New York State Electric School Bus Roadmap

Final Report | September 2023

NEW YORK STATE | NYSERDA

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New York State
Electric School Bus Roadmap

Final Report

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Abstract

The New York State Electric School Bus Roadmap (Roadmap) presents an overview of the key challenges, costs, funding mechanisms, and policy options involved in the effort to transition all school buses in New York State to zero-emission buses by 2035. This goal, as established in the April 2022 State budget, is driven by a strong commitment to reduce greenhouse gas emissions and enhance air quality for New Yorkers.

The Roadmap emphasizes that the benefits of electric school buses go beyond cost savings. They offer cleaner air, improved public health, and help the State achieve its climate goals. With the goal of transitioning the entire fleet to zero-emission buses by 2035, the document suggests a gradual approach for school districts at first, starting with the electrification of more feasible bus routes and leveraging overnight charging opportunities, then ramping up their efforts once school buses reach cost parity and more charging infrastructure is established.

Although electric school buses have higher upfront costs than traditional diesel or gasoline-powered buses, the total cost of ownership is expected to reach parity by 2027 due to advances in battery technology, increased supply chain outputs, as well as lower fuel and maintenance expenses. To support school districts with the high initial costs of transitioning to zero-emissions buses, New York State has secured $500 million through the Environmental Bond Act, alongside existing State and federal programs that will go towards the incremental cost difference of electric school buses and charging infrastructure.

The Roadmap also highlights the need for infrastructure expansion, fleet transition planning, workforce development, and coordination with electrical grid operators. It calls for equitable implementation, focusing on historically overburdened communities and ensuring that training opportunities are available to support a just transition.

To make electrification financially feasible for school districts, the document suggests exploring alternative financing options and simplifying participation requirements for incentive programs. It also emphasizes the importance of leveraging available funding sources, such as State aid programs and purchase incentives.

In conclusion, the Roadmap presents an outline for the electrification of school buses in New York State, which will be updated every three years. It underscores the numerous benefits, addresses challenges, and provides actionable policy recommendations. By investing in this transition, the State can lead the nation in sustainable transportation, benefitting the environment, public health, and future generations.

Keywords

zero-emission, mandate, electric school bus, roadmap, charging, school bus

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Acronyms and Abbreviations

aaS	as-a-Service
ANL	Argonne National Laboratory
BEV	Battery electric vehicle
BOCES	Boards of Cooperative Educational Services
BPA	Blanket Purchase Agreements
CaaS	Charging-as-a-service
CARB	California Air Resources Board
CDPHE	Colorado Department of Public Health and Environment
CEC	California Energy Commission
CMAQ	Congestion Mitigation and Air Quality Improvement
CNG	Compressed natural gas
DAC	Disadvantaged communities
DCFC	Direct current fast charger
DERA	Diesel Emission Reductions Act
DERs	Distributed energy resources
DOE	U.S. Department of Energy
DPS	Department of Public Service
EAM	Earned Adjustment Mechanisms
EEP	Energy Equity Program
EPA	U.S. Environmental Protection Agency
ESB	Electric school bus
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FFH	Fuel-fired heaters
GSA	U.S. General Service Administration
HVAC	Heating, ventilation, and air conditioning systems
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE	Internal combustion engine
ISO	International Organization of Standardization

JTWG	Just Transition Working Group
LCOD	Levelized cost of driving
LIPA	Long Island Power Authority
LPG	Liquefied petroleum gas
NFI	New Flyer, Inc.
NFPA	National Fire Protection Association
NYPA	New York Power Authority
NYSDOL	New York State Department of Labor
NYSEG	New York State Electric and Gas
NYSERDA	New York State Energy Research and Development Authority
NYTVIP	New York Truck Voucher Incentive Program
O&M	Operations and maintenance
OEM	Original equipment manufacturer
OGS	Office of General Services
PAYS	Pay-as-you-save
PGE	Portland General Electric
PHEV	Plug-in hybrid electric vehicle
RFI	Request for Information
RG&E	Rochester Gas and Electric Corporation
SC DEC	South Carolina Department of Education
SEAS	School for Environment and Sustainability
SED	State Education Department
TCO	Total cost of ownership
T&D	Transmission and distribution
VMT	Vehicle miles traveled
V2G	Vehicle-to-grid
WRI	World Resources Institute
ZEV	Zero-emissions vehicle

Summary

In enacting the Climate Leadership and Community Protection Act in July of 2019, New York State committed to reducing greenhouse gas emissions 40% by 2030 and no less than 85% by 2050 from 1990 levels. Because the transportation sector contributes nearly 30% of New York's greenhouse gas (GHG) emissions, the State is keenly focused on greenhouse (GHG) emissions reduction efforts in this sector.[1] In her January 2022 State of the State address, Governor Kathy Hochul highlighted school buses as an early target for electrification as part of an overall statewide transportation decarbonization effort, given the heavy reliance on diesel vehicles in this sector, and attendant health impacts on students. Converting one school bus to electric operation is the equivalent to taking four cars off the road. In the April 2022 budget passed by the New York State Legislature and signed by Governor Hochul, the State established a deadline for the transition to zero-emission school buses. Specifically, all school buses purchased by 2027 must be zero-emission buses, with the entire fleet transitioned to zero emission by 2035.[2] Building on this commitment, New Yorkers overwhelmingly passed the Environmental Bond Act in November 2022, which includes $500 million to support the transition to zero-emission school buses. The transition will benefit the health of students and drivers, improve air quality, and help the State meet its climate goals.

For the purposes of the Electric School Bus Roadmap (the Roadmap), electric school buses, or "ESBs" refers to both battery-powered and hydrogen fuel cell-powered electric buses that meet the definition of zero-emission buses. However, there are no hydrogen fuel cell-powered school buses currently available or expected to be available in the next few years, so the Roadmap is focused on battery-powered buses. Future versions of this Roadmap may include more discussion of hydrogen fuel cell-powered buses as the market develops.

The Roadmap reviews the key issues involved in school bus electrification; summarizes the current costs of school bus electrification; lists available funding mechanisms and financing options; and provides a menu of policy options for the State to consider in order to facilitate the transition to ESBs. It addresses such policy topics as infrastructure expansion; fleet transition planning; considerations for ensuring a just transition; fleet advisory and grid coordination services; and workforce development considerations.

Investing in school bus electrification provides a range of health, environmental, and economic benefits that advance the public interest. Currently, the upfront cost of electric school buses is more expensive than traditional diesel and gasoline powered vehicles. However, the total cost of ownership for electric school buses, due to lower fuel and maintenance costs, is expected to reach parity with internal combustion engine school buses around 2027. In the meantime, New York State voters have voted to make $500 million available through the Environmental Bond Act to hasten the transition and lead the nation in this effort. When the funding is used to lower the purchase cost of ESBs, alongside existing State and federal programs, in many cases the total cost of ownership of ESBs is already below diesel and gasoline buses.

S.1 ESB Transition through 2027

The Roadmap focuses on the next three to five years, and the preparation for the 2027 zero-emission purchase requirement. By 2027, it is estimated that New York State fleet operators could purchase up to 3,000 electric school buses, or roughly 4-5 buses per district., which will allow for a nearly tenfold increase over the State's current inventory of 310 ESBs. Three thousand ESBs is a target that would enable all districts and contractors to gain sufficient experience with ESBs ahead of the all zero-emission purchase mandate in 2027 and is a realistic assumption based on historical purchasing patterns. The updating of factories and supply chains is not instantaneous and prevents the immediate conversion to a 100% electric fleet. By the time the Roadmap is updated in 2026, New York State will have substantially more information about costs, best practices, and vehicle availability, which will inform future Roadmap updates, and the path to a transition to a zero-emission fleet by 2035.

An analysis was conducted for the purpose of this Roadmap that incorporates the cost of ESB procurement as well as charging equipment. The estimated incremental cost to transition approximately 3,000 vehicles to electric school buses (including associated chargers) by 2027 is roughly $780 million. Based on the expected federal and State funding available to support this transition, most of these costs can be covered by federal and State funding sources, especially in high-need school districts (see section 3 for additional details). This would result in moving into 2027 with roughly 8% of the current fleet transitioned to electric. The goal for these assumed 3,000 vehicles is to distribute them across as many school districts as possible, so each district has some experience with ESBs ahead of 2027 and can begin to internalize the operational savings.

S.2 Current New York State School Bus Operational Profile

To help assess the current opportunities and challenges associated with the State's school bus electrification goals, NYSERDA and its support contractors, in consultation with the New York State Education Department (SED), conducted a survey to characterize school bus fleet characteristics and operational information for school districts across the State. The team also collected telematics data to supplement and verify the data collected in the fleet and operations survey. An analysis of the survey's responses and the telematics data indicates the following:

- **Most New York State bus routes are short enough that they could be electrified with today's electric buses.** The average daily mileage per bus across NYS is 80 miles. Beginning with the buses running daily routes under 100 miles would allow for immediate electrification of the majority of routes across the State without concern for range limitations. Lessons learned in electrifying these routes will provide more information ahead of the electrification of longer routes.
- **Lower-cost Level 2 charging may be sufficient for most buses.** Ninety-six percent of district buses outside of New York City return to the depot during the evening/overnight period. [3,4] The survey average for bus downtime in the evening and overnight period is 12 hours, which would allow operators to take advantage of overnight electricity rates, thereby lowering operation and infrastructure costs.
- **Midday charging times can be accommodated.** Well over half of all buses have four or more hours of dwell time during the day and can be partially or fully charged during that time, if needed.
- **Operators have uncertainty about electrical capacity at depots.** Only 11% of respondents indicated that a fleet and/or site electrification assessment had been conducted for their district to date.

S.3 Current Status of ESB Technology

Significant progress on school bus electrification has been made in the past few years, including policy directives, funding resources, and a growing selection of available electric bus models.

S.3.1 Bus Purchasing

- The upfront cost of an ESB is significantly higher than that of a diesel or gasoline powered vehicle, although maintenance and operations costs are lower. Key actions that New York State could take to alleviate the challenge of high upfront costs include the distribution of Environmental Bond Act funds. The purchase of new electric buses will help grow the market, which will in turn help reduce prices.
- Streamline participation requirements for state-funded incentive programs, including simplifying or removing scrappage requirements.

- Explore and demonstrate the potential for alternative bus ownership and operational approaches such as "as-a-service" models that can externalize upfront costs and provide long-term cost certainty.

S.3.2 Battery Range

- The majority of New York State school buses travel on routes that can be electrified today. However, longer routes, or those in hillier or colder areas present challenges as lower temperatures and the extra power draw needed to heat the cabin reduce effective battery capacity. If the pace of battery technology continues to develop at the same rate, it is highly likely that the remaining routes will be manageable in a few years, thanks to improved energy density, lower-cost batteries. And, furthermore, greater prevalence of public charging will help mitigate these issues.

  While the technology around electric school buses develops, fleet operators can focus on more efficient routes, and use the Environmental Bond Act funding to help offset costs while the market for ESBs in NYS is built. Key actions that New York State could take to address bus deployment challenges include:

  - Ensure school districts have access to fleet transition planning support, which will help fleet operators select buses and batteries that align with routing needs.
  - Explore ways to encourage pre-heating while plugged in, fuel-fired heaters, and other approaches to cope with cold temperatures.

S.3.3 Charging

- The ESB transition requires significant investments in charging infrastructure, including both the charging stations themselves and the larger electrical grid. In planning for charging needs fleet operators should be careful to install the correct amount and size of charging infrastructure to match the demands of the fleet. Key actions that New York State could take to address charging constraints include:

  - Working with the major utility service providers to conduct an evaluation of grid capacity incorporating fleet data to provide utilities with up-to-date information on upcoming grid capacity deficiencies.
  - Expanding access to incentives for charging and make-ready infrastructure installations and encouraging planning for future needs before buses are purchased.
  - Undertaking efforts to ensure that a variety of bus charging options are available and to establish regional efforts to support non-depot charging solutions where necessary.

S.3.4 Infrastructure Investment

- The transition will require upfront investment in electrical infrastructure. Infrastructure costs for utility-side or electric grid upgrades and customer-side or site upgrades are variable, depending on local grid and site context. These costs are also expected to be covered to some extent by upcoming programs. Costs can range between 15% and 30% of total transition costs and will be closely monitored as full-scale fleet transition projects begin to take shape. Key actions New York State could take to support infrastructure investments include:
    - Working with all utilities across the State to understand future demand from school bus electrification, enabling proactive grid upgrades to reduce project delays and minimize costs being passed along to school bus fleet operators.
    - Distributing Environmental Bond Act funds to address near-term funding needs, including ESB charger purchasing support.
    - Expanding and increasing funding for utility-led ESB charging and associated infrastructure programs, including the Medium- and Heavy-Duty Make-Ready Pilot Program.

S.3.5 Major Funding Sources

S.3.5.1 State Education Department Aid

SED distributes State aid to school districts through a variety of programs. Expenditures for district-owned and contract buses and associated equipment are eligible for Transportation Aid, subject to a sharing ratio. Although the cost of ESBs are more expensive upfront, school districts will receive reimbursement from the State through Transportation Aid in proportion to their aid ratio, which is as high as 90% for some districts. Transportation Aid will continue to help offset the cost of districts' transportation expenses, including for the purchase of ESBs and related infrastructure.

School districts that own and operate their own fleets may need to secure additional funds through alternative financing and other options, with the balance coming through local funding. Districts that hire third-party contractors to provide pupil transportation may also see the cost of transporting pupils impacted by the switch to ESBs. Districts may find that communicating the additional benefits of fleet electrification can help them win voter approval. The multiple benefits to the community include cleaner air, improved public health, increased energy resilience, and reduced operating costs of buses in the longer term.

S.3.5.2 Purchase Incentives

In New York State, school districts and school bus contractors have access to a variety of funding incentives, including the newly approved $500 million in Environmental Bond Act funding. In addition, fleet operators can access funds through the EPA's Clean School Bus Program and New York Truck

Voucher Incentive Program (NYTVIP). Finally, the Inflation Reduction Act of 2022 creates a new tax credit for some ESBs and charging stations.[5] Taken together, these incentives are expected to be sufficient to close the gap between diesel/gasoline powered vehicles and ESBs for the purchases that are anticipated through 2027.

S.3.6 Equity and Workforce Development

New York State's approach to electrifying its school bus fleet must focus on equity and a just transition. The State will focus its efforts to support electrification in areas that have been historically environmentally and economically overburdened and are most at-risk from harmful transportation emissions. Areas that fall within disadvantaged communities (DACs)[6] or high-need school districts[7] will be considered Priority Districts. Much of ESB general operations support work can be performed by existing fleet operators, provided they receive training. The State should:

- Ensure that funding opportunities prioritize support for high-need school districts and the fleets that serve them.
- Ensure that disadvantaged communities are a specific focus of training opportunities for ESB and EVSE work as a component of an equity strategy specific to ESB deployment in New York State.
- Bolster the workforce by assuring the provision of career training opportunities statewide.

S.3.7 Policy Recommendations

New York State agencies, such as NYSERDA, DEC, DPS, OGS, and SED, and the State's electric utilities have the opportunity to ease the transition to ESBs by considering the following areas for policy and program development:

- Update procurement models and expand incentive programs to encourage ESB adoption.
- Expand funding for transition and site planning so districts have the necessary foundation to procure buses and equipment, as well as build the infrastructure that will meet each district's individual needs.
- Ensure that equity is at the forefront of policy and program design updates by prioritizing disadvantaged communities (DACs) and high-need school districts.

S.3.8 ESB Guidebook

To accompany this Roadmap, NYSERDA is developing a detailed, user-friendly guidebook to help school districts, transportation service contractors, and other interested parties navigate the transition to electrification. The guidebook will address topics such as vehicle procurement, funding opportunities, charger planning and installation, workforce development, safety, and maintenance. It will be available online starting in Fall 2023.

1 Background

In passing the Climate Leadership and Community Protection Act in July of 2019, New York State committed to reducing greenhouse gas emissions 40% by 2030 and no less than 85% by 2050 from 1990 levels. Because the transportation sector contributes nearly 30% of New York State greenhouse gas emissions,[1] the State is keenly focused on reduction efforts in this sector. In her January 2022 State of the State address, Governor Kathy Hochul highlighted school buses as an early target for electrification as part of an overall statewide transportation decarbonization effort. In the April 2022 budget passed by the legislature and signed by the governor, the State set a deadline for the transition to zero-emission school buses. Specifically, all school buses purchased by 2027 must be zero-emission, with the entire fleet transitioned to zero-emission by 2035. For the purposes of the Electric School Bus Roadmap (the Roadmap), electric school buses, or, "ESBs" refers to both battery-powered and hydrogen-fuel cell-powered electric buses that meet the definition of zero-emission buses. However, there are no hydrogen fuel cell-powered school buses currently available or expected to be available in the next few years, so the Roadmap is focused on battery-powered buses. Future versions of this Roadmap may include more discussion of hydrogen fuel cell-powered buses as the market develops. The transition will benefit students' health, improve air quality, and help the State meet its climate goals. New York State voters reaffirmed this commitment when they voted overwhelmingly in favor of the Environmental Bond Act, which included $500 million for school bus electrification, in November of 2022.

This Roadmap explains the benefits of electrifying school buses and contains a guide to current costs for ESBs and chargers, a summary of available funding mechanisms and financing options, and a menu of policy options for the State to consider that support the transition to ESBs. It addresses such policy topics as the best way to ensure a just transition, workforce development considerations, and opportunities for collaboration with public and private entities, including utility operators.

This chapter provides an overview of the current school bus fleet and the state of the ESB market. Sections include:

- **Section 1.1 Why Focus on Transportation?** which summarizes why greening transportation—in general and school transportation in particular—is so critical.
    - Key Takeaways
        - Transportation accounts for the largest portion of New York State's greenhouse gas emissions.

        - Electrifying New York State's approximately 45,000 school buses will improve air quality and health impacts, help achieve NYS ambitious greenhouse gas emission reduction targets, and allow the State to avoid expenditures that would otherwise occur.

