality or state's level of interest and compatibility working with other organizations, and their appetite for doing so. Municipalities which frequently partner with outside organizations are more likely to do so in the future than those which do not.

STEPS FOR ACCELERATING ADOPTION

After determining which areas would most readily adopt electric school buses based on the above criteria, there are five main policy recommendations which should be considered. They are: making the argument, setting goals, assessing partnerships, assessing available incentives, and overcoming regulatory barriers. (**TABLE 1**) These buckets of recommendations strive to provide a guide to accelerate the adoption of electric school buses through school districts, municipalities and states and to influence decision makers.

1. **Making the Argument:** The first step in accelerating the adoption of electric school buses is to identify, quantify and communicate the benefits such assets could provide.

There are myriad benefits associated with the adoption of electric school buses, ranging from health and environmental benefits to grid resilience and potential long-term cost savings. Because each state, municipality and school district is unique, it is important to tailor the benefits communicated to each to make the argument that adopting electric school buses is a savvy transition, as different benefits of such adoption will resonate differently across each. It is also important in this step to communicate to key decision makers the resources available to them in order to accelerate electric school bus adoption. A certain level of support is available across the entire country due to federal grants and funding opportunities, and these, as well as more local financing opportunities, must be communicated to the appropriate stakeholders.

Health and environmental benefits associated with electric school bus adoption include, but are not limited to, greenhouse gas emissions reductions. If the country were to replace all diesel-powered school buses with EVs, then GHG emissions would be reduced by roughly eight million metric tons. Similarly, a 2016 study found that the use of V2G with electric school buses would eliminate an average of 1,000 metric tons of CO_2 equivalent GHG emissions per bus over its lifetime.[125] The same study found that the use of V2G eliminates enough pollution to completely offset air pollution damage caused by the

[125] *Electric School Buses and the Grid - Environmentamerica.org.*

charging needs of electric school buses from the grid. As mentioned in the public health section of the report, school aged children who ride school buses are exposed to 5-15 times more air toxins than those who do not, proving that the health and environmental benefits associated with adopting electric school buses is necessary.

2. **Setting Goals:** States, municipalities and school districts should make public their intention to transition their school bus fleets to electric in a detailed and achievable timescale.

   To develop net-zero and electric school bus fleet targets across states, municipalities and school districts will accelerate the adoption of electric school buses. To study the feasibility and logistics associated with such a transition will also be necessary in order to chart the course for electric school bus adoption, and the transition from diesel fleets. Utilities can assist in this goal setting by updating energy management systems with smart grid technologies which support efficient distribution of energy generated through electric school bus fleets. Utilities may also explore opportunities to profitably utilize distributed energy resources to strengthen grid operation reliability during any influx of intermittent renewable capacity.

3. **Partnerships:** Partnerships between schools and local decisionmakers, utilities and states will prove to be invaluable to the adoption of electric school buses.

   Schools and local decision makers could jointly evaluate the availability of budgetary resources with the documentation of fleet characteristics and an inside understanding of school district budgets and busing contracts. They may also identify relevant points of contact in state and federal grant offices, and look toward city/county collaboration opportunities. Each of these partnership opportunities provides school districts with tools and funding opportunities which benefit them, while also indicating to AEE's network of businesses that these decision makers are not averse to partnerships with its schools or municipalities, but may be averse to the particular project being promoted through such a partnership.

   Utilities also play a substantial role in building partnerships in order to accelerate the adoption of electric school buses. Utility incentives may bridge gaps which exist between policies and school districts, and create a unique and enticing opportunity for school districts or municipalities to lessen the costs associated with adopting EVs. Through the form of rebates and incentives, utilities support the implementation and use of electric school buses in an area by reducing startup costs and encouraging municipalities to participate in V2G practices.

4. **Incentives:** Enhancing incentives and/or direct investments in EVs and EV chargers and codifying statewide targets for EV deployment would improve the overall per capita numbers of EVs and EV charging infrastructure in the state.

   States and utilities should rework net metering policy to facilitate the compensation of exporting distributed energy resource owners, perhaps even at above the geographically relevant retail kWh price for energy.

5. **Overcoming Regulatory Barriers:** State regulators must ensure that rules at the state and local distribution service provider level don't stifle the adoption of electric buses. Further, state legislators should proactively adopt customer protections to prohibit policies or regulations at all levels which inhibit DER development.

Other regulatory barriers such as utility rate structures, distribution barriers and DER interconnection policy all must be overcome in order to adopt electric school buses more broadly across Arizona, Florida and Texas. Once these barriers are overcome to a certain extent, each of the three states and the school districts within them may more easily be able to adopt electric school buses and to reap the political, economic and resilience benefits associated with such a transition.

Infrastructure and Grid Considerations

The infrastructure and grid considerations are relatively straightforward. It is necessary to consider the state of existing charging infrastructure, charging time, interconnection availability, renewables already on the grid and the need for storage capacity, and the age of the grid and state of modernization. As mentioned above, school buses offer a unique opportunity when it comes to revenue and resilience benefits which other EVs do not: they only operate during mornings and afternoons. Unlike other city buses, school buses can be charged during off-peak hours, and can return energy back to the grid during peak demand. That being said, **interconnection availability is crucial to determine whether an electric school bus may reap the benefits of its flexible and low-demand schedule**. A strong indication of the speed and scale at which a municipality or state can scale up interconnection availability is through an analysis of existing renewable energy sources which are already on the grid (one example is solar) to determine an area's need for storage capacity and robustness of existing vehicle to grid capabilities. These considerations also factor in the age of a grid and the state of its modernization, and whether there will need to be a phase to retrofit or update existing infrastructure to accommodate the adoption of electric school buses in a particular area.

Physical and Environmental Considerations

The physical and environmental considerations needed are surrounding peak and average temperatures in a given setting, air quality, and frequency and nature of extreme weather events. Given the technological barriers and risks associated with utilizing EV batteries above certain temperatures as described in the technology portion of this report, it is important to weigh the feasibility and safety of using lithium-ion batteries in particular climates. Air quality in a given setting is also an important consideration to assist in the targeting of a certain area for electric school bus adoption. For instance, communities suffering from poor air quality and looking for solutions to combat this will be most welcoming to adopting electric school buses if it means significant abatement of harmful emissions being produced by diesel buses. And lastly, as the frequency and severity of natural disasters increases due to the harmful effects of climate change, communities which bear the brunt of these disasters will be most likely to consider the resilience benefits associated with adopting electric school buses in their communities. While the physical and environmental landscape of a community does not have to do directly with school buses, the people within these communities will be most swayed to consider electric school buses as a solution when met with the harmful and unavoidable effects of climate change, particularly for the sake of children and community safety.