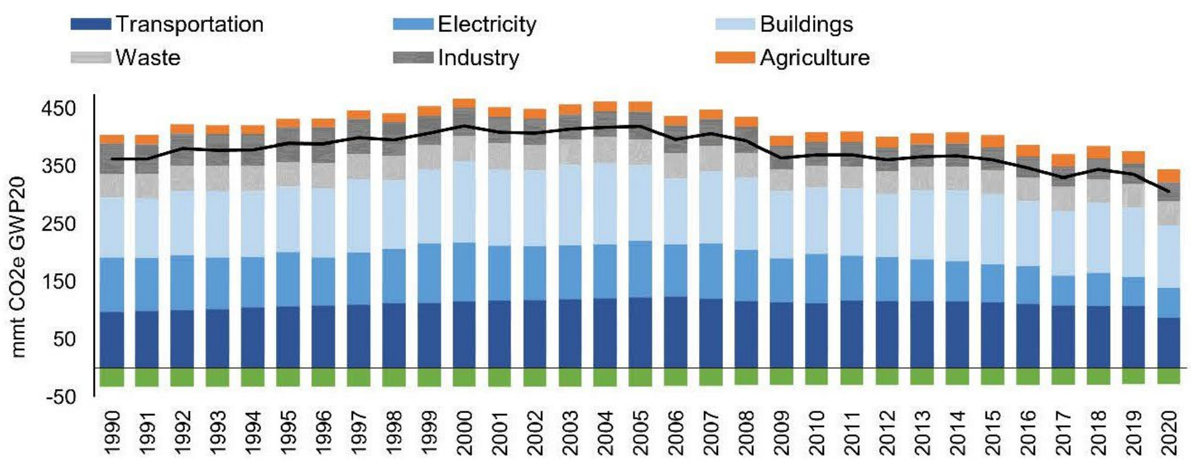
- **Section 1.2 ESB and Charging Technology Options**, which summarizes current ESB and charging equipment offerings and prices.
    - Key Takeaways
        - Numerous ESB makes and models are currently available, with product offerings continuing to increase. ESBs provide 100 to 200 miles of range per charge. ESB purchase prices can range between $325,000 and $400,000 for full size (Type C) buses.
        - Dozens of ESB charger models are currently available and new ones are constantly being added to the US market. Costs vary greatly, from as low as $5,000 for a "Level 2" charger to upwards of $100,000 for a "Level 3" fast charger.
        - A "repower" market is emerging that converts existing conventionally fueled buses to electric, with the potential to lower bus purchase prices by approximately 40% relative to new ESBs.
- **Section 1.3 Data on Current NYS School Buses**, which summarizes current New York State public school bus fleet operations and characteristics. Understanding the current state of operations is crucial to determining the cost of fleet electrification and identifying associated challenges to the transition to ESBs.
    - Key Takeaways
        - The majority of routes are suitable for electrification today.
        - Slower but less expensive "Level 2" charging may be sufficient for most buses.
- **Section 1.4 School District Procurement and Transportation Funding**, which describes current procurement practices and funding sources for conventionally fueled buses, providing context regarding the baseline funding available to New York State school bus fleets.
    - Key Takeaways
        - School districts can use the New York State Office of General Services (OGS) Procurement Services contract to procure ESBs, choosing from a pre-approved list of makes and models. Districts can also run their own bid process, tailoring bus requirements to their specific needs, or rely on third party bus service contractors to procure ESBs.
- **Section 1.5 Market Cost Projections**, which estimates the total cost of ownership (TCO) for various school bus fleet scenarios, along with price projections for future ESBs.
    - Key Takeaways
        - Although ESBs have a higher upfront cost, they have substantially lower operations and maintenance costs, which makes their TCO more competitive with diesel- and gasoline-powered school buses.
        - The TCO for ESBs is expected to achieve parity with diesel- and gasoline- powered school buses in 2027 as increasing production volumes and technological innovation drive down the cost of vehicles and charging infrastructure.

- When current incentive amounts are applied, the TCO of electric school buses is substantially lower than that of diesel buses, underscoring the importance of vehicle purchase incentives today. As TCO continues to improve for ESBs, the narrowing of the upfront cost differential between electric and diesel school buses will result in even more lifetime cost savings for fleet operators.

1.1 Why Focus on Transportation?

Transportation accounts for 30% of New York State's total greenhouse gas (GHG) emissions, more than any other sector. While emissions from most other sectors have declined over the last twenty years, transportation emissions have remained level, see Figure 1.[8] For New York State to achieve its climate goals it must address its transportation emissions.

Figure 1. New York State Greenhouse Gas Emissions by Economic Sector, 1990-2020



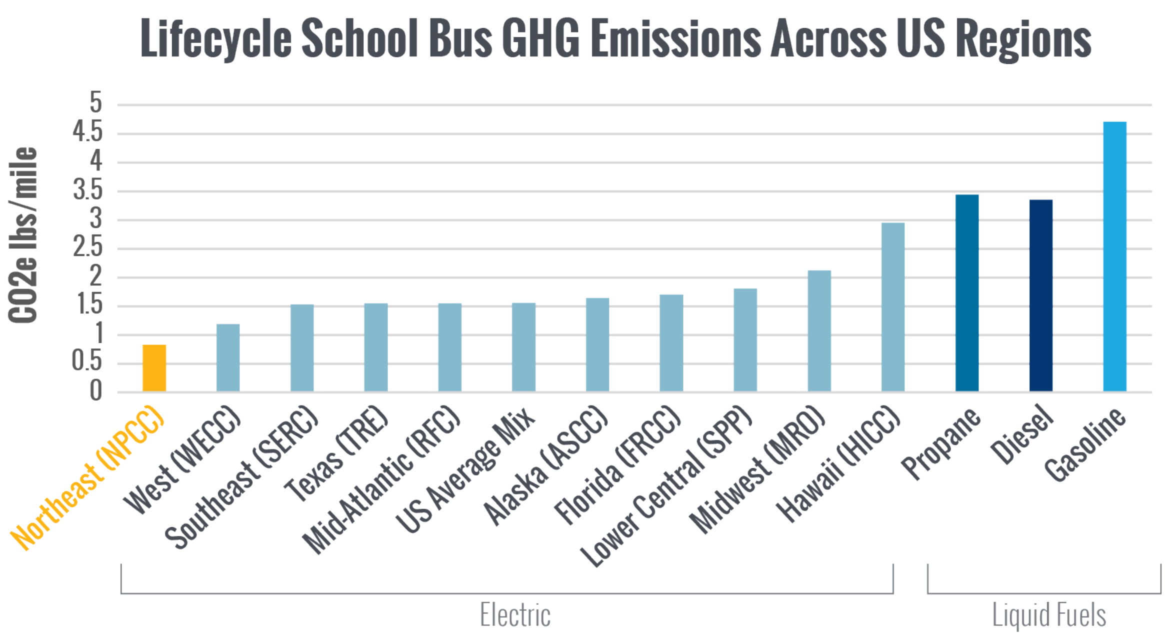
1.1.1 Why Focus on School Buses?

Focusing on school buses allows New Yorkers to address both greenhouse gas emissions and public health. New York State has 45,000 school buses, more than any other state, which transport 1.5 million students daily. Removing the harmful emissions from these buses will improve air quality for everyone, especially school children, and will result in improved health impacts, while also helping to achieve the State's ambitious targets for greenhouse gas emissions. During the course of the vehicles' useful lives, the State's 45,000 buses will be responsible for significant costs associated with public health, climate change, and petroleum dependence. Switching to electric buses would save the State at least \$1.5–\$2.8 billion in avoided emissions-related damages,[9] based on per-vehicle emissions reduction assumptions developed by Argonne National Laboratory.

1.1.2 Greenhouse Gas Emissions

Traditional large school buses, which make up the majority of New York State's fleet, emit approximately 1.5 million tons of greenhouse gas emissions per year. Electrifying New York City's 10,000 school buses (roughly 25% of the NYS school bus fleet) alone would be equivalent to removing almost 40,000 passenger vehicles from the road.[10] Even considering full life-cycle emissions, electric school buses are responsible for substantially lower greenhouse gas emissions than traditional diesel- or gasoline-powered buses. This is because electric vehicles are significantly more energy efficient than internal combustion vehicles.[11] Even running off a relatively "dirty" grid, an electric school bus has lower life cycle emissions than a traditional bus due to improved efficiency. Fortunately, New York State has one of the cleanest grids in the nation, see Figure 2, and so electrifying vehicles here has an even larger impact.[12] Moreover, New York State electricity generation is getting cleaner every day. By 2040, 100% of the State's electricity will come from zero-emission, renewable sources.[13] As electricity produced in the State continues to become cleaner, using electricity instead of diesel and gasoline to power school buses will further reduce greenhouse gas and other emissions and subsequently, improve air quality.

Figure 2. Lifecycle Greenhouse Gas Emissions from Electric School Buses across U.S. Regions



1.1.3 Public Health

Diesel- and gasoline-powered school buses emit significant quantities of criteria air pollutants, such as particulate matter (PM), carbon monoxide (CO), and nitrogen oxide (NOx). Criteria air pollutants are associated with chronic health conditions, including asthma, cancer, and cognitive impairment.[14] When a diesel or gasoline school bus is in motion, it emits pollutants from its tailpipe, which tend to rise and disperse. However, when a school bus stops at a traffic signal, is stuck in traffic, or pauses to pick up and drop off students, the tailpipe emissions can drift back into the cabin and remain there, posing a health risk to students. In addition, exposure to fumes from school buses is linked to diminished performance in school.[15]

Studies show that students with disabilities, those who live in rural communities, those from low-income families, and students of color are more likely to travel long distances on school buses and experience greater exposure to harmful pollutants.[16] For students, exacerbating these health issues by increased exposure to school bus-related pollution can lead to absenteeism and negatively impact academic performance. The American Lung Association in New York State has noted that moving the State's entire vehicle fleet to zero-emission transportation "will result in up to 159,000 avoided asthma attacks statewide."[17]

1.1.4 Ease of Electrification

School buses are relatively easy to electrify compared to other large vehicles, such as trucks and transit buses. They have predictable hours of operation and often have more downtime to allow for charging. They often can take advantage of centralized charging locations and can charge overnight in many instances. Having longer and more predictable vehicle downtimes can be economically advantageous for fleet owners. These downtimes can allow for the use of slower chargers—which may decrease the need for electrical infrastructure upgrades. Because they draw power from the grid more slowly, this can result in lower monthly electric bills since charging is primarily done overnight when electrical rates are often lower.

1.2 Electric School Bus and Charging Technology Options

This section presents information collected through recent market data and cost projections as well as information gleaned from industry stakeholders to estimate capital costs and total cost of ownership (TCO) for electric school buses (ESB) in the 2023–2027 timeframe.

1.2.1 Vehicle Availability and Cost

As of October 2022, there are 18 distinct ESB models from 11 manufacturers available in the U.S. market. This represents an increase from 16 available models in 2021. The vehicle make/models approved for sale in New York State through the New York Truck Voucher Incentive Program (NYTVIP) can be downloaded from the New York Truck Voucher Incentive Program webpage.

There are four categories of school buses, classified as Type A, Type B, Type C, and Type D. Each category of school bus is unique, and the type defines the size, passenger capacity, and shape of the bus.[18] Table 1 identifies the differences between each school bus type. The Type B bus does not currently have an electric alternative; however, it is rarely used in New York State. Type C bus models are the most prevalent ESB model; however, Type A school buses, smaller buses built on a cutaway front-section vehicle carrying 10–25 passengers, are becoming increasingly popular. Type C buses are full-length school buses with a “truck-front” design as opposed to the “transit-front” design of Type D buses. Manufacturers are choosing to expand in the ESB market through the Type A bus due to its versatility and widespread use. Model availability includes offerings from legacy manufacturers in addition to several electric-only manufacturers. All-electric retrofit, or “repower,” options are also available to convert existing diesel and gasoline buses of all types to electric. ESBs currently feature original equipment manufacturer (OEM)-rated driving ranges as low as 100 miles and as high as 210 miles, with median ranges from 120 to 135 miles.[19]

Table 1. Overview of ESB Market by Bus Type

Bus Type	Type A	Type B	Type C	Type D
Example Image				
Passenger Capacity	16-20	20-30	60-72	72-90
# Models Available	7	N/A	4	4
Range (mi)	Low: 100 Medium: 120 High: 150	N/A	Low: 120 Medium: 131.5 High: 210	Low: 120 Medium: 135 High: 155
2019 U.S. Sales (all fuels)	8,242	0	28,787	3,685
NY Bus Market Share[a]	24%	7%	66%	3%
Cost Share (electric)	$265,000 -$335,000	N/A	$300,000 - $400,000	$345,000 - $410,000
Participating Manufacturers	Legacy: Blue Bird (MicroBird), Collins Electric Only: BYD, GreenPower, Lion, Motiv, Lightning e-Motors, Phoenix Motor Cars	N/A	Legacy: Blue Bird, IC Bus, Thomas Built Electric Only: Lion Repowers: SEA Electric, Unique Electric Solutions	Legacy: Blue Bird Electric Only: BYD, GreenPower, Lion Repowers: SEA Electric, Unique Electric Solutions

a Based on NYSERDA Survey, conducted December 2022.

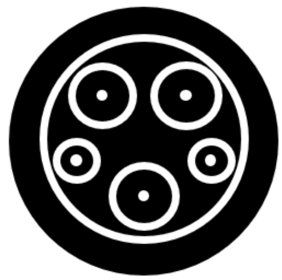
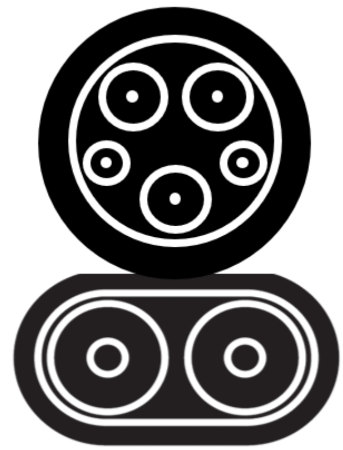
1.2.2 Electric Vehicle Supply Equipment Availability and Cost

Electric Vehicle Supply Equipment (EVSE) includes vehicle chargers and mounting systems, cable management, and communications hardware. Electric bus chargers come in a variety of power levels and are generally grouped into two categories:

- **Level 2 Charger**—Level 2 chargers provide ESBs with alternating current (AC) power. Level 2 charger loads are limited to approximately 19 kW. However, some Level 2 AC chargers are designed for 3 Phase power up to 480V. Assuming a standard ESB battery pack size of 150 kWh, a Level 2 charger should take between 6 and 11 hours to fully recharge a battery.
- **Level 3 Charger—**Level 3 chargers, also known as direct current fast chargers (DCFC), provide ESBs with direct current (DC) power. Most Level 3 chargers require 3 Phase, 480V power. Direct current charging allows for significantly faster charge speeds than Level 2 chargers. Their charging loads typically range from 50kW to 350 kW, though currently available ESBs can charge at a maximum of approximately 125kW. Assuming a standard ESB battery pack size of 150kWh and a 50kW charger, a DCFC charger should take around 3 hours to fully recharge an ESB battery.

Table 2 compares the specifications of Level 2 and Level 3 (DCFC) chargers.

Table 2. Comparison of Level 2 and Level 3 (DCFC) charger specifications

	Level 2	**Level 3 (DCFC)**
Voltage	208V/240V	480V
Charger Speed	Up to 19 kW	30–125 kW
Charge Time for a 150kWh battery	6–11 hours	1–5 hours
Charger Standard	J1772	CCS1
Charge Port		

Dozens of EVSE models are currently available and new ones are regularly added to the U.S. market. *National Grid's Upstate NY Qualified EVSE List* contains several EVSE models. The U.S. Environmental Protection Agency's (EPA) ENERGY STAR® program also publishes a list of ENERGY STAR-certified EVSE. Hardware costs for a Level 2 charger range from $5,000 to $15,000, while costs for Level 3 chargers, which require additional electrical equipment, range from $20,000 to $100,000.

1.2.3 Repowered School Buses

Repowered school buses, or "repowers," are an emerging alternative option to purchasing new ESBs. A repower is a former internal combustion engine (ICE) school bus that has had components (e.g., engine, transmission, exhaust system) removed and replaced with an electric powertrain. The pre-existing 12-volt system that powers auxiliary components (such as compressors and lights) is often integrated into the new electric vehicle (EV) system. Repowers can be performed in two ways. When purchasing a repowered vehicle directly from a repowering company, the company obtains an ICE vehicle from the used vehicle market, performs the repower, and sells the converted vehicle to the purchaser. When purchasing a repower "as a service," the purchaser sends their own (typically used) ICE vehicle to a repower company, which performs the repower and returns the original vehicle as an ESB.

Repowering is a lower-cost alternative to purchasing new ESBs. In contrast to spending up to $400,000 for a new ESB, repowering a school bus costs approximately $50,000 to $100,000 for a Type C bus, roughly comparable to a new diesel bus.

As of April 2023, the repower market for ESBs is quite small, with fewer than 10 repowered school buses in service across the United States. The price of repowers is approximately 40% lower than new ESBs. This price differential could make repowers a viable option for operators who are not awarded federal or state grants or rebates. In New York State, repowers have been eligible for funding through the New York Truck Voucher Incentive Program (NYTVIP) in the past. More data is required to confirm a lower TCO for repowers, but TCO will depend on the age of the vehicle and its remaining service life. The optimal age of an ICE vehicle to be repowered for maximum TCO savings varies across road conditions and duty-cycle.

Companies that sell repowered vehicles may be constrained by having to find, inspect, and acquire many vehicles of the same make and model. Every bus model and year has slight differences that could affect the installation of the EV components, and these variations will therefore require differing engineering and components. This is less of an issue with school buses than other types of vehicles because the market to date has been dominated by three companies with a relatively small number of models. Repowers of Type A school buses may differ slightly from other repowers, as vendors can purchase a new cutaway chassis from a vehicle manufacturer and install an electric powertrain on what is essentially a new vehicle (commonly referred to as an upfit).

As of April 2023, only one manufacturer, Unique Electric Solutions (UES), is offering repowers for all school bus types, and no manufacturers are selling repowered vehicles directly. UES is a New York State-based company and has received support from NYSERDA to develop its product. The repower sector is expected to see a growing number of companies taking orders throughout 2023. SEA Electric recently announced a partnership with Midwest Transit to repower 10,000 buses over the next five years. It is unclear how much of a role repowers will play in school bus electrification over the next three years. Market growth is potentially constrained by restrictions in the EPA Clean School Bus Program, because the program currently excludes funding of repowers and requires scrappage of old ICE buses.

Repowering can be an option for fleets that recently purchased buses that would otherwise not need to be replaced.[20] Incentive programs that are designed to support repower retrofits in addition to (or instead of) new vehicle purchases can support school bus fleets by taking advantage of this alternative path to electrification, particularly for more recently purchased vehicles. The State has been a leader in supporting repowered school buses and will continue to support this pathway in the future.

1.2.4 Data on Current NYS School Buses

To help assess the current environment, NYSERDA and its support contractor, in consultation with the New York State Education Department (SED), developed a survey to characterize school bus fleet characteristics and operational information for school districts across the State. The survey questions covered five topic areas:

- School district information
- Bus fleet data
- Route descriptions
- Operation characteristics
- Depot information

Tailored questionnaires were developed for school district personnel as well as contractors that own and/or operate buses on behalf of the districts. appendix B provides a detailed summary of survey results, as well as the complete school district questionnaire. Telematics data from Geotab USA was also collected to supplement and verify the data collected in the fleet and operations survey. Highlights of the survey results include:

- More than 90% of buses are Type A or Type C buses.
- With only nine submissions received from contractors, these responses are not necessarily well-representative of all contractor fleets.
- Reported values for the average daily miles per bus range from 1 to 250, with an average of 80 miles per day and a median of 74 miles per day.
- The survey average replacement age is 8.9 years.
- The number of buses parked at each depot ranges from 3 to 135, with a survey average of 35 and a median of 24, with the distribution skewed toward lower numbers of buses.

Analysis of the survey and telematics data suggest:

- **Most buses have routes that are short enough to allow for electrification today.** The average daily mileage per bus is 80 miles. Electric school buses currently on the market typically have a range of at least 100 miles. Beginning with the buses with the shortest daily routes would allow for immediate electrification of many routes across the State. The installation of vehicle telematics would improve the ability to select routes currently suitable for ESBs.
- **Level 2 charging may be sufficient for the majority of buses**. Ninety-six percent of districts' buses outside of New York City return to the depot during the evening/overnight period. The survey average for bus downtime in the evening and overnight period is 12 hours, which would allow operators to take advantage of overnight electricity rates, thereby lowering operation and infrastructure costs.
- **Mid-day charging can be accommodated.** Well over half of all buses have four or more hours of dwell time during the day, allowing fleet operators the opportunity to recharge after morning runs if needed.
- **Many operators have uncertainty about electrical capacity at depots.** While over 95% of depots addressed in survey responses have electrical service, only 11% of respondents indicated that a fleet and/or site electrification assessment had been conducted for their district. This leaves the majority of sites with both the need for assessment and a lack of clarity about the ability of existing electrical services to support charging infrastructure.

1.3 School District Procurement and Transportation Funding

School districts currently rely on State funding to cover a portion of purchase costs for conventional buses and a portion of fuel and other transportation operating costs. These same funding sources will be used to cover a portion of their future ESB and Electric Vehicle Supply Equipment (EVSE) purchases and operating costs. The following discussion summarizes current school bus procurement processes and State funding sources and associated restrictions.

1.3.1 School District Procurement Process

When purchasing a school bus, school districts have the option of running their own competitive bid process or using the New York State Office of General Services (OGS) Procurement Services contract as a starting point. This contract value is anticipated to be as much as nearly $163 million annually.[21] Fourteen different options for ESBs are included in this contract; however, bus leasing and EVSE are not included.[22] While OGS offerings might not be a direct fit for all school districts, the OGS contract provides a transparent pricing list and a secure, trusted pathway to ESB procurement that may be ideal for many districts.

School districts are held to certain rules for their procurement processes, and some of the innovative purchasing programs offered to bus fleets might not align with a district's mandated procurement requirements. More information and guidance on purchasing ESBs is included in the ESB Guidebook on NYSERDA's website.

Furthermore, operational needs vary from district to district, which might make it challenging to recommend a single approach to purchasing. In many cases, contractors may have more flexibility in their procurement procedures than school districts.

1.3.2 New York State School Aid

The New York State Education Department (SED) distributes State aid to school districts through a suite of formula aid programs. These aids are distributed in different ways including flat grant per pupil, wealth-equalized State aid per pupil, and wealth-equalized expenditure-based aid. In some cases, aid calculations consider the application of other funding sources prior to distributing aid, and thus the aid is reduced proportionately. Since expenditure-based aids are intended to reimburse a certain percentage of the cost that would otherwise be paid entirely by the school district, other funding sources are applied to the State Aid and local share proportionally. For example, the expenditure for aid for a school bus purchase is reduced by federal or State grants when determining Transportation Aid.

Expenditure-based aids. New York State provides school districts with funding through the Transportation Aid formula for transportation-related expenses, including those specifically related to ESBs. Although the cost of ESBs are more expensive upfront, Transportation Aid helps cover these costs in proportion to a district's aid ratio, which is as high as 90%.

Transportation Aid includes both operating and capital aid. SED estimates that non-capital aid totaled $2.15 billion and capital aid totaled $121 million in the 2022–23 school year. Expenditures for the operation of a school district supervisor's office and for the operation of district-owned buses, contract buses, and public service vehicles are eligible for aid. A sharing ratio and a sparsity factor are applied to eligible expenditures. The sparsity factor is based on enrollment per square mile. The sharing ratio is selected from one of three options, and the district is allowed to select the formula that gives the highest ratio. The final State sharing ratio (including the sparsity factor) used cannot be greater than 90% or less than 6.5%. These ratios are based on the relative fiscal capacity of the district, in which the wealthiest districts receive 6.5% reimbursement, and the school districts with the most financial need receive 90% reimbursement for transportation aidable expenses.[23]

1.3.3 Aid Restrictions and Challenges

The sale of buses in a school year directly reduces the district's SED Transportation Aid expenditures available for aid for that year.[24] Alternatively, if the old buses are used as trade-ins to reduce the purchase cost of new ESBs, the impact is spread over the course of the amortization. Trade-ins for ESBs are discouraged through the scrappage requirements of some funding sources, including the Volkswagen Settlement funds (made available through the New York Truck Voucher Incentive Program) and the EPA Clean School Bus Program. Under certain circumstances there may be an opportunity to further leverage available funding by retrofitting old chassis with electric drivetrains. Fleets aiming to accelerate their transition to ESBs can use retrofits to maximize the lifetime value of a bus by getting additional value from its remaining life rather than trading it in earlier.

SED Transportation Capital Aid is paid on a different amortization schedule for the purchase or lease of zero-emission school buses and the purchase of charging stations compared to conventional vehicles (12-year amortization versus 5 years).[25] This amortization schedule provides partial reimbursement over a longer timeframe for assets owned and leased by school districts, for costs remaining after vouchers and other funding incentives. The amortization schedule also has the potential to impact school districts that experience more rapid degradation of their vehicles due to salt corrosion but may be balanced by the anticipated higher value of ESB at the end of its useful life (e.g., due to relatively high battery pack salvage values).

In addition, school districts may need to secure additional funds through alternative financing and other options (see sections 2 and 3), with the balance coming through local funding. If the local funding needs exceed the levy limit ('tax cap'), this would require a supermajority (60%) voter approval for districts outside of the Big 5 school districts.[26] Districts may find that communicating the additional benefits of the project may help ensure funding approval, particularly the net financial benefit to the community through cleaner air, improved public health, reduced operating costs, and potential revenue benefits of buses in the longer term. Sharing the cost/benefit analysis of the project prior to implementation and voting may assist in making the case to their community and voters.

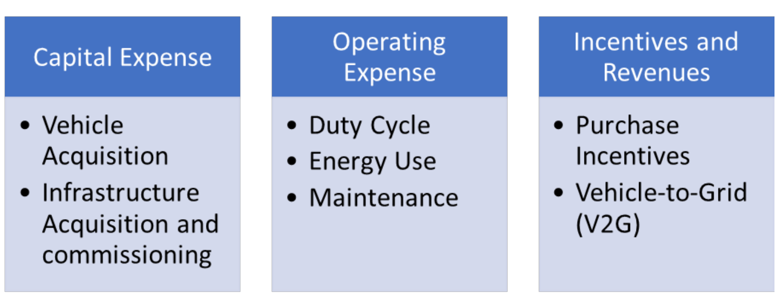
1.4 Market Cost Projections

ESB purchase and operation typically entails a significantly higher upfront capital outlay followed by potentially lower operations (i.e., fuel/energy and maintenance) costs relative to comparable diesel and gasoline-powered buses. In some cases, the initial incremental cost of an ESB may be largely offset by the stream of operational cost savings realized over the bus's useful life. These savings can vary widely but can range from a few thousand dollars to more than $10,000 per bus, per year. In addition to lower operating costs, electric buses may offer school bus fleets the opportunity to generate revenue by storing and selling electricity back to the grid, utilizing bidirectional charging or vehicle-to-grid (V2G) technology in the near-future. As such, TCO analysis is typically performed to assess the net financial impact of electrification for individual fleets. The following presents the key elements of the TCO analysis, results for different fleet scenarios, and a discussion of future ESB cost trends.

1.4.1 TCO Determinants

Calculating TCO provides school bus operators with information to evaluate direct and indirect costs of EV purchases, as well as potential savings over the life cycle of the vehicle. The transition to EVs involves a shift in perspective regarding TCO components. Traditional ICE bus costs are usually presented in terms of capital cost for vehicles and dollar per gallon ($/gal) costs for fuel, as well as maintenance expenses. TCO for EVs includes additional factors, such as electricity rates ($ per kilowatt-hour), demand charges ($ per kilowatt), purchase and installation costs for charging equipment, and grant/incentive programs. EVs are typically more expensive up front, but with appropriate planning and proper management, they can be less expensive to operate and maintain than comparable ICE vehicles, and in certain cases, this lower operating expense can offset the higher upfront cost.

Figure 3. Vehicle Planning Considerations that Can Impact TCO of EVs



The capital investment and operational decisions that affect the TCO of ESBs are shown in Figure 2 and discussed in the next section.

1.4.1.1 Capital Expenses

Vehicle acquisition. In the current ESB market, vehicle acquisition costs contribute significantly to the TCO. The average retail price of an ESB is approximately three times the cost of diesel-powered vehicles. For example, Type C electric buses listed on the Office of General Services (OGS) State Contract for School Buses cost between $350,000 and $400,000, compared to an average cost of $130,000 to $140,000 for comparable diesel models.[27] Vehicle upgrades can further inflate the upfront acquisition costs. For example, fleet managers interested in bidirectional, or vehicle-to-grid, charging may face the added cost of upgrading onboard chargers found on many base models, though some manufacturers are starting to build this technology into their base models.[28]

Vehicle depreciation and residual value. ESBs are less costly to maintain and are expected to have a higher residual value at the end of the vehicle's useful life. However, the current adoption rates for ESBs in New York State have not yet created enough demand for an ESB resale market, with battery degradation being a key uncertainty for future market development. Battery degradation results in reduced battery capacity with use and age. Batteries are subject to capacity degradation through charge/discharge cycles, and after an unknown period of operation may no longer reach 100% state of charge (SOC) upon charging. As an example, Thomas Built anticipates their batteries to have roughly 80% of their original capacity by around 8 years. This is also accounted for in their warranty coverage; Thomas Built's electric school bus includes an 8-year, 175,000-mile battery warranty. Increased vehicle deployment and data collection will lead to more accurate estimates of battery degradation and residual bus value.

Charging infrastructure purchase and installation. In addition to vehicle purchase, other capital expenses that factor into TCO include the costs to acquire and install EVSE and other vehicle components or infrastructure. The cost of EVSE acquisition and installation varies widely depending on factors such as:

- The type and quantity of charging equipment (Level 2 or Level 3).
- The physical intensiveness of installation (e.g., if the charger location is far from the electrical service panel).
- Whether an electrical upgrade is required (e.g., utility infrastructure).
- Future fleet composition, including size and number of vehicles.

ESBs can typically use Level 2 charging equipment that operates when the buses are not in use for extended periods, such as between shifts and overnight. Level 2 chargers are considered relatively inexpensive, ranging from $5,000 to $15,000, while fast chargers range from $20,000 to $100,000.[29] Level 2 stations for a few buses or a small fleet may cost a few thousand dollars and may not require any electrical upgrades to the school bus facility. Level 2 charging also provides electricity at a rate that is less likely to incur large additional demand charges.[30] In cases where fleet operators must purchase and install specialized charging infrastructure, such as direct current (DC) fast charging stations, infrastructure costs can increase substantially. Fast charging may be desired when dwell time windows are insufficient to guarantee a full charge at Level 2 speeds. It may also be required if a project plans to harness bidirectional charging, or vehicle-to-grid technology to generate operating revenues (discussed further below).

Additional potential cost considerations include the price of hardware, electrical system upgrades, charging equipment installation, administering permits and software, warranties, spare parts, and acquiring and managing additional parking facilities if more space is required.[31]

1.4.1.2 Operating Expenses

Operating expenses that affect TCO include vehicle maintenance costs, energy costs, and costs for vehicle repair and replacement parts (e.g., batteries, brakes).

Even with the high capital costs associated with ESBs, a beneficial TCO is still possible when operating expenses can be managed to be sufficiently lower than the per-mile cost of operating petroleum buses. Whether or not an ESB can fully offset the capital premium within its service life depends on two factors: (1) how much lower the per-mile operating costs will be and (2) how many miles will be driven.

When ESB operating expenses are lower than those of an ICE bus, higher-mileage applications will present a more favorable TCO than lower-mileage applications. This means that buses that have longer daily trips (e.g., in certain rural districts) will be more likely to have an attractive TCO than those with shorter daily trips (e.g., in certain urban environments).

Energy use. The electricity costs for a bus are determined by the utility tariff structures (the various electricity rates that apply to different uses and timeframes) to which a bus operator is subject. Most commonly, these are commercial tariffs, with both volumetric ($/kWh) and demand-based ($/kW peak demand) elements. For planning purposes, utilities can evaluate a customer's expected load profiles to forecast an average cost per kilowatt-hours (kWh) inclusive of all utility charges. In New York State, electricity costs downstate (i.e., New York City, Long Island, and Westchester) tend to be higher, while upstate electricity costs tend to be lower. Different utilities across NYS also have different time of use (TOU) rates and demand charges. For example, Rochester Gas and Electric (RG&E) has zero demand charges for overnight hours making this time period more cost-efficient for charging for RG&E customers. This disparity can significantly influence the TCO for school bus electrification; all else being equal, a deployment with lower electricity costs will be able to recoup the upfront investment associated with ESBs sooner.

Managed charging, sometimes called "smart charging," can reduce the operational costs associated with fleet electrification. Depending on electricity rates, charging prices are often based on time of day, where pricing is greater during times of high demand and lower when strain to the grid is at its lowest. However, charging when electricity costs are lowest is not always feasible, nor is it operationally convenient for drivers to plug and unplug vehicles at strategic times of day. Charge management software automates charging to ensure that buses are charged to the appropriate level for the next trip while shifting energy consumption to lower-cost time-of-use periods and/or mitigating potential demand charges incurred when power use hits peak levels.

Managed charging requires purchasing EVSE that can actively track and modulate charging and a subscription for energy management software that can control which buses are charging and how much electricity they draw at any given time. While there are additional up-front and monthly costs associated with these technologies, their long-term benefits help lower the TCO.

Maintenance. Maintenance and repair costs are typically lower for electric-powered vehicles than ICE vehicles.[32] These savings are largely due to the simplicity of vehicle design, particularly the electric powertrain, which requires fewer components and is easier to maintain.[33] For example, both the engine and transmission of a diesel bus require lubricating oils that must be replaced regularly. ICE-powered vehicles also include an extensive system of filters, some of which must be replaced every six months. Electric powertrains eliminate engine oil, fuel filter, and exhaust filter services.[34] ESBs also tend to require fewer brake changes; electric buses use their motors to recover energy when slowing down, reducing wear on brake pads.[35]

Although maintenance and repair costs for electrified powertrains are lower than the costs for ICE powertrains for all vehicle sizes, the difference in maintenance and repair costs for medium- and heavy-duty EVs depends on the specific application and vehicle use pattern.[32] In school buses, for example, the costs to maintain or repair tires, could be higher for ESBs than for ICE buses due to the weight added by ESB batteries.

1.4.1.3 Incentives and Revenues

Purchase incentives. School districts and contractors in New York State already have access to a variety of purchase incentives to reduce the up-front costs associated with the transition to electric school buses. In addition, the State's recently approved Environmental Bond Act makes an additional $500 million available for this effort. It is anticipated that existing and upcoming funding opportunities, including Environmental Bond Act monies, will be sufficient to cover most of the incremental cost difference of electric school bus purchases expected over the next three years.

New York Truck Voucher Incentive Program

In New York State, school districts and school bus contractors can access up to $220,000 to reduce the purchase price of a zero-emission bus at the point of sale through the New York Truck Voucher Incentive Program (TVIP). Most Type A buses qualify for $100,000 to $120,000 in purchase assistance, while Type C and Type D buses qualify for $200,000 to $220,000 in assistance.[36] Bus operators receiving voucher assistance can also qualify for utility assistance for up to 90% of utility-side, make-ready infrastructure when preparing their sites to charge buses through the Joint Utilities of NY Medium- and Heavy-Duty Electric Vehicle Make-Ready Pilot.[37] New York State's current program design, focused on point-of-sale incentives, has been cited as a best practice nationally and addresses one of the key issues raised by schools, navigating the complexity of incentive applications and allowing for the reduction in up-front cost (which directly reduces the amount school bus fleets need to borrow). Roughly $7 million remains in the TVIP program for school buses.

EPA's Clean School Bus Program

School districts and contractors can apply to the EPA's Clean School Bus Program, which commenced in 2022 and will provide $5 billion to accelerate school bus electrification nationwide through 2026.[38] In the first round of Clean School Bus awards, announced in October 2022, EPA funded prioritized applicants a maximum of $375,000 per zero-emission bus and $20,000 for infrastructure.[39] For other eligible districts the caps were $250,000 per zero-emission bus and $13,000 for infrastructure. The 2022 round of the program included initial awards to 20 NYS school districts and included nearly $67 million in funding for 174 school buses and associated charging needs.

Inflation Reduction Act of 2022

In addition, the Inflation Reduction Act[40] of 2022 creates a new tax credit for some ESBs, which can be applied through 2032. For EVs, the potential tax credit is the lesser of 30% of the purchase cost or the incremental cost of the new vehicle compared to a comparable diesel or gasoline model. The credit has a limitation of $40,000 for vehicles weighing greater than 14,000 pounds and $7,500 for vehicles weighing less than 14,000 pounds that are assembled in North America.[41] For tax-exempt entities, including school districts, the tax credit is available as a direct payment.

New York State's Environmental Bond Act

New York State's Environmental Bond Act passed in 2022 and includes $500 million for school bus electrification. It is expected that Bond Act funds will be used to fund both the purchase of school buses and charging equipment.