School District Considerations

Before transitioning to electric buses, school districts must consider their own operational needs based on student demographics and the logistical capabilities of their bus fleets. The operational elements include the number of school aged children within a municipality or school district, the fleet ownership model within a school district, a school's budget for transportation, and a school's credit rating and credit history. These elements are important indicators of the need for additional school buses, identifying opportunities to offset the cost of electric school bus ownership through models such as buses as a service, as well as a school's likelihood of being considered for debt financing for electric school buses through alternative financing options. Fleet characteristics relate closely to these considerations, but include factors such as the age of a fleet (including the make and models of the fleet and whether it is under warranty, and what that warranty structure is), fleet operations (miles per gallon, maintenance costs, etc.), population density, and vehicle miles traveled. These considerations are important to determine whether it is the optimal time for a school district to replace its diesel fleet, either entirely or partially, with electric school buses, and determine the practicality of considering an electric school bus in terms of miles traveled and avoided costs through diesel and maintenance costs. Considerations surrounding school districts are necessary in order to determine which districts within a municipality or state are most likely going to adopt electric school buses sooner and more readily than others.

CONCLUSION

Despite the significant value proposition offered by V2G, school bus electrification faces an uphill battle. Utility and policy incentives in Arizona and Texas will likely lead to accelerated adoption in these states as compared to Florida. While electric buses are on the road to cost parity with their diesel counterparts, additional funding from private and public institutions is essential to increase deployment.

As described above, there are four main federal policy incentives which deliver funding for states, municipalities and school districts, and more state and utility incentives within each state which supplement these funding options. In addition, it would help for districts to benefit from other financial mechanisms, from wholesale market revenues to utility funding to green banks and municipal bonds, to reduce the cost differences between electric and diesel vehicles. However, to accelerate the adoption of EVs in Arizona, Florida and Texas, changemakers must also consider factors related to policy, infrastructure, the environment, and district-specific financial and logistical needs and capabilities

By accelerating the adoption of electric school buses in Arizona, Florida Texas, and beyond, states become more environmentally conscious and while saving money on energy resilience measures. States will nurture a safer environment for their citizens by cutting down on state-wide emissions and improving the air quality in a particular area, all while also providing grid resilience benefits to help communities mitigate the consequences of natural disasters**. As the frequency and intensity of severe storms increases due to climate change, these resilience benefits will become all the more important.**

While barriers to adopting electric vehicles exist, they bring with them the opportunity to change the landscape of renewable energy in the U.S. Electric school buses can reduce harmful emissions in the country on a large scale, can equip communities to be best prepared for climate-related disasters, and can assist states and municipalities in achieving emissions-reduction goals. The policy and financing considerations to target specific areas with an emphasis on funding opportunities will most effectively accelerate the adoption of electric school buses, and all the benefits it brings.

APPENDIX

Success Stories

While Arizona, Florida and Texas each face unique barriers to, and possess varying windows of opportunity for the adoption of EVs, it is helpful to look at success stories outside of these three subject states. The adoption of electric school buses in other settings can teach valuable lessons to decision makers and businesses interested in accelerating such transitions in Arizona, Florida and Texas. Specifically, there are valuable insights to discuss in Colorado, Maryland, Massachusetts and California. While these four states represent vastly different political and economic climates compared to our focus states, the ways in which they adopted electric school buses, and how they did so, can help us identify commonalities and opportunities that will better help to accelerate the adoption of EVs in Arizona, Florida and Texas.

BEVERLY, MASSACHUSETTS

The fleet upgrade now underway in Beverly, Massachusetts, is due in large part to Highland Electric. Highland provides buses and V2G-capable fast chargers from Thomas Built Solutions and Protera, as well as routine maintenance, in a turnkey service model with a fixed monthly subscription rate. This model is a powerful tool for scaling the market in inhospitable environments.

Beverly drew headlines last year for purchasing a single bus, a Thomas Built Saf-T-Liner C2 Jouley, through this model in association with the National Grid of New England, but the plan is ultimately to electrify the whole fleet of 27 vehicles[126]. In making the decision to purchase its electric bus, Beverly was motivated, in part, by the fact that more than 45% of emissions within the city come from transportation. This project was financed largely through contributions from the Volkswagen settlement over Clean Air Act violations from the state of Massachusetts, as well as the statewide Accelerating Clean Transportation Now grant program. **This bus successfully delivered roughly three megawatt hours of electricity** back to the electricity grid for more than 50 hours over the course of 30 transfer sessions spanning a summer[127]. In doing so, the bus helped **reduce local emissions and decreased the need to fire up costly fossil fuel "peaker" plants.**[128]

[126] Shemkus, S. (2020). Start-up bets on new model for putting electric school buses on the road. https://energynews.us/2020/11/02/start-up-bets-on-new-model-for-putting-electric-school-buses-on-the-road/;
Motavalli, J. (2021). How VW's Diesel Settlement Is Changing Fleets, From Schools to Seaports. New York Times. https://www.nytimes.com/2020/11/05/business/vw-diesel-settlement-states.html.

[127] Thomas Built Buses. (2021). Beverly Massachusetts Electric School Buses Make V2G Energy Transfer History. https://thomasbuiltbuses.com/resources/articles/beverly-massachusetts-electric-school-buses-make-v2g-energy-transfer-history/.

[128] Proterra. (2021). Massachusetts Electric School Bus Helps Power Electricity Grid in Breakthrough for Vehicle-to-Grid Technology. https://www.globenewswire.com/news-release/2021/10/13/2313394/0/en/Massachusetts-Electric-School-Bus-Helps-Power-Electricity-Grid-in-Breakthrough-for-Vehicle-to-Grid-Technology.html.