Revenues. School buses sit idle at predictable times, including midday and early evening peaks and for longer periods over the summer during the electric grid's summer peak when electricity tends to be most expensive. Therefore, when not in use, ESBs can provide value by injecting power stored in battery packs into the electric grid through vehicle to grid/bidirectional charging (V2G). Not all vehicles have the capability for bidirectional power flow, and those that do must be paired with certain types of fast charging equipment to export power back onto the distribution system. However, if technical capabilities permit, V2G exports can provide a valuable revenue stream under utility demand response programs or under New York State's Value of Distributed Energy Resources tariff. This revenue stream can improve TCO over the life of the vehicle.

V2G charging is an emerging technology that relatively few fleets have adopted, and the impacts on TCO are only beginning to be understood and documented. Evidence from a pilot program in White Plains, NY, suggests that the business case for V2G is often mixed. While selling energy to the electric grid produced revenues in excess of the cost to charge batteries, the "profit" generated was not enough to offset the cost of the V2G investments. These investments included upgraded EVSE as well as replacement batteries (in some cases, batteries have been shown to degrade faster if used in V2G operations). V2G operations have also suffered from reliability issues; factors such as less mature systems and communication protocols as well as a lack of operator familiarity with the technology create more opportunity for outages and errors that lead to downtime. However, as V2G technology matures and becomes further integrated with existing systems and maintenance capacities, reliability is expected to improve.[42]

1.4.2 Current TCO Assessment

1.4.2.1 TCO profiles

TCO was assessed under a range of ESB scenarios including permutations of diesel and electric Type C buses, urban (short) and rural (long) duty cycles, and Consolidated Edison (Con Ed) with high utility rates and National Grid (NG) with low utility rates (see Table 3).

Table 3. Overview of TCO Scenarios

Scenario #	1	2	3	4
Bus type	Type C	Type C	Type C	Type C
Duty cycle	Urban	Urban	Rural	Rural
Utility rates	Con Ed	NG	Con Ed	NG

The above scenarios included numerous assumptions about costs and revenues for both electric and ICE buses. These scenarios assume a $385,000 ESB purchase cost, a $123,000 diesel school bus purchase cost, and a 12-year vehicle life for both vehicle types. Detailed assumptions are included in Table 4. The results of these simulations for an individual Type C bus with and without subsidies are shown below in Figure 4 and 5.

Table 4. TCO Scenario Assumptions (without subsidies)

Cost Factor	ESB	Diesel
Battery Size (kWh)	190	-
Lifetime (Years)	12	12
2025 Vehicle Price ($)	$385,000	$123,000
NY Sales Tax[a]	0.079	0.079
2025 Fuel Economy (kWh/mi or gal/mi)	2.54	0.15
Fuel Price ($/kWh 2025 & $/DGE 2025)	0.10 (National Grid)/ 0.21(ConEd)	4.23
Maintenance ($/mi)	0.705	0.94
Registration Fees	$23,359	$29,398
Charging Power (kW)	19	0
Charger Cost	$5,000	0
Infrastructure Upgrade Cost	$25,000	0

a NYS Sales Tax does not apply to purchases made by school districts, only private entities (e.g., third-party contractors) pay Sales Tax and amounts may vary across the State.

Figure 4. Example Type C School Bus Unsubsidized and Subsidized Cost Comparisons–Con Ed Rates (2023)

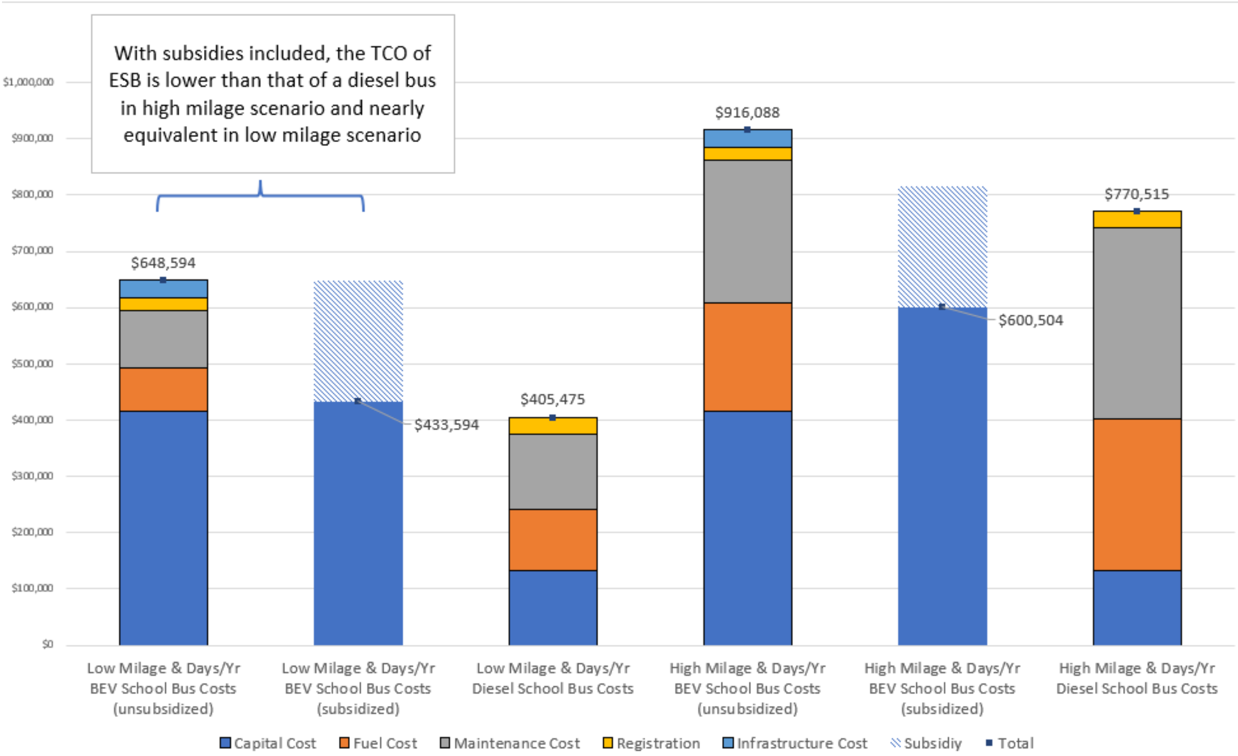


Figure 3 highlights the comparison for the TCO of an ESB and a diesel school bus. The Con Ed charging rate was calculated at $0.21/kWh, with the low-mileage scenario assuming 60 miles/day and 200 days/year, and the high-mileage scenario assuming 120 miles/day and 250 days/year. The increased capital and infrastructure costs for the ESB result in a higher TCO, which is exacerbated in the low-mileage scenario because the savings associated with the lower fuel and maintenance costs of an ESB are proportional to the miles driven over their useful lives. Both use-case scenarios assume ample overnight charging time. However, the impact of typical bus purchase incentives is also demonstrated. When a $215,000 incentive amount is applied (including $200,000 for an ESB and $15,000 for a charger) the TCO of an ESB is only slightly higher than a diesel bus in the low-mileage scenario and substantially lower than a diesel bus in the high-mileage scenario.

Figure 5. Example Type C School Bus Unsubsidized and Subsidized Cost Comparisons–National Grid Rates (2023)

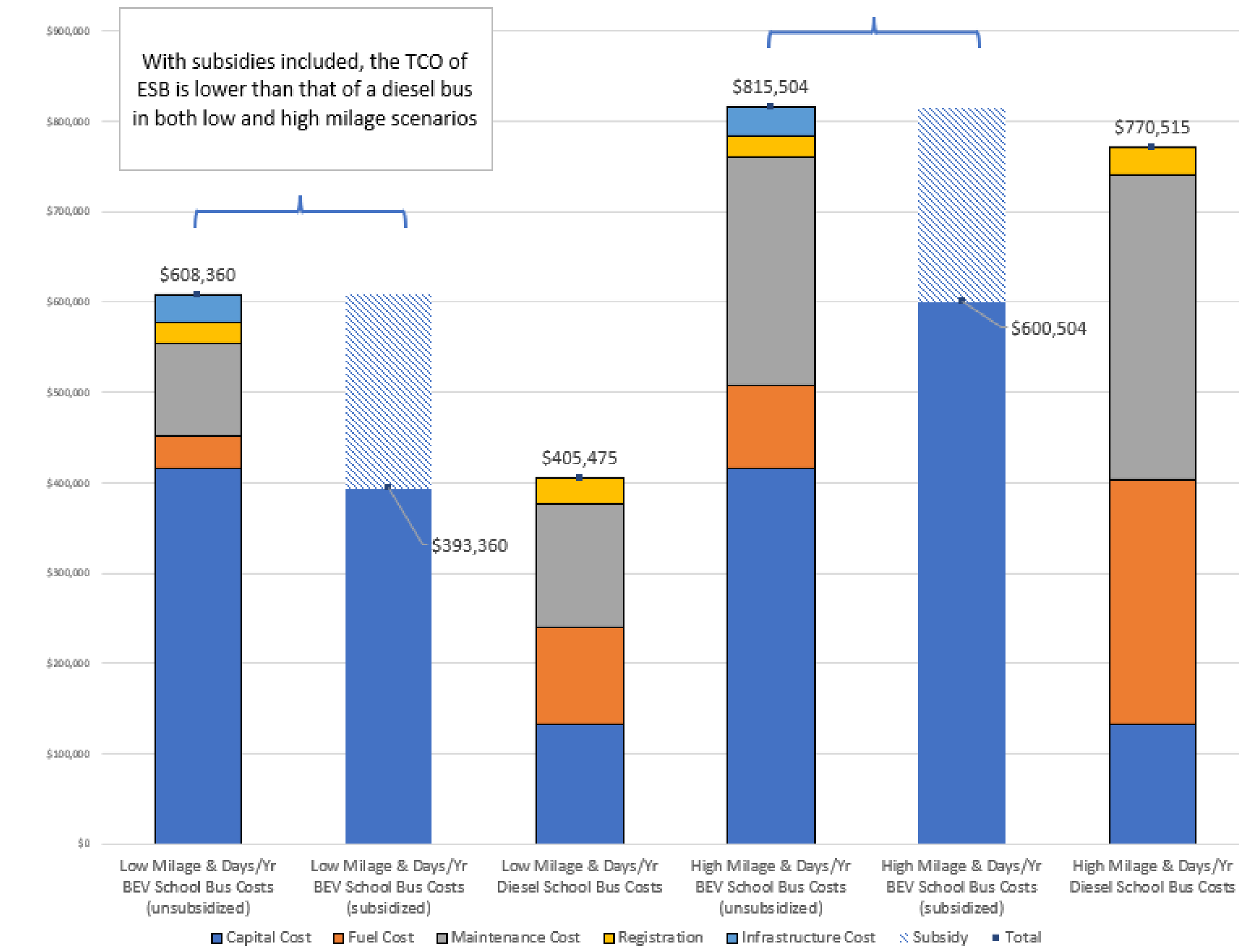


Figure 5 features the same assumptions as Figure 4 but using a charging rate of $0.10/kWh for National Grid. In the low-mileage case, the TCO for ESBs is nearly at parity with diesel buses when the incentive amount is applied and the TCO is much more favorable in the high-mileage scenario.

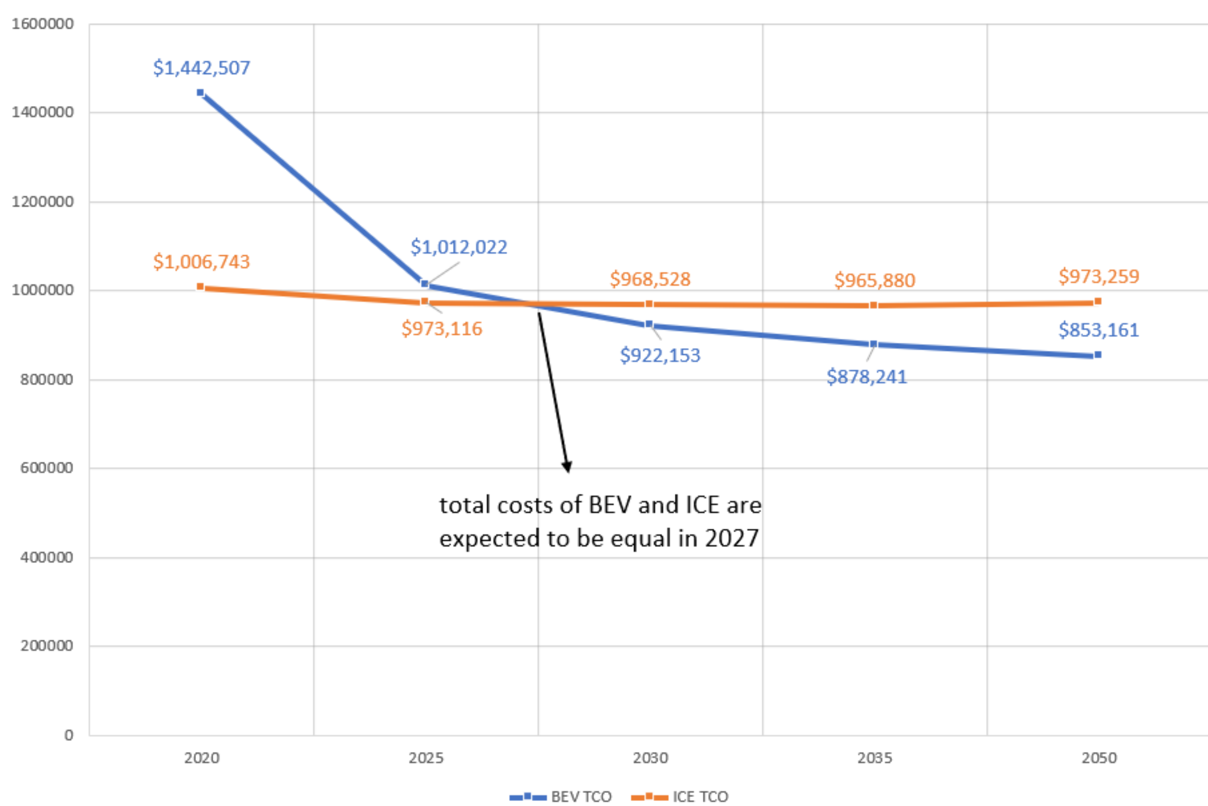
1.4.3 Expected TCO Forecast

The TCO for ESBs is expected to become increasingly favorable as production scale and technological innovation drive down the cost of vehicles and charging infrastructure, which are the largest drivers of ESB costs.

While limited information is available for school buses right now, estimates can be extrapolated from other larger vehicles. Argonne National Laboratory (ANL) conducts research on total costs of ownership for a wide range of vehicle types and projects that the TCO for electric day cab tractors (a similar vehicle type to Type C and D school buses) will decline steeply, falling from 2020 model year values by 36% in MY2030 and 41% in MY2050.[43] These cost declines are driven largely by significant reductions in vehicle cost and also by reductions in total fueling cost.

In contrast, the TCO for diesel ICE day-cab tractors is projected to fall only modestly during the projection period before rising slightly by MY2050. Diesel vehicle costs are projected to increase by 6% by MY2025 and 17% by MY2050. Diesel fueling is projected to grow less expensive, dropping 16% by MY2025 and 23% by MY2050. If similar trends apply to the school bus market, it would be expected that predicted TCO for diesel and electric school buses will reach parity in 2027, as shown in Figure 6.

Figure 6. TCO of Electric and ICE Class 8 Day Cab Tractors, MY 2020–MY2050



The results of these expected price changes are summarized in ANL's levelized cost of driving (LCOD) statistic, which presents lifetime costs in a cost per mile of driving format. Class 8 electric day cabs currently have an LCOD of $2.80/mile, which is expected to fall to $1.70/mile by 2050, while the diesel equivalent remains constant at $2.00/mile over that time. Much of this relative decrease for electric day cabs is expected to occur by 2027, when ANL expects LCOD for BEVs to drop below diesel vehicles.

In summary, TCO for ESBs relative to ICE buses is currently highly dependent on duty cycle, electricity cost, and incentives; however, market factors, including battery pricing and economies of scale, will improve economics of school bus electrification. In particular, the cost reductions anticipated in the coming three to five years will shift more ESB deployments into TCO-positive values even without purchase incentives and will make fewer deployments reliant on current levels of funding support.

2 ESB Key Issues and Solutions

This section presents some of the main issues associated with the electric school bus transition, as well strategies to overcome these issues. This list was informed by issues raised by school districts and bus contractors in their responses to a recent survey. Sections include:

- **Section 2.1 Costs and Funding Opportunities**, which addresses the main concerns around the upfront costs of both school buses and charging equipment.
  - Key Takeaways
    - New ESB purchase prices can be three or more times the price of an equivalent diesel- or gasoline-powered bus today, but prices of electric vehicles are dropping.
    - Total cost of ownership of electric school buses is expected to achieve parity with that of diesel buses around 2027.
    - Federal, State, and private funding incentives can close the gap between diesel- and gasoline-powered school buses in the next 3–5 years, which will help grow the market for ESBs, and allow the price to decline and the technology to improve.
- **Section 2.2 Planning, Purchasing and Electrical Grid Coordination**, which discusses how to manage fleet planning and coordination with electric utilities.
  - Key Takeaways
    - Purchasing and installing ESB charging infrastructure requires planning, permitting, and other administrative support and may require electrical upgrades and other depot improvements.
    - Fleets can take advantage of NYSERDA and utility planning resources.
- **Section 2.3 Equipment Concerns**, which addresses some of the main concerns about the transition, such as battery range, fire risks, and useful life.
  - Key Takeaways
    - The range of currently available ESBs is sufficient for most bus routes today.
    - Fleets should focus on the easy to electrify buses as they start to electrify their fleets, which will allow them to gain experience as the technology improves and the market develops. The expectation is that costs will decline and battery ranges will increase over time.
- **Section 2.4 Equity and Employment**, which highlights how equity must be centered to ensure a just transition to clean school buses.
  - Key Takeaways
    - New York State will prioritize disadvantaged communities (DACs) and high-need school districts in the allocation of Bond Act funding and will cover the majority of the incremental cost difference between ESBs and ICE vehicles in these Priority Districts in the initial stage of the transition to electric vehicles.

2.1 Costs and Funding Opportunities

2.1.1 Costs for Buses and Charging Equipment

Although the upfront prices of electric school buses are higher than those of traditional diesel and gasoline buses, prices for both electric school buses and charging equipment are declining. Significantly, the total cost of ownership of ESBs, the cost from purchase through vehicle retirement, is expected to reach parity with ICE buses around 2027, see Figure 1-4. In the interim, federal, State, and private entities offer incentives that can close the price gap.

2.1.2 Supply Chain and Costs

Supply chain constraints have limited the delivery of ESBs, EVSE, and electrical switchgear and transformers across the country, but manufacturing capacity has been increasing and most major bus manufacturers have announced large ramp-ups in production in the next three to five years.[44] Build America Buy America Act restrictions on internationally sourced materials and components may limit products that can be purchased with federal funds. Given the anticipated spike in demand for EVSE installation, electrical and construction contractor labor shortages, and permitting delays are all possible. Utility system improvements and make-ready projects might also be slowed due to workforce shortages and funding limitations. Because the upgrades needed for full-scale electrification may require years of lead time to complete, the New York State Public Service Commission (PSC) and utilities are identifying ways to speed up this process and make sensible proactive investments that cut down on the time needed to complete these upgrades.

2.1.3 Navigating Funding Opportunities

As mentioned in section 1.0, there are numerous federal, State, and private funding opportunities available to help support the transition to ESBs. These include the New York Environmental Bond Act, New York Truck Voucher Incentive Program, EPA Clean School Bus Program, and the Inflation Reduction Act. NYSERDA is preparing ESB Guides on a number of topics, including funding opportunities. In addition, NYSERDA will likely employ a help center to help applicants access Bond Act incentives, as it does today for the New York Truck Voucher Incentive Program (NYTVIP). In addition, NYSERDA may hire engagement-focused positions as part of the Bond Act administration.

Refer to **appendix D: Funding Sources** for more information.

2.2 Planning, Purchasing, and Electric Grid Coordination

2.2.1 Planning

2.2.1.1 Fleet Transition Plans

School districts and bus contractors can access funding for fleet advisory services to develop fleet transition plans. These plans include the types and quantities of vehicles, batteries, and chargers needed to meet current and future operational demands; associated equipment and site modifications needed to accommodate bus charging; initial cost estimation of major components, as well as opportunities for workforce development, utility engagement, and implementation timelines. Fleets can leverage existing State programs such fleet assessment services offered by electrical utilities and NYSERDA's P-12 Schools: Clean Green Schools Initiative and Flexible Technical Assistance Program to create their own fleet transition plans with support from a qualified contractor. In addition, investor-owned utilities have EV specialists to start a discussion of grid capacity at bus depot locations.

Fleet advisory and grid coordination services can smooth the process of fleet electrification, and can assist with planning, permitting, and other administrative support. Organizations can partner with utilities and/or participate in NYSERDA's technical assistance program to prepare fleet transition plans. For districts served by an investor-owned utility, engaging in the utility's Fleet Assessment Service process is strongly recommended so districts and their utility both understand the upgrades needed to charge buses at the sites where they are expected to be charged. Most utility-funded studies are focused on the electric grid-related elements of bus electrification. Technical assistance provided by NYSERDA (as described below) can help districts understand a wide range of technical and logistical issues around school bus electrification and can help gather more accurate information to share with their utility through the utility's Fleet Assessment Service Application. School bus fleet owners may choose to work with both their utility and NYSERDA to get a comprehensive understanding of the electrification process.

2.2.1.2 Investor-Owned Utilities

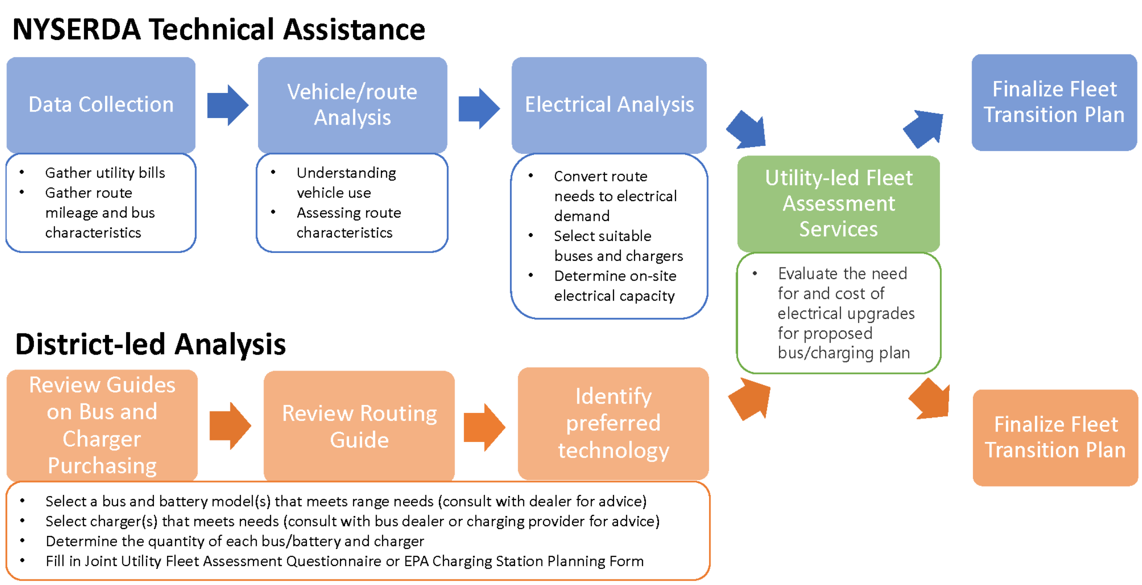
The six investor-owned utilities in New York State (Con Edison, Orange & Rockland, Central Hudson, National Grid, NYSEG, and Rochester Gas & Electric), collectively known as the Joint Utilities or JU, offer Fleet Assessment Services that focus on the feasibility and cost of accommodating the anticipated bus charging based on the charging location and local grid constraints and identifying any equipment the customer needs to install on-site. For the utility to provide an accurate assessment, school bus operators need to provide the number and type of buses and chargers, the proposed timetable for purchasing buses, and the proposed "charging plan" (i.e., when buses will be plugged in and charging).

2.2.1.3 NYSERDA Technical Assistance

NYSERDA's technical assistance program provides fleets with comprehensive fleet transition plans. Importantly, this includes conducting analysis that will enable bus fleet operators to complete the Joint Utilities of New York's (the JU) Fleet Assessment Service Application to reflect their intended ESB and charger needs. The contractors supporting this work will also support fleet operators in completing the JU's Fleet Assessment Service Application and facilitate utility engagement. Districts and their contractors can also use NYSERDA's ESB Guidebook to understand the steps needed to develop a transition plan and work with their utilities through the Fleet Assessment Services programs provided by the JU to finalize their fleet transition plans. There is also technical assistance provided by some bus dealers and contractors, advocacy groups, and the EPA (for Clean School Bus Program applicants).

Figure 7 shows how school bus fleet operators can undertake these important planning steps with or without utilizing NYSERDA's technical assistance offering.

Figure 7. Fleet Assessment Options Process Flow Chart



Refer to **appendix G: Fleet Advisory and Grid Coordination Services** for more information.

2.2.1.4 Route Optimization and Fleet Right Sizing

The transition to ESBs may provide an opportunity for fleets to reassess their current vehicle use and adjust their operational practices and vehicle inventories. Specifically, conducting route and facility assessments in advance of ESB deployment may identify changes to vehicle applications, types, and quantities that can improve efficiency and lower costs (i.e., right-sizing). For example, research may highlight the number of idle vehicles fleet owners currently have and the associated causes (e.g., reduced transportation demand, staffing limitations, or incorrectly sized fleets).

2.2.2 Purchasing

2.2.2.1 Purchasing via Centralized Contract

School districts and bus companies can pursue purchase models in which a central entity organizes the procurement of vehicles, charging infrastructure, and/or related services on behalf of individual fleets. Fleets can take advantage of a centralized contract to procure a wide range of goods and services, including ESBs and EVSE procurement, operations and maintenance (O&M) services, telematics, and other services such as site planning and prep, utility coordination, equipment installation, and project management. Fleets have several centralized purchase options to consider, including, among others, the New York State OGS's contract with to procure EVSEs and network services. OGS currently has only one provider on their contract for EVSE, however, they are working to provide access to an additional 11 contractors through a 'piggyback' on the Sourcewell Master Contract #042221, which runs through July 2025.

Refer to **appendix F: Centralized Purchase Models** for more information.

2.2.2.2 Sharing Infrastructure across Districts

School fleets may be able to facilitate the introduction of ESBs and reduce their electrification costs significantly by providing one another with charging infrastructure access. Having access to known, reliable charging locations away from their own depots should decrease concerns regarding range limitations and reduce the need for oversizing battery capacities for relatively infrequent long-range sports runs and field trips. The timing of charging demand from visiting districts should align with lower charging demand periods for host districts since a portion of their fleet may still be in service.

2.2.3 Electrical Grid Coordination

2.2.3.1 Electrical Service Upgrades

Electric utilities are accustomed to partnering with sites to perform detailed site assessments to determine if electrical system upgrades are necessary to accommodate increased power demand or if other modifications need to be made.

Some districts or contractors may need to seek new sites due to the additional space requirements of charging infrastructure or because of the cost of bringing additional electrical capacity to their existing depot sites. As school bus fleet operators plan for future infrastructure expansion, they will want to evaluate the costs and benefits of installing as much infrastructure up-front as possible as opposed to a potentially less efficient piecemeal approach. Even if ESBs are gradually brought into a fleet, it could be beneficial to have more of the charging infrastructure work done at one time, something that can be identified by a fleet transition plan.

Refer to **appendix G: Fleet Advisory and Grid Coordination Services** for more information.

2.2.3.2 Demand on the Grid

Most school buses can charge overnight, when electricity demand is low, and many customers can access lower electric rates. School bus fleets can use "managed charging" to schedule their charging to take advantage of lower rates. New York State's investor-owned electric utilities offer financial incentives to businesses to shift their power demand to off-peak hours.[45] Programs that allow utilities to either notify fleets when prices will be lower, so they can decide to shift when they charge or directly control minute-to-minute charging loads, could help manage demand and help fleet owners save money. Alternatively, utilities may subsidize or cover the cost of charging infrastructure in exchange for agreements around managing the charging load.

Bus recharging can be managed to ensure that ESBs are adequately charged and available for service on schedule. Utilities can help assess charging schedules during the detailed fleet transition plans. Incorporating these strategies and technologies during transition planning can help fleet owners reduce up-front and operating costs and improve TCO. In addition, the NYSERDA ESB guidebook will provide information regarding how to make decisions about smart charging and demand management needs and strategies.

Managed Charging Examples

Dominion Energy

In Virginia, Dominion Energy partnered with Fairfax County Public Schools to electrify its fleet, which included both ESB and charging infrastructure deployment. Unlike conventional utility-sponsored incentives, Dominion Energy assumed ownership of ESB batteries and propulsion systems and maintains and operates the associated charging infrastructure. This enables Dominion to use buses as flexible grid assets and (eventually) realize benefits from V2G use in the future. This V2G initiative within the Dominion Energy program is still in an early stage and at-scale results are yet to be seen.

Brookville Smart Energy Bus Depot

In Maryland, the Montgomery County Department of Transportation entered into an agreement with Duke Energy that allowed the utility to access the county's microgrid a certain number of days per year for load management, in exchange for payments.

Refer to **appendix E: Procurement and Operational Models** for more information on managed charging.

Refer to **appendix G: Fleet Advisory and Grid Coordination Services** for more information on utility coordination.

2.2.3.3 Procurement Options

When transitioning from ICE vehicles to ESBs there are several procurement options to consider:

- **Traditional:** School district owns and operates all buses and equipment.
- **Lease:** A third party owns the ESBs, while the school district owns the chargers and charging infrastructure and manages operations.
- **Turnkey:** The district or bus contractor owns the ESBs, chargers, and charging infrastructure, but procurement, design, and construction is handled by a third-party (typically as-a-service providers, as described below) while the school district or bus contractor manages operations.
- **Transportation-as-a-Service (TaaS):** A third party owns some combination or all of the ESBs, chargers, and charging infrastructure and manages operations of those assets but the school district maintains responsibility for providing daily transportation services or contracting this service out.[46]

- **Contractor service:** A third-party school bus contractor owns the school buses and any associated charging infrastructure and provides a comprehensive service, including drivers, operation of buses, and all other aspects of student transportation, to the school district. The contractor may engage another third party for a Turnkey or TaaS contract for electrification and charging support.
- **Contractor operation:** The school district maintains ownership and maintenance responsibilities for the buses and charging infrastructure, while the contractor operates the buses.

NYSERDA can help familiarize fleet managers with some of the procurement options that could assist with the ESB transition. NYSERDA will make available guides on new procurement methods and how they compare to procurement methods schools may be more familiar with and will prepare template requests for proposals (RFP) and requests for information (RFI) that can be used to bring new partners on board.

Refer to **appendix E: Procurement and Operational Models** for more information.

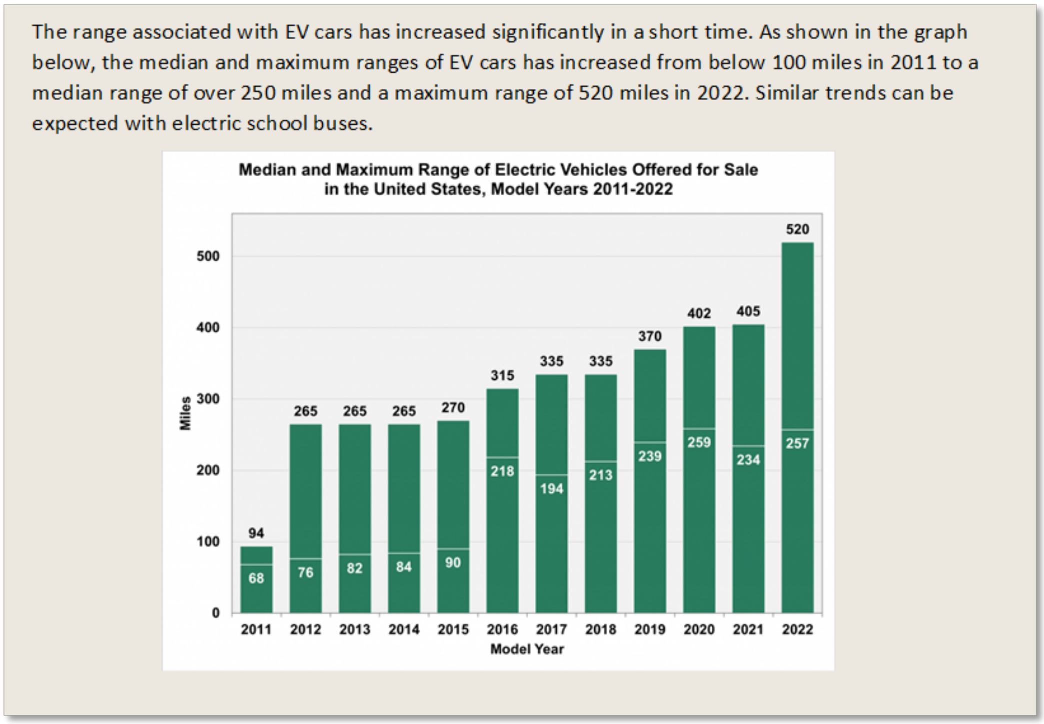
2.3 Concerns about Owning and Operating the Equipment

2.3.1 Battery Range

ESBs on the market today have ranges of 100 to 210 miles. While the range of currently available ESB models is sufficient for most routes and is expected to increase, it may be inadequate for specific needs of some school bus operators. In this initial tranche of electrifications, school districts can focus on the easy-to-electrify routes, which are shorter than 80 miles and return to the depot overnight. The range of electric vehicles has been steadily increasing over the last decade, as shown in Figure 8, and the same trend is likely to continue with electric school buses.[47]

Figure 8. Median and Maximum Range of EVs Offered for Sale in the US, MY 2011–MY 2022

Source: U.S. Office of Energy and Renewable Energy[48]



Focusing on buses with shorter routes in school bus fleets' initial ESB rollouts will ensure successful first experiences as fleets gain experience using ESBs. Waiting to electrify longer routes will allow for battery technology that is more appropriate for these routes.

2.3.2 Level 2 and Level 3 Chargers

Most school buses have long layover times and can be charged using Level 2 chargers. However, certain fleets may require faster charging due to specific use requirements or logistical constraints. Fleets should assess their charging needs as part of their fleet transition plans to determine what speed of charging is needed in their specific circumstances.

Other needs, such as long routes, sports trips, and field trips, may require different charging solutions. As best practices evolve, NYSERDA will study harder-to-electrify routes and advise fleets on how many Level 3 fast chargers may be required to service buses that need to recharge quickly, especially away from the depot. In addition, thanks to an influx of federal funding, the next several years will see a dramatic expansion of publicly available Level 3 chargers, from which school bus operators may be able to benefit.

2.3.3 Siting Chargers

It can be difficult to fit chargers into crowded bus depots. Level 2 charging stations don't take up a lot of space since they are typically wall-mounted or pole-mounted and have a small footprint. Level 3 chargers can have significantly larger footprints, taking up the space that might be used to park one or two cars. However, most fleets can accommodate at least a small number of Level 2 stations initially and can add more with thoughtful planning. Transit bus depots have been developing systems with overhead charging to alleviate space constraints, which could be a practical solution in certain depots with space constraints. Space constraints are of particular concern in regions where the ability to expand existing lots or find alternative depot locations is limited (i.e., New York City). In addition, leases for depots located on leased property might need to be renegotiated (e.g., to allow for construction operations).

2.3.4 Vehicle-to-Everything Programs

Vehicle-to-everything programs include any bidirectional charging functions allowing ESBs to discharge stored power from their onboard battery storage. The power can be used to power on-site energy needs like backup power in building applications (known as vehicle-to-building or V2B), or, in more sophisticated arrangements, be fed back into the grid to generate revenue (known as vehicle-to-grid or V2G). This latter option can provide an added revenue stream for operators. While many bus and charging manufacturers make V2G capable products, they are still in their early stages of development and utilities are working to set up programs to enable their use widescale. The amount of revenue that can be generated through V2G in New York State is still unclear; school bus fleets should be cautious in relying on V2G revenue to justify large investments, although it may provide some benefit to schools.

As-a-service providers offer bundled solutions to help enable V2G while limiting the challenging process of installing and operating the system. If school bus fleets are considering V2G, they should consider talking to companies that have expertise and can offer to oversee the process.

NYSERDA has historically funded cutting-edge energy research and sometimes offers funding opportunities to demonstrate new technologies, such as V2G and other innovative charging solutions. Check NYSERDA's Current Funding Opportunities page to see if any funding programs are currently soliciting proposals.

Refer to **appendix H: Vehicle-to-Everything Solutions** for more information.