CALIFORNIA

California is considered a leader in policies which support the electrification of transportation. In October 2019, the state passed a bill that required the California Public Utilities Commission to maximize the use of effective and cost-efficient vehicle to grid integration by 2030. Since this bill has been passed, it has been backing up programs to ensure the adoption to scale of V2G technology.[129]

One of the most notorious methods to accelerate adoption of V2G is the creation of working groups to answer questions essential to eliminate barriers. Working groups are usually comprised of utilities, car manufacturers, environmental groups and charging infrastructure manufacturers.[130]

Policies focused on facilitating the adoption of EV technology through incentives that reduced costs of purchase and operations. Policies were implemented in phases to address different barriers to large scale adoption of V2G such as finances and adequate infrastructures. Addressed readiness of the grid, particularly distribution grid, interconnection and tariff issues, storage and demand responses.

The states performed multiple V2G demonstrations or pilots with car manufacturers to study the applications and possibilities of V2G. Most demonstrations were concluded with reports that highlighted successes, barriers and economic values.

Florida, with its increasing number of EV, could benefit from working groups to increase the number of policies that could address challenges that come with the adoption of V2G. The state can also collaborate with utilities to create policies that could support school buses operations. The increasing incentives to make school buses affordable could serve as a long-term investment to meet electricity demands in case of natural disasters.

DURANGO, COLORADO

In January of 2022, Colorado had its first EV bus transport children in the Durango School District while that same school bus also provided energy to the grid[131]. The catalyst which led to the adoption of this electric school bus was in June of 2021, when the City of Durango voted to adopt the city's and La Plata Electric Association's (LPEA) first EV Readiness Plan[132]. The EV Readiness Plan is a partnership between the city of Durango and LPEA to help residents and visitors to the city make the switch to EVs while saving money and reducing costs. The plan focuses on EV charging infrastructure, LPEA fleet electrification and public adoption of EVs.[133] While the EV Readiness Plan is a powerful partnership, there

[129] "California's Vehicle-to-Grid Experiments Offer a Glimpse of the Future." 2022. Morning Brew. Accessed March 29. https://www.morningbrew.com/emerging-tech/stories/2022/03/18/california-s-vehicle-to-grid-experiments-offer-a-glimpse-of-the-future.

[130] Galtieri, Francisco, Alejandro Neira, Daniel Propp, and Claudio Protano. n.d. "Vehicle-Grid Integration in California: A Cost-Benefit Comparison Study," 52.

[131] Burney, Christian. "Durango's Electric School Bus Is like a Huge Battery on Wheels." *Durango Herald*, 5 Jan. 2022, https://www.durangoherald.com/articles/durangos-electric-school-bus-is-like-a-huge-battery-on-wheels/.

[132] "Electric Vehicles." *Electric Vehicles | Durango, CO - Official Website*, https://durangogov.org/1383/Electric-Vehicles.

[133] "Electric Vehicles." *Electric Vehicles*

were many policies leading up to its development, including:[134]

- In Nov. 2018 the Colorado Air Quality Control Commission adopted Low Emission Vehicle standards and then in Aug. of 2019 they adopted the Zero Emission Vehicle Standards
- The Colorado Energy Office set a goal of having LDV be 100% electric and medium and heavy-duty vehicles be zero emission, and a goal of having 940,000 EVs on the road by 2030.
- The City of Durango set a plan in 2015 to support EV adoption, increasing municipal fleet efficiency
- In 2019, the City of Durango voted on a transportation goal: 80% reduction in GHG emissions from 2016 levels by 2050
- In 2019, LEPA adopted a goal to reduce its carbon footprint by 50% from 2018 levels by 2030

In addition to the goals and policies put in place above, this EV Readiness Plan was developed in October of 2020 and was passed in June of 2021. This strategic plan includes V2G explorations in phase 3 which is 2026 – 2030.[135] The plan also included working with Durango School District 9-R to electrify their bus fleet and was set to be done from 2021- 2022.[136]

MONTGOMERY, MARYLAND

In 2021, the Montgomery County Public School District signed an agreement with Highland Electric to **electrify 326 school buses over a four-year period.**[137] This project was possible due to a grant awarded from Maryland's Energy Association, and will be providing energy to the grid in partnership with Pepco[138]. This project will break the record for the single largest procurement of electric school buses in North America. With support from the Maryland Energy Association, they're also building charging stations at each bus depot site. This project is a **blueprint for explosive market growth**. The following policies in place also led to this project becoming implemented:

- Montgomery County's Climate Action Plan includes a goal to cut GHG 80% by 2027 and 100% by 2035.[139]
- 100% of private and public transportation will need to be powered by zero emissions technologies by 2035.[140]
- Converting the school bus fleet will reduce carbon emissions by 25,000 tons per year while cutting diesel pollution harmful to human health, contributing to both

[134] *Electric Vehicle Readiness Plan - Durangogov.org.* https://www.durangogov.org/DocumentCenter/View/20368/Durango-EV-Readiness-Plan.
[135] *Electric Vehicle Readiness Plan - Durangogov.org.*
[136] *Electric Vehicle Readiness Plan - Durangogov.org.*
[137] Posted March 5, 2021 by Charles Morris & filed under Newswire. "Proterra to Deliver over 320 V2G-Equipped School Buses to Montgomery County, Maryland." *Charged EVs*, 5 Mar. 2021, https://chargedevs.com/newswire/proterra-to-deliver-over-320-v2g-equipped-school-buses-to-montgomery-county-maryland/.
[138] Charles Morris & filed under Newswire. "Proterra to Deliver over 320 V2G-Equipped School Buses to Montgomery County, Maryland."
[139] *Zero-Emission Vehicles*, https://www.montgomerycountymd.gov/green/zev/index.html.
[140] *Zero-Emission Vehicles*

Maryland and Montgomery County goals.[141]

- Maryland's Energy Administration created and manages the Clean Fuels Incentive Program (CFIP) that supports the purchases of alternative fuel vehicles and provides funding to do so.[142]
- In 2016, the GHG Emission Reduction Act was signed into law. It requires the state to reach a minimum of 40% reduction in GHG emissions from 2006 levels by 2030.[143]
- Maryland adopted the Zero Emissions Program (ZEV) in 2007, a goal of 300,000 ZEVs on the road by 2025.[144]
- Maryland signed an MOU with 13 other jurisdictions to electricity medium and heavy-duty trucks, with that a goal of `00$ ZEV sales by 2050.[145]
- Pepco's energy goals are aligned with the State of Maryland, that 50% of electricity delivered to customers by come from renewable energy sources by 2030.