2.3.5 Cold Weather Performance and Auxiliary Cabin Heaters

Batteries do not charge as quickly or provide power as efficiently in very cold weather, and a significant portion of battery energy can be used to heat the cabin of a school bus. The same is true for diesel engines, to a lesser extent. Charging limitations are less pronounced for Level 2 charging, so school buses should not be faced with charging speed issues very frequently. Bus manufacturers offer and are developing technologies to address the need for cabin heat and better battery performance, including automatic pre-heating of batteries and interiors while connected to power and auxiliary cabin heaters that can reduce battery draw for cabin heating. Buses are integrating new heat pump technology that provide more efficient heating and cooling than traditional heaters.

2.3.6 Rusting

While ESBs are no more rust prone than petroleum-fueled buses, the viability of ESBs as an economic investment is dependent on taking advantage of the buses' lower operating costs over a long vehicle lifespan. Some manufacturers are experimenting with new material designs to combat rust and thereby extend vehicle life. For example, Lion Electric offers ESBs constructed with a rust-free external material. Other investments in rust protection coatings may be more attractive for ESBs compared to traditional buses because of the large upfront investment and desire to keep the buses on the road for longer.

2.3.7 Weight Concerns

ESBs typically weigh more than diesel buses, but the buses are still well below the weight limits for the vast majority of bridges. Most bridges in the State are designed to support all types of registered vehicles, which can reach up to 80,000 lbs. The heaviest ICE and electric school buses only weigh around 35,000 lbs. For bridges with lower weight ratings, it will be exceedingly rare for the weight difference between an ICE and electric school bus to push a bus from allowable to overweight. NYSERDA will continue to monitor these issues in coordination with New York State Department of Transportation (DOT) and vehicle original equipment manufacturers (OEMs), but it is not anticipated that specific action will be needed.

In some rare instances the existing bus lifts used for repairs, or the floors of depots, may not be able to support any additional weight and could require replacements. The ability of existing depot equipment to withstand heavier vehicles can be assessed during the development of fleet transition plans.

2.3.8 Fire Safety

Although there have been a number of tragic fires related to e-mobility devices in recent years, these are generally associated with low-quality, retrofitted batteries used on low-cost e-bikes and e-scooters. Batteries purchased from reputable manufacturers have strong safety records. Electric school bus batteries are well protected on the vehicles and have a wide range of sensors and safety mechanisms built in. In addition, guidance to manage fire risk is available from the National Fire Protection Association (NFPA).

2.3.9 Battery Degradation

Lithium-ion batteries are currently expected to support the entire service life of the vehicle, and battery technology is expected to continue to evolve and improve over the next 10 to 15 years. Data on passenger electric vehicles, which are more widespread and have been around for longer, indicate that electric vehicle batteries are showing little degradation over time.[49] However, at present, there is not enough data available to confidently estimate the degree of degradation impacts over a 12-year bus service life. To help mitigate the performance and financial risks associated with battery degradation, each vehicle is backed by an OEM warranty, typically ranging from 5 to 8 years, so only post-warranty operation needs to be evaluated.

2.4 Equity

A critical consideration as decarbonization moves forward is the extent to which these changes ensure an approach that advances environmental justice. That is, policy options and implementation should aim to avoid negative impacts and ensure positive impacts for vulnerable populations and DACs who have traditionally been most negatively affected by past energy, transportation, and land use policy decisions, while enabling a smooth workforce transition to new technologies. As a first step, New York State will aim to ensure at least 40% of funding is allocated to disadvantaged communities (DACs) and will cover the majority of the incremental cost difference between ESBs and ICE vehicles in Priority Districts through 2027, or as funding is available.[50] This goal is in keeping with the Biden Administration's Justice40 initiative, which aims to ensure that at least 40% of the benefits of certain federal investments, including those in clean transportation, are distributed to the disadvantaged communities that have been most negatively impacted by pollution.[51]

2.4.1 Job Training and Impacts on Labor Market

Much of ESB maintenance and general operations support tasks can be performed by existing in-house fleet technicians, provided they receive training on the nuances of working on ESBs, such as high-voltage power control when working on components connected to the battery pack. There are several existing training programs already in New York State, and more to come. For example, Hudson Valley Community College has developed training courses for EV mechanics and EV charging installers, which are being shared throughout the SUNY system and could be leveraged for ESB training.

In addition to these initiatives, under NYSERDA's Clean Transportation Prize program, the prize-winning New York City School Bus Umbrella Services (NYCSBUS), a school bus operator in NYC, is developing an "ESB Center of Excellence" at their Zerega Depot. The goal of the center is developing and contributing to a statewide knowledge base about ESB implementation and providing a space for hands-on training in clean energy in partnership with technical colleges. The center will include ESB curriculum development and coordination, production of training videos and web animations, outreach to New York State school districts via a cohort program that uses materials from the Center of Excellence to support school districts in the development of transition plans and share project findings and resources for their deployment planning and workforce training.

NYSERDA is identifying needs and working with stakeholders to deliver appropriate training programs for fleet and facility managers, bus technicians, and drivers.

Please see **appendix I: ESB Workforce Training Needs and Options for Meeting Demand** for more information.

3 Statewide Cost and Funding Analysis

This chapter estimates the costs of school bus electrification in New York State, focusing on the first three years of the transition, through 2027 and demonstrates how the funding available to support vehicle and charger purchases could be applied. The amounts represented are the incremental costs of electrification unless otherwise stated. The first Roadmap update (due in 2026) will adjust this analysis with updated information and provide more insight on the anticipated costs after 2027.
This approach is advantageous because:

- As with all new technologies, costs are high, and technologies are rapidly changing in the early phases of adoption. The electric school bus industry is in this phase of adoption, statewide and nationally. This makes predicting the full cost of transition challenging, as price and technology changes will be frequent until the market is further developed. There is an expectation that prices of electric school buses, like those of most new technologies, will decline significantly, but the timing is uncertain. The analysis is based on currently available cost information and assumptions about funding allocations. The amounts shown are for planning purposes and should not be considered final determinations.
- New York State has substantial funding resources in place today such as the voter-approved Environmental Bond Act, alongside other State and federal programs to leverage in these years. As reported in section 1, the total cost of ownership of ESBs is expected to reach parity with ICE buses around 2027. By maximizing the use of funds now and scaling down funding amounts over time, Bond Act funds can be distributed widely, catalyzing fleet transition in every interested district. The first few buses can be the most challenging and expensive to integrate into fleets, and the help here will go a long way toward setting districts up for long-term success.
- The survey conducted during the Roadmap development process affirms that there is a significant opportunity to support ESB purchases in the next few years, with as many as half of the buses in the State targeted for replacement during this time.

Refer to **appendix B. School Bus Fleet and Operations Survey Results** for more information.

3.1 Assumptions

This section describes the inputs and assumptions that were used to determine the potential costs associated with electrifying school buses between 2024 and 2027. Information used, either directly or to inform the assumptions made, was gathered through market research and industry outreach.

3.1.1 Operations and Costs

- **Replacement opportunities**: Based on the survey conducted as part of this project, up to 22,000 ICE vehicles could be available for replacement between 2024 and 2027. The survey covered 139 school districts. However, the results could be overstated. Using a typical 'rule of thumb' of 10% fleet turnover per year, there would still be up to 13,500 vehicle replacement opportunities during this timeline. While the survey may be over-representing the number of replacements that are possible, it indicates ample opportunities for fleets to purchase ESBs.
- **Adoption curves:** Based on adoption curves for electric vehicles, it is reasonable to assume that only a fraction of the vehicles purchased between 2024 and 2027 will be replaced with ESBs. However, EV adoption for fleet vehicles, all else held equal, is expected to progress more rapidly than for the general public because fleet-owners have regular intervals for replacing vehicles and have more control over installing charging infrastructure. For this reason, it is assumed that between 10-15% of retired vehicles by 2027 could be replaced with ESBs, or approximately 3,000 total ESBs by 2027. Market outreach suggests that more than enough ESBs will be produced by 2027 to meet New York State's assumed demand.[52]
- **Fleet owner readiness**: Fleet owners need to plan and prepare for receiving ESBs, including coordinating with utilities and installing infrastructure. Given this need, it is reasonable to assume most fleet owners will only be able to purchase a few vehicles before 2027. The approximately 3,000 vehicles noted above would align with 4 to 5 ESBs per district in the State.
- **Vehicle type**: Based on the survey conducted as part of this project, the current split between Type A and Type C/D buses in New York State is approximately 30% Type A/B and 70% Type C/D. In NYC, which represents roughly 25% of the statewide school bus fleet, the numbers are roughly flipped with 65% Type A and 35% Type C. External factors including decreasing enrollments, school consolidation, and driver shortages may influence vehicle type choices going forward in unpredictable ways. Price may also be a driver, with Type A buses being cheaper, but Type C/D offering more capacity with fewer vehicles. Given these data and unknowns, this analysis assumed a 35% Type A/65% Type C/D split for future purchases.
- **Incremental cost**: As noted earlier, OGS operates a State contract for school bus purchasing. The contract was updated in December 2022 and offers a realistic comparison between ICE and electric school buses for the next few years. Based on the average prices for each vehicle type and powertrain (ICE or electric), the incremental cost for each vehicle class is approximately $190,000 for Type A buses and approximately $260,000 for Type C/D buses. In total, the aggregate incremental cost for ESBs by 2027 is expected to be between $675 million and $725 million.

3.1.2 Funding

- **Priority Districts**: Due to the greater impact vehicle emissions have had on residents of disadvantaged communities, the cost analysis assumes a higher incentive amount per vehicle for Priority Districts. It is assumed that Bond Act funds will cover the majority of the incremental cost difference between ICE and ESBs for Priority Districts, and that non-DAC/high-need school districts will receive at least 50% of the incremental cost per bus. Actual funding opportunities may differ from this allocation. In line with the Climate Leadership and Community Protection Act (Climate Act), the assumed funding allocation is at least 40% Priority Districts.
- **Environmental Bond Act**: The $500 Environmental Bond Act allocation for zero-emission school buses will be available soon but the exact program structure is still being finalized. For planning purposes, it is assumed that funds will be used to cover *up to* 100% of the incremental cost of an ESB compared to a diesel equivalent, along with a charging allocation for each vehicle. The charger allocations for the purpose of this analysis are assumed at $15,000 for Type A buses and $30,000 for Type C/D buses.
- **Other funding sources**: The Environmental Bond Act funds will be offset by other existing State and federal programs assumed at the following amounts:
  - The EPA Clean School Bus Program is estimated to bring an additional $263 million in total funding to NYS in the remaining four years of the program. For prioritized school districts, the Clean School Bus Program currently provides a higher award per school bus than the incremental cost difference between an ESB and a diesel/gasoline powered bus. The portion of this funding supporting this incremental cost is estimated at $178 million over the next four years.[53]
  - The NYTVIP remaining funds (roughly $7 million) will be expended.
  - The EPA Clean School Bus Program and NYTVIP program are projected to support the incremental purchase cost of roughly 720 ESBs, leaving 2,280 ESBs to be funded to reach the planning target of 3,000 ESBs.
  - The IRA Tax Credit will apply to the incremental cost of the remaining 2,280 buses and the 35 buses expected to be covered by NYTVIP, yielding about $93 million for New York State school bus fleets.[54]

3.1.3 Infrastructure

- **Utility and customer-side infrastructure costs**: Utility- and customer-side infrastructure costs are not considered at this stage because:
  - The goal in the years ahead of 2027 is to make the program widely accessible and help districts purchase their first few buses. As such, infrastructure costs may be minimal since many districts will have the ability to charge a small number of buses without having to increase their electrical capacity.
  - The Medium- and Heavy-Duty Make-Ready Pilot Program can cover up to 90% of any utility-side costs bus operators may incur in the major utility service territories.
  - The Department of Public Service (DPS) is reviewing the Make-Ready Program in 2023 to make it more accessible and inclusive.

- NYSERDA and DPS, along with the electric utilities, are conducting analysis to determine where grid upgrades may be needed, and DPS is conducting a proceeding on Medium- and Heavy-Duty vehicle electrification that may provide additional resources between now and 2027.

- While costs can vary significantly, it is currently assumed that these costs can make up between 15-30% of total project costs for a full fleet transition. In total, the aggregate cost for chargers by 2027 based on the assumed allocations noted above is expected to be between $60 million and $90 million. These percentages will continue to be monitored as projects are completed and updated information will be included in the 2026 update of the Roadmap.

3.2 Results

3.2.1 Funding Assessment

Based on these assumptions it is expected that the incremental cost of the 3,000 ESBs and their associated chargers that school bus fleets in New York State are expected to purchase between 2023 and 2027 is roughly $780 million. The EPA CSB Program and NYTVIP are expected to reduce the number of buses for which the purchasers are seeking incremental funding for by approximately 720 buses, providing approximately $278 million in estimated funding.

A portion of the incremental funding for the remaining 2,280 buses and chargers could be supported by approximately $420 million of the Environmental Bond Act allocation. The projected amount of Bond Act funds used could deviate from the estimated $420 million, depending on the determined award amounts per vehicle.

An estimated $80 million in additional costs, or approximately $59,000 per bus, would remain for non-Priority Districts to be supported by a local share and the State's expenditure-based aid, with roughly 60% of the amount covered by Transportation Aid. The remaining local share is approximately $32 million, or roughly $24,000 per bus, although the exact amount will vary by school district based on their Transportation Aid ratio.

The key finding from this cost analysis is that existing funding sources should be able to cover the overwhelming majority of additional funding required to help districts deploy ESBs between now and 2027.

3.2.2 Operational Savings

As noted in section 1.5, ESBs cost less to operate and maintain than diesel school buses. The World Resources Institute estimates these savings at between $4,000 and $11,000 annually per bus, primarily due to cheaper fueling and maintenance. The use of incentives to overcome the current upfront cost differential in bus prices helps school districts start benefitting from the operational savings sooner. School districts may then be able to reinvest these savings into future bus purchases and/or charging installations. This underscores the benefit of maximizing the use of existing incentive programs in the near-term. As an example, the total additional cost for non-Priority District buses ($80 million) can be recouped through the first 5 to 6 years of operations, when assuming an annual cost-savings of $11,000 per bus (a reasonable assumption for these first 3,000 buses because electrical upgrades are expected to be minimal).

3.2.3 Infrastructure Planning

Charger Funding Allocations and Charger Selection: The assumed range of charging incentives included in this analysis ($15,000 to $30,000) reflect the wide array of charging technologies and approaches that are available. The assumption is that most Type A buses will be able to use Level 2 (slower) charging given the smaller vehicle size and higher level of utilization in urban areas. While many Type C/D applications will be able to use Level 2 charging as well, Level 3 charging may also be needed. The discussion box below provides more information about choosing chargers, and further information is included in the Charger Purchasing Guide of the ESB Guidebook. These allocations are subject to change and the costs of purchasing and installing charging infrastructure will continue to be monitored in future iterations of the Roadmap.

Charger-to-Bus Ratios

In most medium/heavy duty EV deployment projects, one charger is typically installed per vehicle. This is a useful planning assumption for school districts adopting ESBs. Providing a charger for every bus can simplify the charging process by allowing fleets to take advantage of longer dwell times—typically overnight—and by increasing the likelihood that each bus will have a dedicated charging source ready during typical staff working hours. In many instances, school districts have seen success installing a mix of Level 2 and Level 3 chargers. This approach allows fleets to accommodate midday or on-demand charging when needed but avoids excessive energy pull from the grid. Level 3 chargers can serve multiple buses and do not need to follow the one-to-one ratio.

Further Infrastructure Subsidies: As noted above, the customer-side and utility-side electrical infrastructure upgrade costs are not included in this analysis. For this reason, the Inflation Reduction Act Tax Credit for charging stations was also omitted. This program can yield up to an additional $100,000 in subsidies to school districts and contractors installing bidirectional, or V2G-capable, charging infrastructure. Between this program, the New York State Electric Vehicle Make-Ready Program, and the future outcomes of the New York State Medium- and Heavy-Duty Electric Vehicle proceeding, it is expected that substantial funding will be available for the infrastructure associated with chargers as school districts begin scaling up their fleet transition efforts.

3.2.4 Future Vehicle Replacements

The Assumptions section (3.1) notes that up to 22,000 school buses could be replaced between now and 2027. This presents a significant opportunity to convert vehicles ahead of the 2027 zero-emission bus purchase timeline. The availability of Bond Act funds to support purchases beyond the 3,000 buses included in this analysis means that additional purchases could be supported ahead of 2027 as well. However, the ICE vehicles purchased ahead of 2027 also present an opportunity to transition a limited number of newer ICE vehicles to electric through the "repower" process discussed in section 1. Newer vehicles with several years of life left may be good candidates for repowering. Since the cost of repowering a vehicle is substantially lower than purchasing a new vehicle, NYSERDA supports the idea of incentivizing repowers of certain vehicles, where it is cost effective.

4 Recommendations

This section identifies policy and program recommendations the State can undertake to support the statewide transition to ESBs. Summarized recommended actions are listed below, and the agencies with a potential role in implementing each policy are listed next to the summary. Following each summarized action is more detail on the issue addressed, context around the issue, and more detail on the action(s) recommended. This section also includes potential research areas to explore related to electrification of school buses.

- **Sections 4.1 to 4.8 Policy and Program Recommendations**
  - Key Takeaways
    - Suggested policy actions that the State can undertake are presented, focusing on fleet purchase requirements; vehicle purchase incentives; infrastructure expansion; centralized purchases; fleet advisory and grid coordination services; O&M training services; and transition considerations.
- **Section 4.9 Additional Research Priorities**, which examines topics for additional consideration relevant to the ESB market in New York State.
  - Key Takeaways
    - Zero-emission (ZE) electric heaters included as stock on many ESB models do not produce emissions; however, they draw power from the battery, further reducing the vehicles' range in colder operating conditions. Key items include potential research by NYSERDA on ways to mitigate range reduction from cabin heating.
    - Key challenges remain on the path to scaling up bidirectional charging/V2X technology, and there are several areas of research that NYSERDA could undertake to address these challenges.
    - Other topics for potential NYSERDA research include rusting issues, vehicle weight impacts, and battery performance.

4.1 Fleet Purchase Requirements

Align Fleet Purchase Requirements with Manufacturer Inventory Targets (NYSERDA, DEC)

Issue: The school bus manufacturing industry lacks guidance on the number of buses that will be needed per year between now and 2035, and school districts and fleets are already reporting issues with vehicle availability.