There may be many more policies that all lead to the support of the big Highland project in the county. The school district will pay Highland an annual fee to lease the buses, and Highland will operate and maintain the buses for 12 years in addition to training drivers and installing charging equipment.[146]

While Arizona, Florida and Texas certainly encompass political, cultural and financial characteristics which make them unique to the success story state discussed above, there are valuable lessons that can be learned from California, Colorado, Massachusetts and Maryland. For instance, it is likely that Arizona and Texas could invest in comprehensive policies that accelerate the use of electric school buses. Barriers and challenges can be explored through working groups that can attempt to answer critical questions. Demonstrations and pilot projects can also serve as short term opportunities to gather insights. Collaboration with utilities and car manufacturers can also serve in addressing challenges to adoption of V2G technology in the long run. These are valuable lessons that can be gleaned from analyzing the successes of other states in their adoption of electric school buses at various scales.

---

141 "Montgomery County Public Schools Approves the Nation's Largest Procurement of Electric School Buses with Highland Electric Transportation." *Business Wire*, 25 Feb. 2021, https://www.businesswire.com/news/home/20210225005412/en/Montgomery-County-Public-Schools-Approves-the-Nation%E2%80%99s-Largest-Procurement-of-Electric-School-Buses-With-Highland-Electric-Transportation.

142 "Maryland Energy Administration." *MEA Success Stories*, https://news.maryland.gov/mea/2021/02/24/new-maryland-clean-fuels-incentive-program-greens-transportation-sector-1-3-million-awarded-to-five-organizations-largest-electric-school-bus-deployment/.

143 *2021 Work Plan - Maryland.* https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG%20Workplan%202021.pdf.

144 *Maryland Department of the Environment*, https://mde.maryland.gov/programs/Air/MobileSources/Pages/ZEV.aspx.

145 *2021 Work Plan - Maryland.*

146 Mufson, Steven, and Sarah Kaplan. "A Lesson in Electric School Buses." *The Washington Post*, WP Company, 3 June 2021, https://www.washingtonpost.com/climate-solutions/2021/02/24/climate-solutions-electric-schoolbuses/.

TABLE 1 – KEY CONSIDERATIONS

Dimension	Element	Indicator
Policy	Incentives	State Incentives Utility Incentives Federal Incentives Goals, comprehensive strategy and mandates around renewables and climate resilience
	Barriers	Administrative capacity of schools and municipalities Policy barriers (net metering, interconnection rules, etc.) Tax revenue sources History and orientation towards partnership arrangements
	Voter support	Household adoption of EVs
Physical & Environmental	Factors	Peak Temperatures Air Quality Frequency and nature of extreme weather events
Infrastructure and Grid	Charging Specific Infrastructure	State of existing charging infrastructure Type of charger(s) in existing infrastructure
	Grid Modernization	Interconnection availability Renewable generation portfolio Age of the grid and state of modernization
School Districts	Operational	Number of school aged children BaaS/Ownership Model School budget for transportation School credit rating and credit history
	Fleet Characteristics	Fleet operations (MPG, maintenance, etc.) Population density Vehicle miles traveled
Financial	Funding Levers	Establishment of Green Banks Municipal bonds
	Financial Partners	Investors (Pension funds, VCs, etc.)