Context: New York State has adopted California's Advanced Clean Truck (ACT) rule, which requires manufacturers to sell increasing percentages of new medium- and heavy-duty zero-emission vehicles in New York State beginning in 2025. The sales percentages progressively increase through model year 2035. The Climate Action Council's Scoping Plan recommended that New York State adopt some or all of the Advanced Clean Fleets (ACF) rule that requires specific fleets to meet increasing electrification targets as well.

Recommended actions:

- Develop projections for the number of electric school buses expected to be needed per year between now and 2035 and monitor manufacturer production.
- Explore how these purchase expectations can be incorporated into NYSERDA's reporting requirement on the availability of domestically manufactured ESBs beginning with model year 2025.

Support Fleet Transition Planning (NYSERDA, SED, DPS, electric utilities)

Issue: Many school bus fleet managers are uncertain of the types and quantities of vehicles, batteries, and chargers needed to convert their fleets to electric power. Guidance is needed to ensure that fleet managers purchase the right equipment for their unique situations.

Context: NYSERDA and the State's investor-owned utilities offer technical assistance and fleet advisory services to help fleet managers map out their vehicle and infrastructure purchases and installations. In addition, transition plans address opportunities for workforce development, utility engagement, and implementation timelines. Fleets can leverage existing State programs described in appendix G: Fleet Advisory and Grid Coordination Services to create their own fleet transition plans.

Starting in 2025, school districts will need to report on their progress toward meeting the 2027 and 2035 zero-emission transition timelines.

Recommended actions:

- Release and update an "ESB Guidebook" with resources to help school bus fleets develop transition plans, apply for funding, request proposals, and help speed up review and permitting processes.
- Explore whether eligibility requirements for State purchase incentives could encourage school bus fleets to develop fleet transition plans. Any requirements could initially be flexible to enable districts to purchase some ESBs without delay.

- Possibilities include exploring whether fleet transition plans should be required for smaller school bus fleets for whom vehicle replacement decision-making is more straightforward and whether third-party operators could submit one report on behalf of all districts they currently serve.

- Consider incorporating fleet right-sizing guidance and assistance as part of its overall fleet transition planning support.
- Continue to expand available funding for fleets to obtain services and participate in advisory and transition planning. Continued funding of these efforts would enable many more fleet owners to conduct assessments ahead of 2027.
- Consider tier fleet planning requirements and resources, accounting for fleets with differing needs and complexities, including fleet size, number of depots, mixed operations, Priority District status, and routes/duty cycles.
    - In the near-term, focus on supporting districts that do not have access to utility programs, namely the approximately 25 districts served by municipal utilities, as well as Priority Districts, and districts with larger bus fleets. NYSERDA is exploring ways to expand this offering.
- Continue to fund fleet advisory services provided by the utilities and expand funding for utility fleet assessment projects. Continue to coordinate and ensure that projects are complementary, coordinated, and not overlapping, and ensure that each entity participating in fleet advisory has a single point-of-contact identified for assisting school bus fleet operators.

Ensure the Approach to Meet the ESB Legislation Accounts for School Districts' Various Needs across New York State (NYSERDA, SED, DEC, OGS, DPS, NYPA)

Issue: Local context will impact a district's timeline for converting to electric school buses.

Context: Numerous issues will impact the ability and speed at which districts can transition to ESBs, including whether a district owns, leases, or contracts out their bus fleet; climate and topography; district size; local financing; local voter awareness and support; and grid readiness. As more is learned about the real-world operation of these buses, policies and programs that support the zero-emission transition timeline should be adapted to reflect these challenges.

Recommended actions:

- Consider providing interim targets for fleet adoption between 2023 and 2035 and ensure that these targets reflect the demands and resources of various school fleet types (i.e., market segments).
- Explore ways to address the need for fuel-fired heaters or other non-battery powered heater technologies to cope with cold temperatures.

- Explore the possibility of allowing and/or encouraging utilities or other entities to provide temporary power solutions in cases where grid upgrade timelines are hampering fleet transition and when delays in charging equipment delivery impact or delay on ESB operations.
- Monitor proposed charging stations and evaluate whether they are accessible to school buses and provide this information to school districts concerned with their longer routes, field trips, and out-of-district transportation services.
- Develop a list of common options for managed charging software for fleets transitioning to ESBs. This will increase fleet operators' visibility into charging problems, reduce demand charges and peak electrical load, and increase reliability of bus recharging.

4.2 Vehicle Purchase Incentives

Design Incentive Programs to Help Address High Up-Front Capital Costs (NYSERDA)

Issue: Incentive programs should be sufficient to cover the incremental cost differences between ICE and electric school buses in the pre-2027 period. However, additional incentive programs may be necessary after 2027 to help address high up-front costs—even though TCO parity is expected in 2027. Incentive program design will be critical for advancing the market; poorly designed incentives can lead to price inflation in the ESB market or can inadvertently favor bus fleets in districts with more resources. Those lacking access to sufficient capital to front the initial costs for non-subsidized ESB procurements may struggle to take advantage of purchase subsidies not available at the point of sale.

Context: Incentives should help districts accommodate the significant start-up costs associated with transitioning to electric buses. Over the long-term, however, as bus prices decrease and TCO parity is achieved, the cost-savings associated with transitioning should be achieved faster, especially if school districts frontload infrastructure installation. Therefore, it is assumed that incentives will be slowly scaled-down and then phased-out following 2027.

Recommended actions:

- Distribute Environmental Bond Act funds to address near-term funding needs, focused on purchase incentives for vehicles.
- Explore the feasibility of reporting estimates of the TCO and/or annual operational savings of ESBs alongside the upfront purchase price.
- In the near-term, streamline participation requirements for State-funded incentive programs, including through the simplification or removal of scrappage requirements. Where possible, NYS can allow incentives to be stacked with federal incentives and tax credits.

- In the medium- to long-term, along with OGS, solicit detailed information from school bus manufacturers as a part of its program design, as CARB did to calculate its HVIP subsidy levels. Establishing price limits for eligible vehicles or prohibiting additional funding sources for vehicles procured under the program can also help lower prices. Price control methods should be considered along with their impact on program participation and the quality of associated jobs, as price controls may spur lower quality work environments or compensation packages at OEMs.[55]
- Explore a declining-block incentive structure to reflect the (likely) declining technology cost trajectory as component costs decrease and manufacturers increase production. If TCO reporting is feasible, design incentive levels to address cost differential with respect to differences in TCO, rather than initial purchase price. This approach would help address price inflation on the part of OEMs and encourage fleets to take steps toward reformulating vehicle replacement budgets. This incentive design strategy might be particularly useful as ESB costs could decline toward the end of the decade.
- Design incentives to account for the many fleet- and community-specific challenges to adoption, including those with Priority District status, colder climates, longer bus routes, or limited local access to maintenance technicians.

4.3 Infrastructure Expansion

Conduct an Evaluation of Grid Capacity Incorporating Fleet Data (DPS, NYSERDA, SED)

Issue: Grid capacity constraints may slow down fleet transition and increase costs for school districts and contractors.

Context: Most depots across the State currently lack sufficient electrical capacity to charge more than a few buses, and many are in areas with limited capacity, which means that utilities will need to make significant upgrades to meet this new demand. Requests for utility service increases or new service for ESB charging are expected to grow significantly between now and 2027. Furthermore, there is no comprehensive database detailing where school buses are stored, which makes planning for capacity increases challenging. PSC launched a proceeding in April 2023 that will develop policies and programs to address charging needs of the medium- and heavy-duty vehicle sector and develop a proactive planning framework to address long lead times for capacity upgrades where grid constraints may impact timelines for installing chargers.

Recommended actions:

- Work with the State's utilities (including the Joint Utilities, LIPA/PSEG-LI and municipal utilities) to identify likely locations for grid upgrades for charging ESBs and evaluate the likely level of distribution system upgrades needed due to the new load imposed by school bus fleets. This work would be led by DPS and NYSERDA and bolstered by required reporting of fleet size, status, and domicile locations. NYSERDA could consider incorporating telematics or other networked systems to automatically capture data needed to determine charging demand for infrastructure supported by public funds.
- Review the methods and findings of similar prior work, including:
    - The 2022 California grid capacity study, which used feeder circuit data from PG&E to determine necessary upgrades to individual feeders to support future EV load scenarios.[56]
    - The 2022 National Grid-led analysis of highway charging corridors and necessary load and distribution requirements for high-penetration heavy duty electric vehicle adoption in its New York State and Massachusetts service areas.[57]

Expand Access to Incentives for Charging and Make-Ready Infrastructure Installations (DPS, NYSERDA, LIPA)

Issue: Make-ready costs—the costs associated with upgrading a site with the necessary electrical infrastructure to support EV charging, both on site and on the grid—are an unpredictable and sometimes significant expense. They vary based on utility territory and are not broadly covered by incentive programs.

Other incentives offered, such as DEC's ZEV Fueling Infrastructure Grant for Municipalities, require charging stations be publicly accessible, which likely disqualifies most ESB fleet domicile locations (though fleets could potentially prioritize charger development in nearby publicly available locations).[58]

Context: NYTVIP does not currently provide funding to cover the cost of charging stations. The Joint Utilities can cover up to 90% of utility-side make-ready costs ESB charging under their MD/HD Make Ready Pilot Program. However, the program currently:

- Does not cover customer-side costs.
- Is available only to fleets that receive funding through NYTVIP.
- Does not cover school districts on Long Island and those served by NYPA or municipal and cooperative utility companies.[59]

- In the Make-Ready Midpoint Review Whitepaper, Staff recommends increasing the MHD Pilot by $30 million as well as making up to 50% of customer-side costs eligible for funding for sites located in disadvantaged communities. Staff also recommends including other incentives that require the scrappage of a diesel vehicle such as the EPA Clean School Bus program as an eligible incentive to unlock funding. Staff contends that the new Proceeding on Motion of the Commission to Address Barriers to Medium- and Heavy-Duty Electric Vehicle Charging Infrastructure is the best venue to develop "comprehensive policies and full-scale programs necessary to facilitate MHD electrification, which engenders its own particular challenges that are separate and distinct from the light-duty vehicle focus of this proceeding."

Recommended actions:

- Develop new funding opportunities for EVSE and associated facility upgrades beyond the currently available MD/HD Make-Ready Pilot Program.[60] Opportunities could include programs that incentivize the purchase of charging ports (Level 2 and/or DCFC) and new programs specific to school bus fleets rather than all medium- and heavy-duty fleets, to allow program administrators to narrow their focus.
- Work with utilities to explore ways to streamline implementation of grid-side and customer-side projects to support fleet transition.
- Consider packaging EVSE incentives with vehicle purchase incentives to lower the application burden and upfront cost for recipient fleets.
- Ensure that all New York State ESB procurement incentives are available with the option to support associated EVSE deployment and utility service reinforcements/upgrades. These optional additional incentive amounts could include "futureproofing" to encourage districts to install all customer-side equipment ahead of bus purchases.
- Consider additional program requirements for incentive funding, requiring chargers at schools and school bus depots to be available to visiting vehicles.
- Consider requirements that focus on standardization of charger compatibility for school fleets throughout the State, as well as networking programs for simplified cost accounting.

4.4 Update Procurement Models to Help Support the ESB Transition

Explore New Procurement and Operational Models that Might Ease the Burden of Transition on Districts (NYSERDA, NYGB)

Issue: Up-front costs of fleet transition and the steep learning curve for operating an electric bus fleet can be a barrier to many districts.

Context: School bus fleet operators are having to adjust to the near-term capital costs while filling institutional knowledge gaps on operating ESBs. This may push fleet operators to explore alternative ownership and operational models, including fully outsourcing ownership and operation of electric buses.

Recommended actions:

- Explore ways for school bus fleets owned by third-party contractors to access capital markets and enter into agreements that minimize financial and operational risk for school districts, including:
  - Identify and address challenges to as-a-service operational models.
  - Identify opportunities to supplement private financial markets and keep borrowing costs manageable by participating in offering long-tenor debt that reflects best estimates of residual values, optimizing the use of financing structures that monetize federal tax credits, and facilitating financing for high-need school districts that might have difficulty receiving financing otherwise.

Review Amortization of Transportation Aid as More Data is Gathered on ESB Lifecycle and Purchase Price (NYSERDA, SED)

Issue: Based on the anticipated longer useful life of ESBs, districts will receive repayment of their State aid component of electric bus purchases over 12 years instead of five years.

Context: The actual lifecycle of ESBs is still unknown as the first-generation buses have only been in operation for a few years. Additionally, many districts must retire buses when the powertrain still has useful life due to rusting of the bus body. Districts will be fronting the costs of ESB purchases over a longer period, and in some cases, recoupment may outlast the life of the vehicles. This issue could become more acute if prices do not decline and available public funding diminishes.

Recommended action:

- Continue to review vehicle lifecycles and review the amortization schedule once more information about ESB lifecycle is known, and as State and federal funding availability begins to decline.

Explore Roles Key State Partners Can Play in Easing the Purchase and Installation Charging Infrastructure (NYPA, OGS, SED, BOCES)

Issue: School districts and third-party contractors will need assistance in selecting and purchasing chargers and supporting installation of chargers and associated equipment.

Context: Purchasing school buses through the Office of General Services (OGS) is an established practice, but purchasing and installing charging is a new venture for most school districts. OGS and NYPA have existing programs and offerings that can help school districts with the process of purchasing and installing charging infrastructure.

Recommended actions:

- Expand State contract for chargers to include additional charging vendors and operators, under a common specification with a focus on including vendors and operators that cater to ESB charging needs.
- Identify school districts where charging installations may be complex, and/or where charging will be needed outside of school bus depots (e.g., at school buildings or existing or planned public charging sites) and offer support for the design and construction of these facilities.

Leverage Planned Charging Infrastructure Projects to Support Charging for ESBs (NYSERDA, NYPA, NYSDOT, Thruway Authority)

Issue: Lack of accessible charging (especially Level 3 fast-charging) away from school bus depots can restrict their use for longer trips.

Context: Diesel and gasoline buses can rapidly refuel on longer trips, while ESBs may struggle to find fast-charging options and payment methods they can access on longer trips.

Recommended actions:

- Ensure that certain planned EVSE installations, including NEVI or rest-area charging, include chargers and charging spaces that can accommodate ESBs, both in the types of chargers provided and the amount of space provided for parking and maneuvering larger vehicles.
- Consider additional program requirements for incentive funding, requiring chargers at schools and school bus depots to be available to visiting vehicles. Additional requirements could focus on standardization of charger compatibility for school fleets throughout the State, as well as networking programs for simplified cost accounting.

Consider Providing Resources for Fleet Operators to Send Staff to Vehicle Manufacturer-Sponsored and Emerging Training Programs (NYSERDA, NYS Department of Labor, BOCES)

Issue: Operations and maintenance training resources will be required to bring existing fleet staff up to date on the differences in working with ESBs.

Context: Most high-voltage vehicle maintenance is currently handled by manufacturers, some of which offer training programs. These manufacturer-sponsored programs are currently the only way to train for high-voltage vehicle maintenance and there are additional training needs that are not associated with high-voltage vehicle maintenance.

Recommended actions:

- Consider new funding for the on-the job training for Energy Efficiency and Clean Technology program and expanding its offerings to target electric vehicle mechanic and technician programs.
- Explore alternative measures of developing and disseminating training programs, including through the Clean Transportation Prize award to New York City School Bus Umbrella Services (NYCSBUS), which includes the development of a 'Center of Excellence' for school bus electrification.
- Work with regional and State partners to offer programs to help New York State meet new demand for in-State electrician labor associated with EVSE installation and maintenance by fostering statewide programs in coordination with trade schools to meet the anticipated growth in demand for electricians. School districts and bus operators can leverage existing transportation related BOCES Co-Ser agreements and ongoing community college program development to provide additional support for district maintenance staff to expand the electrician and ESB maintenance workforce.

4.5 Center Equity in School Bus Electrification

Develop High-Level School Bus Electrification Equity Strategies (NYSERDA)

Issue: Far-reaching efforts to mitigate environmental and health impacts need to be closely monitored to ensure disadvantaged communities are not left behind.

Context: The impacts of climate change and poor air quality fall disproportionately on historically disadvantaged communities. Efforts to transition to cleaner transportation should prioritize identifying and working with these communities. In addition to DAC and high-need school district status, small and hard-to-reach rural communities, caregivers and/or families of children with disabilities, and other vulnerable populations are critical to engage with to create an equitable transition to ESBs in New York State. Broad stakeholder engagement in developing a school bus electrification equity plan will help ensure that key equity measures and best practices outlined in the plan accurately reflect the needs and concerns of these stakeholder groups at an early stage.[61] The State should engage with disadvantaged communities during the initial development of ESB-specific strategies. Specific strategies and metrics are needed around provisions for the transparent measurement and verification of distributional impacts and identifying and addressing any specific issues faced by disadvantaged communities in the fleet transition process.

Recommended actions:

- Review resources such as the 2022 framework from the Energy Equity Program (EEP) developed by the University of Michigan's School for Environment and Sustainability (SEAS) and WRI's Equity Framework to Guide the Electric School Bus Initiative (2022) to outline guidance for developing school bus electrification equity strategies[62, 63] that emphasize:
    - The need to center intersectionality in developing equity plans.
    - A range of considerations for multiple audiences.
    - The value of monitoring, evaluation, and learning in the development and ultimate success of equity-based energy initiatives.
- Build on its existing work to prioritize equity and the needs of DACs, including:
    - Its Energy and Climate Equity Strategy in response to the Climate Action Council Scoping Plan.[64]
    - Identifying challenges and opportunities for improving access to NYSERDA-sponsored programs for DACs.[65]
- Applying the elements from the resources listed above, develop an approach to ESB planning and transition. For example, draw on the SEAS EEP's templates and scorecards and WRI Equity Framework's evaluation criteria recommendations.
- Engage a broad group of ESB stakeholders from both Priority Districts and hard-to-reach rural communities to develop a needs assessment to help build a school bus electrification equity strategy. An appropriate forum might be the Energy Equity Collaborative that NYSERDA plans to create in 2023 and that will provide a platform for collaboration among NYSERDA, other State agencies, and New York State community-based organizations and stakeholders.
- Explore requirements for school bus operators submitting fleet transition plans or requesting funding to engage with local stakeholders throughout the planning process to ensure that school districts and fleet operators have the resources they need to serve their communities' needs. Documented evidence of stakeholder participation could be required to ensure compliance.

4.6 Equity-Specific Electric School Bus Purchasing Incentive Program Design

Couple Incentives for ESB Purchasing with Supplemental Amounts for Fleets Serving Priority Districts, as Described in the Vehicle Purchase Incentives Design Section (NYSERDA)

Issue: Priority Districts, rural communities, and vulnerable populations may have greater needs for financial assistance than other communities.