FIGURES 1-3
ELECTRIC SCHOOL BUS TOTAL COSTS BY STATE

Figure 1: Texas Electric School Bus Total Cost

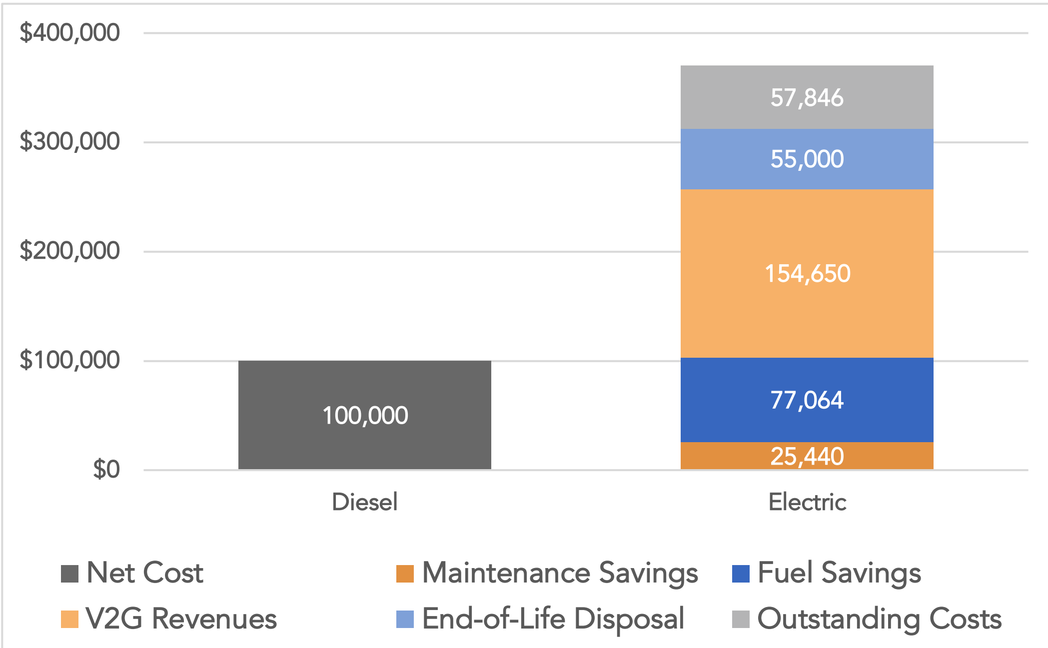


Figure 2: Florida Electric School Bus Total Cost

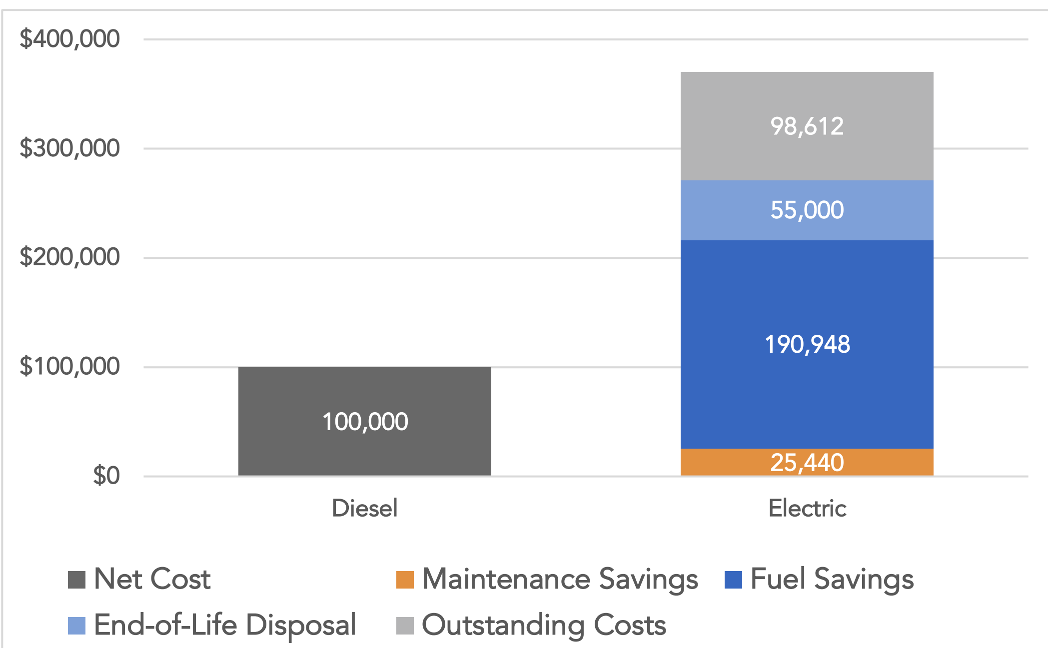
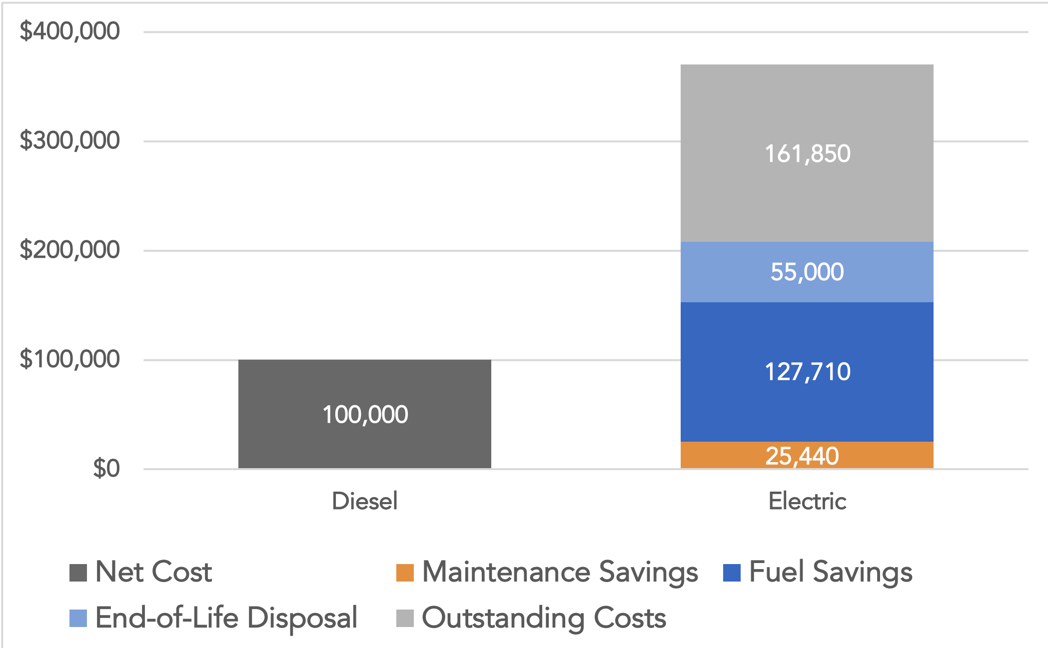


Figure 3: Arizona Electric School Bus Total Cost



Works Cited

2020. Distributed Generation. *ERCOT*. https://www.ercot.com/services/rq/re/dgresource.

2021 American Rescue Plan (ARP) Electric School Bus Rebates. https://www.epa.gov/dera/2021-american-rescue-plan-arp-electric-school-bus-rebates.

2021 Work Plan - Maryland. https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG%20Workplan%202021.pdf.

Accelerating the Transition to Electric Buses. https://masspirg.org/sites/pirg/files/reports/MA_EL%20buses%202021%20scrn.pdf.

"Alternative Fuels Data Center: Electric Vehicle (EV) Infrastructure Support." *Alternative Fuels Data Center*, https://afdc.energy.gov/laws/12774. Accessed 19 April 2022.

"Arizona Electric Utilities Voluntarily Commit to 100% Clean Energy." *Sitefinity-2020-Oct*, https://www.azcc.gov/news/2022/01/27/arizona-electric-utilities-voluntarily-commit-to-100-clean-energy.

"Arizona Laws and Incentives." Alternative Fuels Data Center: *Arizona Laws and Incentives*, https://afdc.energy.gov/laws/all?state=AZ.

"Beverly Massachusetts Electric School Buses Make V2G Energy Transfer History." *Thomas Built Buses*, 19 Nov. 2021, https://thomasbuiltbuses.com/resources/articles/beverly-massachusetts-electric-school-buses-make-v2g-energy-transfer-history/.

Blue Bird Electric School Buses. *Blue Bird*, 21 July 2020, https://assets.ctfassets.net/ucu418cgcnau/362sQcGinJzFxVqFh0DBCr/cb2ee507e5c8f646ee133bfdabbccbfb/02_Blue_Bird_Electric_Bus_Presentation_Truck_and_Bus_NOTES_V2.pdf.

Brown, D. (2019). "Arizona Receives Failing Grade on VW Settlement Spending Plan." *Arizona PRG*. https://arizonapirg.org/news/azp/arizona-receives-failing-grade-vw-settlement-spending-plan.

Burney, Christian. "Durango's Electric School Bus Is like a Huge Battery on Wheels." *Durango Herald*, 5 Jan. 2022, https://www.durangoherald.com/articles/durangos-electric-school-bus-is-like-a-huge-battery-on-wheels/.

Carruthers, Alexandra. SIPA-New York Green Bank Interview on Electric School Bus Financing. 5 Apr. 2022.

"California's Vehicle-to-Grid Experiments Offer a Glimpse of the Future." 2022. *Morning Brew*. Accessed March 29. https://www.morningbrew.com/emerging-tech/stories/2022/03/18/california-s-vehicle-to-grid-experiments-offer-a-glimpse-of-the-future.

Casale, Matt and Brendan Mahoney. "Paying for Electric Buses: Financing Tools for Cities and Agencies to Ditch Diesel." *U.S. PIRG Education Fund*, Fall 2018, https://uspirg.org/sites/pirg/files/reports/National%20-%20Paying%20for%20Electric%20Buses.pdf.

Chang, Judy, et al. "The Value of Distributed Electricity Storage in Texas." *Brattle Group*, Mar. 2015, https://www.brattle.com/wp-content/uploads/2017/10/7924_the_value_of_distributed_electricity_storage_in_texas_-_proposed_policy_for_enabling_grid-integrated_storage_investments_full_technical_report.pdf.

"Clean Buses." *Florida Conservation Voters Education Fund*, https://fcvef.org/portfolio/clean-buses/.

"Clean Diesel Program." *Clean Diesel Program | Maricopa County, AZ*, https://www.maricopa.gov/4509/Clean-Diesel-Program.

Clean School Bus Program Funding. *EPA*. https://www.epa.gov/cleanschoolbus.

"Distributed Energy Resources Could Save Texas Customers $5.47 Billion." *Microgrid Knowledge*, 3 Dec. 2019, https://microgridknowledge.com/distributed-energy-resources-texas/.

Contributor, ByGuest. "School Bus Electrification: Charging Q&A." *CleanTechnica*, 3 Feb. 2022, https://cleantechnica.com/2022/02/02/school-bus-electrification-charging-qa/.

"Credit." *ERCOT*, https://www.ercot.com/services/rq/credit. 2022.

Czapla, Ewelina, et al. "Energy Technology Export Controls." *AAF*, 21 Dec. 2020, https://www.americanactionforum.org/insight/energy-technology-export-controls/.

Day, James. "School Buses as the Largest Transit System in the US (recent stats)." *DMV List*, 3 March 2020, Day, James.

"DEMP - Volkswagen Settlement and DERA." *Florida Department of Environmental Protection*, 25 February 2022, https://floridadep.gov/Accessed 19 April 2022.Distributed Energy Resources. The South-central Partnership for Energy Efficiency as a Resource. https://eepartnership.org/

Doris, Tony. "City getting electric school buses that recharge FPL grid at peak times." *Palm Beach Post*, 31 July 2019, https://www.palmbeachpost.com/ Accessed 19 April 2022.

Dragonfly Energy. "What Is Thermal Runaway in Batteries?" *Dragonfly Energy*, 5 Apr. 2022, https://dragonflyenergy.com/thermal-runaway/.

Dyson, M. Matson, J. Mullaney, D. (2021). "Can Electric Pickup Trucks Save the Grid in Texas?" *RMI*. Retrieved March 2, 2022 from https://rmi.org/can-electric-pickup-trucks-save-the-grid-in-texas/.

"Electric School Buses: Dominion Energy." *Electric School Buses | Dominion Energy*, https://www.dominionenergy.com/our-stories/electric-school-buses.

Electric School Buses and the Grid - Environmentamerica.org. https://environmentamerica.org/sites/environment/files/reports/US_V2G%202022%20scrn.pdf.

"Electric Vehicles." *Electric Vehicles* | Durango, CO - Official Website, https://durangogov.org/1383/Electric-Vehicles.

Electric Vehicle Readiness Plan - Durangogov.org. https://www.durangogov.org/DocumentCenter/View/20368/Durango-EV-Readiness-Plan.

Environmental Technical Assistance Program Newsletter, https://etapnews.transportation.org/.

EPA Awards Rebates Totaling $17 Million to Fund School Buses that Reduce Diesel Emissions and Protect Children's Health. *EPA*. https://www.epa.gov/newsreleases/epa-awards-rebates-totaling-17-million-fund-school-buses-reduce-diesel-emissions-and-0.

EV Connect. (2021, December 20). Retrieved March 31, 2022, from: https://www.evconnect.com/blog/what-is-vehicle-to-grid-for-electric-vehicles.

Galtieri, Francisco, Alejandro Neira, Daniel Propp, and Claudio Protano. n.d. "Vehicle-Grid Integration in California: A Cost-Benefit Comparison Study," 52.

Gheorghiu, Iulia. "Florida passes net metering bill that will gut rooftop solar, advocates say, as they call for a veto." *Utility Dive*, 8 March 2022, https://www.utilitydive.com/news/florida-passes-net-metering-bill-that-will-gut-rooftop-solar-advocates-say/620000/. Accessed 20 April 2022

"Governor Ron DeSantis Announces Budget Proposals for Everglades Restoration, the Protection of Water Resources, and the Resilient Florida Program." *Florida Governor Ron DeSantis*, https://www.flgov.com/2021/11/16/governor-ron-desantis-announces-budget-proposals-for-everglades-restoration-the-protection-of-water-resources-and-the-resilient-florida-program/.

Habib, S. Kamran, M. Rashid, U. (2015). Impact analysis of vehicle-to-grid technology and charging strategies of electric vehicles on distribution networks – A review. *Journal of Power Sources*. Volume 277, 1 March 2015, Pages 205-214. https://www.sciencedirect.com/science/article/pii/S0378775314020370?via%3Dihub.

Hall, J. Jewell, M. Ryan, S. (2020). Encouraging the Development of Distributed Energy Resources in Texas. *Environmental Defense Fund*. https://www.edf.org/sites/.

Harris, Alex. "Florida to set goals for 100% renewable energy by 2050. But will it actually happen?" *WUSF News*, 12 February 2022, https://wusfnews.wusf.usf.edu/environment/2022-02-12/florida-to-set-goals-for-100-renewable-energy-by-2050-but-will-it-actually-happen. Accessed 20 April 2022.

Hawkins, Celeste. "Montgomery CO Approves Nation's Largest Electric School Bus Procurement." *Proterra*, 11 June 2021, https://www.proterra.com/press-release/montgomery-county-approves-largest-electric-school-bus-order/.

Horrox, James, et al. "Electric School Buses and the Grid." *Environment Texas*, TexPIRG, 2022, https://environmenttexas.org/ Accessed 19 April 2022.

Howard, B. Vaidyanathan, S. Cohn, C. Henner, N. Jennings, B. (2021). *The State Transportation Electrification scorecard. ACEEE.* https://www.aceee.org/sites/default/files/pdfs/t2101.pdf.

Illume Advising, LLC. https://illumeadvising.com/

JEA Electrification Rebate Program, https://erp.programprocessing.com/. Accessed 19 April 2022.

Johnson, Caley, et al. Financial Analysis of Battery Electric Transit Buses. Technical Report, NREL/TP-5400-74832, *National Renewable Energy Lab*, June 2020, https://afdc.energy.gov/files/u/publication/financial_analysis_be_transit_buses.pdf.

Kahn, Michael W. "The Big Yellow, All-Electric School Bus - America's Electric Cooperatives." *National Rural Electric Cooperative Association*, 6 July 2017, https://www.electric.coop/. Accessed 19 April 2022.

Kane, Mark. "First Student Orders 260 Lion Electric School Buses." *InsideEVs*, InsideEVs, 22 May 2021, https://insideevs.com/news/508387/first-student-lion-electric-buses/.

Kopanko, Whitney. "Top 5 Safety Considerations for Fleets Going Electric." *Sonny Merryman Inc.*, 14 Apr. 2022, https://sonnymerryman.com/news/top-5-safety-considerations-for-fleets-going-electric/.

Loveday, S. (2022). Texas EV Drivers May Get $200-$400 Fee To Replace Gas Tax. *Inside EVs.* https://insideevs.com/news/568956/texas-ev-fee-potential/.

Lytle, Rosemary. "Electric School Bus." *Mothers out Front*, 8 April 2021, https://www.mothersoutfront.org/ Accessed 19 April 2022.

"Maintenance and Safety of Hybrid and Plug-In Electric Vehicles." Alternative Fuels Data Center, *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy*, https://afdc.energy.gov/vehicles/electric_maintenance.html#:~:text=EVs%20typically%20require%20less%20maintenance,reduced%20due%20to%20regenerative%20braking.

"Maryland Energy Administration." *MEA Success Stories*, https://news.maryland.gov/mea/2021/02/24/new-maryland-clean-fuels-incentive-program-greens-transportation-sector-1-3-million-awarded-to-five-organizations-largest-electric-school-bus-deployment/.

Maryland Department of the Environment, https://mde.maryland.gov/programs/Air/MobileSources/Pages/ZEV.aspx.

McLaughlin, K. Balik, J. (2022). 5 ways US states can get more electric school buses on the road. *GreenBiz.* https://www.greenbiz.com/article/5-ways-us-states-can-get-more-electric-school-buses-road.

Mehrjerdi, H., & Rakhshani, E. (2019). Vehicle-to-grid technology for cost reduction and uncertainty management integrated with solar power. *Journal of Cleaner Production*, 229, 463-469.

"Members." *Electric Cooperatives*, https://feca.com/members/. Accessed 19 April 2022.

"Montgomery County Public Schools Approves the Nation's Largest Procurement of Electric School Buses with Highland Electric Transportation." *Business Wire*, 25 Feb. 2021, https://www.businesswire.com/news/home/20210225005412/en/Montgomery-County-Public-Schools-Approves-the-Nation%E2%80%99s-Largest-Procurement-of-Electric-School-Buses-With-Highland-Electric-Transportation.

Morris, Charles, March 5, 2021, Newswire. "Proterra to Deliver over 320 V2G-Equipped School Buses to Montgomery County, Maryland." *Charged EVs*, 5 Mar. 2021, https://chargedevs.com/newswire/proterra-to-deliver-over-320-v2g-equipped-school-buses-to-montgomery-county-maryland/.

Motavalli, J. (2021). How VW's Diesel Settlement Is Changing Fleets, From Schools to Seaports. *New York Times.* https://www.nytimes.com/2020/11/05/business/vw-diesel-settlement-states.html.

Mufson, Steven, and Sarah Kaplan. "A Lesson in Electric School Buses." *The Washington Post*, *WP Company*, 3 June 2021, https://www.washingtonpost.com/climate-solutions/2021/02/24/climate-solutions-electric-schoolbuses/.

"Municipal Members." *Florida Municipal Electric Association*, https://www.flpublicpower.com/. Accessed 19 April 2022.

Neeley, J. (2020). "How to Make Distributed Energy Resources Work for Texas." *R Street.* https://www.rstreet.org/2020/.

"North Central Texas Clean School Bus Program." North Central Texas Council of Governments - North Central Texas Clean School Bus Program, https://www.nctcog.org/trans/quality/air/for-fleets/clean-school-bus-program.

Pesaran, A., Santhanagopalan, S., & Kim, G. H. (2013). Addressing the impact of temperature extremes on large format li-ion batteries for vehicle applications (presentation)(No. NREL/PR-5400-58145). *National Renewable Energy Lab.* (NREL), Golden, CO (United Staes), https://www.nrel.gov/docs/fy13osti/58145.pdf.

Presidio NAS® Battery Project Facts at a Glance. *Electric Transmission Texas*, 5 Apr. 2010, http://www.ettexas.com/Content/documents/NaSBatteryOverview.pdf.

"Programs." *DSIRE*, https://programs.dsireusa.org/system/program/detail/268.

Prine-Robie, Michael. (September 2020). How Does Temperature Affect Battery Performance? Retrieved March 18th, 2022 from https://www.cedgreentech.com/article/how-does-temperature-affect-battery-performance.

Proterra. (2021). Massachusetts Electric School Bus Helps Power Electricity Grid in Breakthrough for Vehicle-to-Grid Technology. https://www.globenewswire.com/news-release/2021/10/13/2313394/0/en/Massachusetts-Electric-School-Bus-Helps-Power-Electricity-Grid-in-Breakthrough-for-Vehicle-to-Grid-Technology.html.

"Pupil Transportation Statistics." *School Bus Fleet*, vol. 66, no. 11, Dec. 2020, pp. 32–33, https://mydigitalpublication.com/publication/?m=65919&i=696373&p=1&ver=html5.

Randazzo, Ryan. "Arizona Shutters Energy Program; Remaining Workers Fired." *The Arizona Republic, The Arizona Republic*, 3 Nov. 2015, https://www.azcentral.com/.

Randazzo, Ryan. "In Major Reversal, Arizona Utility Regulators Kill 100% Clean-Energy Rules in the State." *The Arizona Republic, Arizona Republic*, 26 Jan. 2022, https://www.azcentral.com/

Recommended Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Houston Area. City of Houston. https://www.houstontx.gov/fleet/ev/evdeploymentguidelines.pdf. Date Accessed: 2/21/2022.

"Reduce School Bus Diesel Pollution Today." *Environmental Defense Fund*, https://www.edf.org/sites/default/files/8085_school_bus_brochure.pdf. Accessed 19 April 2022.

Reedy, Steve. SIPA - CIM View Consulting Interview on ERCOT Market Participant Rules for DERs. 8 Apr. 2021.

SB 1224 - Azleg.gov. https://www.azleg.gov/legtext/54leg/2R/bills/sb1224p.pdf.

School Bus Rebates: Diesel Emissions Reduction Act (DERA).

https://www.epa.gov/dera/rebates#:~:text=The%202021%20DERA%20School%20Bus,to%20EPA's%20cleanest%20emission%20standards.

"School Buses: Diesel Technology Forum." https://Www.dieselforum.org, n Respiratory Journal, vol. 17, no. 4, 2001, pp. 733-746. *ERS Publications*, https://erj.ersjournals.com/content/17/4/733.

Shemkus, S. (2020). Start-up bets on new model for putting electric school buses on the road. https://energynews.us/2020/11/02/start-up-bets-on-new-model-for-putting-electric-school-buses-on-the-road/.

"State of Florida Beneficiary Mitigation Plan." *Florida Department of Environmental Protection*, https://floridadep.gov/ Accessed 19 April 2022.

Steffy, Loren. "Griddy Argues It Was, in Fact, a Champion of Consumers." *Texas Monthly*, June 2021, https://www.texasmonthly.com/news-politics/griddy-argues-it-championed consumers/.

Spielberg, Brett. "NY's Electric School Bus Push: What to Know." *New York League of Conservation Voters*, 25 Mar. 2022, https://nylcv.org/news/nys-electric-school-bus-push-what-to-know/.

Sydbom, A., et al. "Health Effects of Diesel Exhaust." *European Respiratory Journal*, vol. 17, no. 4, 2001, pp. 733-746. ERS Publications, https://erj.ersjournals.com/content/17/4/733.

Syed, Zayna. "Groundwater, Electric School Buses Are among the Environmental Issues at the Legislature." *AZ Central*, 9 Feb. 2022, https://www.azcentral.com/; SB 1224 - Azleg.gov. https://www.azleg.gov/legtext/54leg/2R/bills/sb1224p.pdf.

"TERP Grant Programs." *Texas Commission on Environmental Quality*, https://www.tceq.texas.gov/airquality/terp/programs.

Templeton, Brad. (2021, July 15). Electric Yellow Schoolbus Will Try To Make Vehicle To Grid Power Work. Retrieved April 4th, 2022 from https://www.forbes.com/sites/bradtempleton/2021/07/15/electric-yellow-schoolbus-will-try-to-make-vehicle-to-grid-power-work/?sh=465a5a3c675a.

"The Lion Electric Co.: Electric School Bus." *The Lion Electric Co. | Electric School Bus*, https://thelionelectric.com/en/products/electric.

The Value of Integrating Distributed Energy Resources in Texas. https://www.texasadvancedenergy.org/hubfs/TAEBA%20(2019)/Valuing%20DERs%20in%20ERCOT%20final.11.13.19.pdf.

"Transportation Electrification in Florida." *Southern Alliance for Clean Energy*, https://cleanenergy.org/wp-content/uploads/. Accessed 19 April 2022.

"Valuing the Resilience Provided by Solar and Battery Energy Storage Systems." *Department of Energy*, https://www.energy.gov/sites/prod/files/2018/03/f49/Valuing-Resilience.pdf. Accessed 19 April 2022.

Vehicle to grid - save money on electric car charging. *Flexi*. (2021, May 12). Retrieved March 31, 2022, from https://www.flexi-orb.com/electric-vehicles/vehicle-to-grid/.

Volkswagen Environmental Mitigation Trust. *Texas Commission on Environmental Quality*. (2020). https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg-537.pdf.

VW Settlement Information. *New York State*. https://www.dec.ny.gov/chemical/109784.html.

Wachunas, Joseph. "The Big Deal About NYC's First Electric School Buses Being Diesel Repowers." *School Transportation News*, 8 Jan. 2022, https://stnonline.com/blogs/the-big-deal-about-nycs-first-electric-school-buses-being-diesel-repowers/.

Wenzel, E. Valarino, Philip. (2019). Vehicle to Grid (V2G) Technology. *IEEE*. Retrieved February 22, 2022 from https://innovationatwork.ieee.org/vehicle-to-grid-v2g-technology/.

Wichner, David. "Arizona Regulators Reject New Clean-Energy Rules after Years of Debate." *Arizona Daily Star*, 15 Apr. 2022, https://tucson.com/

"Workplace Charging." *Austin Energy*, https://austinenergy.com/ae/green-power/plug-in-austin/workplace-charging.

Wright, N. (2020). Is Vehicle-to-Grid Technology the Key to Accelerating the Clean Energy Revolution? *Power Magazine*. Retrieved February 2, 2022 from https://www.powermag.com/is-vehicle-to-grid-technology-the-key-to-accelerating-the-clean-energy-revolution/.

Wu, W. Lin, B. (2021). Benefits of electric vehicles integrating into power grid. *Energy*. https://www.sciencedirect.com/science/article/pii/S0360544221003571?via%3Dihub.

"Your Full-Service Bus Dealer." *Sonny Merryman Inc.*, 21 Mar. 2022, https://sonnymerryman.com/#.

Zero-Emission Vehicles, https://www.montgomerycountymd.gov/green/zev/index.html.