Context: Certain communities (e.g., rural) might experience greater operational challenges during the transition to ESBs as they cope with longer routes and lower density of students. Priority Districts may experience funding challenges. Accounting for these needs through incentive design will ensure a more equitable transition across the State.

Recommended actions:

- Develop vehicle comparison information for a range of new vehicles, including repowers, to release alongside the incentive or rebate information.
- Design incentives to provide additional support for Priority Districts.
- Implement an incentive bonus for electrifying vehicles that operate primarily within DACs and/or high-need school districts.[66]

4.7 Equity-Specific Infrastructure Incentive Program Design

Couple Incentives for EVSE Purchasing with Supplemental Programming to Reduce Challenges to Charging Station Installation in Priority Districts. (NYSERDA, PSC)

Issue: Issues impacting the ease of transition to electric buses may be more challenging to overcome in certain areas of the State.

Context: Making funding available and increasing funding amounts for Priority Districts can help encourage a more equitable transition to electric school buses. However, awareness of funding, access to those funds, and technical support in selecting, purchasing, and receiving buses, and installing the associated infrastructure, may also be needed to a greater extent in certain areas. Priority Districts, in particular but not exclusively, may face additional challenges, including insufficient infrastructure (e.g., power distribution infrastructure), a need for bus depot upgrades to support electrification, outdated zoning laws and local land use plans, and lack of nearby construction crews or developers.

Recommended actions:

- Design a new EVSE-assistance program to support fleets with the greatest challenges to adoption, with an emphasis on fleets serving and operating in Priority Districts.

4.8 Just Transition Employment Considerations

Promote Equitable Employment Practices and Support the Growth of an EV-Savvy Workforce with Opportunities to Pursue ESB-Specific on-the-Job Training or Retraining

Issue: The current technician workforce is not adequately prepared to maintain or repair ESBs or EVSE.

Context: To ensure a successful transition, fleet operators will need access to a qualified pool of vehicle technicians and electricians along the same timelines as vehicles are purchased. Because location of bus depots does not in itself guarantee workforce participation to frontline communities, additional efforts to identify key workforce metrics supported by requirements for participation may also be helpful.

Recommended actions:

- Encourage fleet transition plans to include provisions for on-the-job training or retraining for vehicle mechanics employed by school bus fleets and encourage fleet operators to prioritize hiring workers, where roles cannot be filled by retraining existing workers, living in DACs and areas that have historically had limited economic opportunities, where appropriate.
- Deploy or incentivize training for local individuals interested in ESB repair employment. Incentives can support student fees for manufacturer-hosted training if NYSERDA chooses not to host or sponsor training to cover a variety of ESB models and EVSE equipment.
    - Pair training with ongoing measurement and verification of distributional impacts in the workforce, using metrics such as demographics of trainees, program signup and completion, job replacement rates, job retention milestones (e.g., six months, 12 months).[67] EEP recommends developing a process for collecting and reporting data with a focus on sophisticated data management, best practices for qualitative data management, and most importantly, transparency.[68]
- Include target metrics for employment from disadvantaged communities when designing state infrastructure development initiatives.
    - Pair this step with ongoing job quality assessment, using metrics such as benefits, wages, full-time work availability, health and safety, and training or professional development opportunities.

4.9 Additional Research Priorities

This section discusses potential avenues for additional research relevant to ESB deployment. It provides a review of existing research and identifying additional steps NYSERDA might take on each topic.

4.9.1 HVAC Systems

ESB operators and route planners, particularly in northern regions of New York State, face range constraints during the colder months of the year due to vehicles' slightly diminished cold-weather battery capacity. The need to heat bus interiors during cold days can further affect range. Heaters in diesel vehicles harness byproduct engine heat to warm the cabin space, a cost and energy efficient (though not zero emission) solution. The zero emission (ZE) electric heaters included as stock on many ESB models do not produce emissions; however, they draw power from the battery, further reducing the vehicles' range in colder operating conditions.

A strategy to mitigate range reduction from cabin heating is to install auxiliary diesel or propane fuel-fired heaters (FFH) in ESBs. While not zero emission, FFHs can be switched on and off as weather conditions and energy demands dictate.[69] [70] As battery capacities improve and manufacturing prices decline, electric heaters could be able to address a larger share of bus heating needs, but the current technology outlook points toward FFHs playing an important role in some ESB deployment contexts.[71] Key items for potential additional research by NYSERDA on the topic of HVAC systems in ESBs include:

- **ZE technology development.** Alternatives to electric heaters and FFHs are in the early stages of testing and demonstration but show promise as effective, energy-efficient, zero-emission methods to meet heating needs without sacrificing bus performance. Two potential ZE technologies include electric heat pumps and fuel cell heaters.
- **ZEB classification for program requirements.** New York State's current NYTVIP requirements allow for funded ESBs to include pre-installed FFHs but NYTVIP funds cannot be put toward the installation of FFH, however the cost of installation is typically a few thousand dollars.[72] As NYSERDA considers new programs to support New York State school bus fleet electrification targets, it may be beneficial to preserve ESB owners and operator discretion to purchase FFHs, particularly while battery and electric cabin heating technology are improving.
- **Emissions regulation.** To assess the tradeoffs between the use of FFHs and other ZE heating technologies in the ESB, NYSERDA could consult with NYS DEC to consider measures to assess emissions from FFH. This will be of increasing importance if FFHs make up a more significant share of school bus fleet emissions as ESB deployment progresses, as their emissions can still contribute to cabin air quality concerns.

- **Policy tools.** To maximize emissions reductions associated with ESB deployment, New York State could consider policy measures to encourage the adoption and use of ZE HVAC technologies in applications that make sense. To accomplish this, NYSERDA may consider restricting the use of non-ZE FFH to approved routes, as has been done in California under implementation of the Innovative Clean Transit regulation.[73] On the purchase incentive side, implementing an incentive structure that rewards fully ZE ESBs may be an effective tool for restricting school bus-related emissions in the most viable contexts while encouraging the use of new zero-emission HVAC technologies.

4.9.2 Vehicle-to-Everything (V2X) Programs

Due to their predictable schedules and the size of their batteries, ESBs are strong candidates for leveraging V2X technology; however, as with most bidirectional charging applications, this use remains in the early stages of testing and development. A recent (2022) roundup of pilot programs for ESB applications found 15 utilities across 14 states that have pilot programs for ESB V2X technology.[74] Many of these programs remain in formative stages, and only two have been implemented to the point of results assessment. These pilot programs also tend to be small in scale. However, Montgomery County, Maryland's program plans on deploying 326 V2X-capable buses over the next few years.[75]

Key challenges remain on the path to scaling up V2X technology and associated programs, including:

- **Assess potential V2X benefits.** Given that V2X technology remains unproven at large scale as a significant grid resource, NYSERDA could dedicate further resources to the study of potential benefits. Additional steps toward the standardization, incentivizing, requiring, and implementation of V2X applications at scale, as discussed below, will require significant resources, and could slow other priorities, such as fleet turnover. NYSERDA could consider the timing for policies specifically targeting V2X based on their anticipated grid and owner/operator benefits to determine the optimal timing for pursuing this technology development. There is also some concern that additional battery discharge cycles involved in V2X may prove damaging to battery health. Additional research on this topic is needed.
- **Technology standardization.** No national or state level technology standards for bidirectional charging currently exist in the U.S. As standards are introduced, NYSERDA could consider whether to recommend, formally endorse, or otherwise support the incorporation of this technology into ESB charger deployments for New York State. Without the standardization of V2X charger connection and control technology, the development of the V2X market will remain fragmented as different fleets may use different protocols across charging and utility service providers.
- **V2X incentivization.** Because the installation of V2X-ready charging infrastructure requires a cost premium above the already significant investments needed for standard EVSE, New York State could consider additional incentive support for facilities investing in V2X-ready infrastructure. Requirements for the implementation of V2X-ready EVSE could further accelerate its adoption.

- **Rate design.** As V2X usage becomes more widespread, State regulators will need to consider how best to structure time-of-use charging rates and other power usage incentives to fairly leverage the resource. This includes allowing for utility demand response control, compensation for vehicle owners and operators, and coordination between fleets and the utility.[76]

4.9.3 Battery Life Modeling

- NYSERDA may consider taking advantage of battery life modeling tools, such as those developed by the National Renewable Energy Laboratory (NREL), after collecting real world operating data over the first several years of ESB operation to better understand the risks associated with end-of-life battery performance. The analysis could also evaluate the potential efficacy of performing mid-life battery overhauls, similar to diesel engine rebuilds, and upgrading battery packs with fresh cells and/or the latest technologies.

5 Conclusion

In order to adhere to the zero-emission transition timeline set forth in the April 2022 New York State Budget, school districts will need to completely electrify their fleets by 2035. This report summarizes the key issues surrounding this transition, including equipment capabilities, grid planning, and workforce training, as well as costs and funding opportunities.

The Roadmap's findings indicate that most of the initial incremental costs of electrification can be covered by federal and State funding. This will allow fleet operators to learn more about how ESBs work and how they fit into their operations with minimal cost to local taxpayers. The federal and State funding opportunities will help bridge the gap to when ESBs reach total cost of ownership parity with diesel and gasoline buses.

Section 4 of this report identifies a comprehensive list of actions that New York State, NYSERDA, other State entities, and utilities can take to assist the transition. These recommendations highlight the need to support fleets as they prepare transition plans, coordinate planning between State agencies and utilities, center equity in the transition and leverage State funds to build momentum for the transition.

Transitioning to a fully electric fleet by 2035 is an ambitious but achievable goal, thanks to start-up funds from the Bond Act, planning assistance from State entities and utilities, and declining costs and improving technologies in the electric vehicle market. This transition will help put New York State on track to meet its climate goals and will greatly benefit the health of the 1.5 million students who ride the State's school buses each day.

Appendix A. ESB Stakeholder Advisor Group Membership

Association of School Business Officials of New York
Tom Tatun

Bethlehem Central School District
Karim Johnson

Bird Bus Sales
Robert Reichenbach

BOCES
Aaron Bochniak
David Ziskin

bp pulse
Jon Van Bogart
Brian Ross

ConEd
Britt Reichborn-Kjennerud
Allison Kling

Conference of Big 5 School Districts
Jennifer Pyle

Highland Electric Transportation
Amy McGuire

Hudson Valley Community College
Chris McNally

Jobs to Move America
Moi-Yain Tham

Lion Electric
Richard Lee

Logan Bus Company
Corey Muirhead

Matthews Buses, Inc.
Mark Hanrahan

Mothers Out Front
Tatiana Orlov

National Grid
Ryan Wheeler

Navistar – IC Bus
Matthew Smith

New York Association for Pupil Transportation
Dave Christopher

New York City Environmental Justice Alliance
Kevin Garcia

New York League of Conservation Voters
Caroline Hahn

New York School Bus Contractors Association
Tammy Mortier, Thomas Smith

New York State Council of School Superintendents
Greg Berck

New York State School Facilities Association
Keith Langlotz

Nuvve Holding Corp.
Steve Letendre

Rolling V Bus Corporation
Nick Vallone

Total Transportation Corp.
Todd Farber
Joseph Sgro

Unique Electric Solutions
Joseph Ambrosio

WE ACT
Lonnie Portis

White Plains City School District
Sergio Alfonso

World Resources Institute
Brittany Barrett,
Sue Gander

Appendix B. School Bus Fleet and Operations Survey Results

NYSERDA's support contractor, ERG, developed a survey in coordination with NYSERDA and SED to characterize school bus fleet characteristics and operational information for school districts across the State. The survey questions covered five topic areas:

- School district information
- Bus fleet data
- Route descriptions
- Operation characteristics
- Depot information

Tailored questionnaires were developed for school district personnel as well as contractors that own and/or operate buses on behalf of the districts.

The SED sent email notifications to each school district superintendent requesting participation and including links to an online version of the survey. NYSERDA staff also asked industry stakeholder groups to encourage their members to respond to the survey as well. Participants were informed that information regarding their individual bus fleets and operations would remain confidential, with responses anonymized and aggregated before reporting.

Data collection began on November 10, 2022, and continued through December 13, 2022.[77] The ERG team provided a helpline for respondents seeking assistance in completing the survey. Once ERG received the submitted surveys, staff reviewed the responses for key missing information, internal consistency and potential outliers, and then followed up with points of contact to resolve remaining questions as needed. ERG developed tables and histograms breaking out the data by:

- Respondent type (i.e., school district or contractor)
- Fleet size (small <= 20 buses, medium 21 to 50 buses, large 51 to 100 buses, very large > 100 buses)
- Area type (urban, suburban, rural)[78]
- Geographic region, determined by county based on reported depot address[79]
    - North Country
    - Finger Lakes
    - Western New York
    - Mohawk Valley

- Southern Tier
- Capital Area
- Mid-Hudson
- Central New York
- Long Island
- New York City

The following discussion highlights key findings from the completed surveys.

B.1 Survey Findings (excluding New York City)

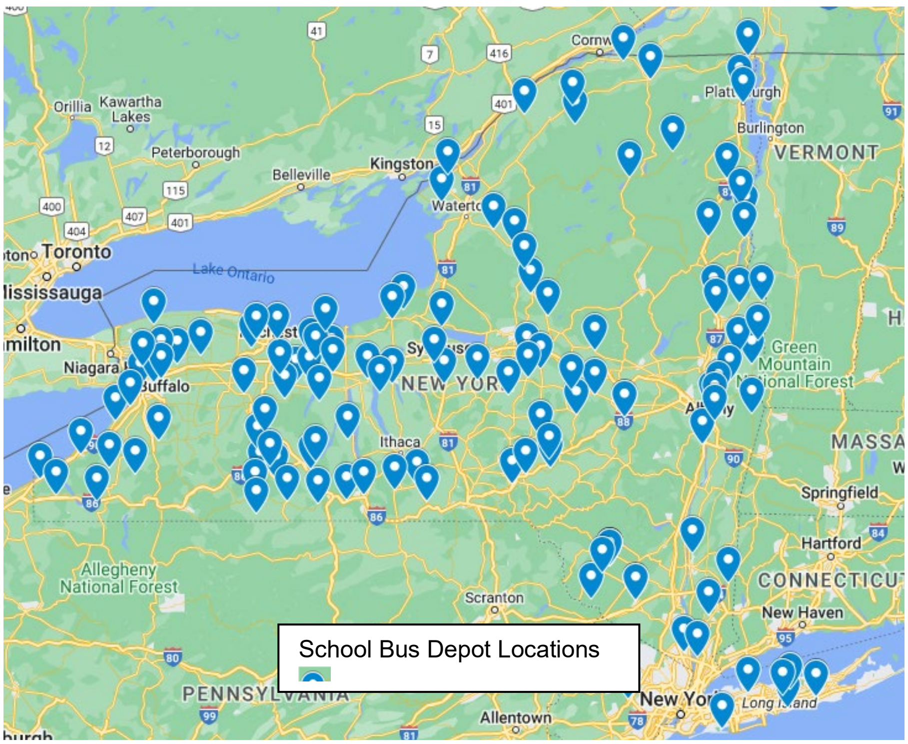
School District Information: 138 school districts (19.7% of the 699 districts outside of New York City[80]) submitted complete or partial responses to the survey request. The respondent breakouts are presented in Table B-1, followed by key observations.

Table B-1. School District Survey Response Breakouts

Fleet Size	Number of Respondents
Small	60
Medium	52
Large	18
Very large	8
District vs Contractor Owned/Operated	**Number of Respondents**
District	129
Contractor	9
Area Type	**Number of Respondents**
Rural	99
Suburban	31
Urban	8
Geographic Region	**Number of Respondents**
North Country	22
Finger Lakes	20
Western NY	19
Mohawk Valley	16
Southern Tier	15
Capital	13
Mid-Hudson	13
Central NY	11
Long Island	9

- Small and medium-sized bus fleets are most heavily represented.
- With only nine submissions received from contractors, these responses might not be representative of all contractor services. According to information obtained from the SED, over 56% of school districts used contractor-owned (or leased) and/or operated buses during the 2021-2022 school year.
- Rural school districts are most heavily represented, with an under-representation from urban areas. This heavy representation of rural districts may be beneficial, as the lower population density of these areas may present greater challenges for fleet electrification, so the high response rate can help capture concerns from rural districts.
- The geographic distribution of the responding districts is relatively uniform across the State, as shown in Figure B-1.

Figure B-1. Geographic Distribution of Responding School District Depots



Bus Fleet Data: Information was provided on 4,694 school buses in operation across the State corresponding to roughly 10% of the total fleet. Of these 4,301 are directly owned (or leased) and/or operated by school districts with an additional 394 by contractors. Key information about bus numbers and characteristics are provided below.

- The number of buses reported per district ranges from 3 to 225 with an average of 31. Bus fleet sizes also varies substantially by area type (Figure B-2 and Table B-2).

Figure B-2. Number of Buses Owned/Leased per District

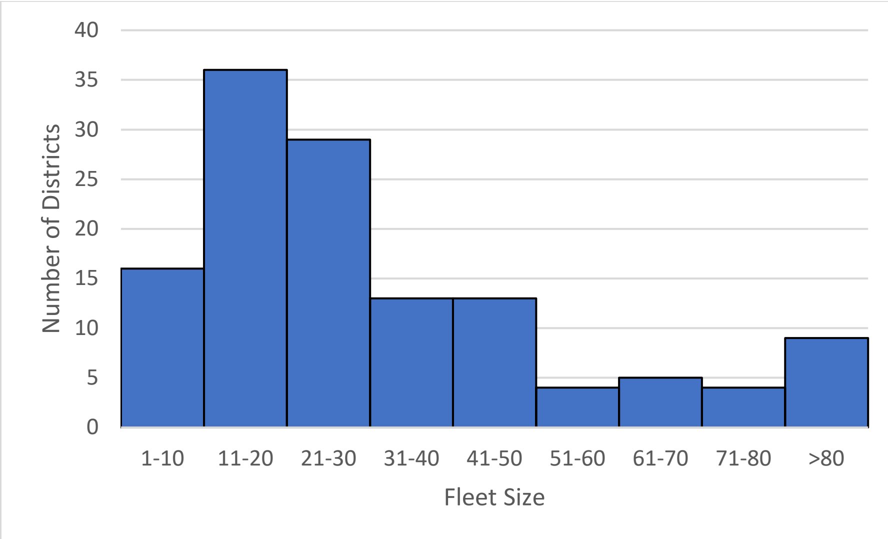
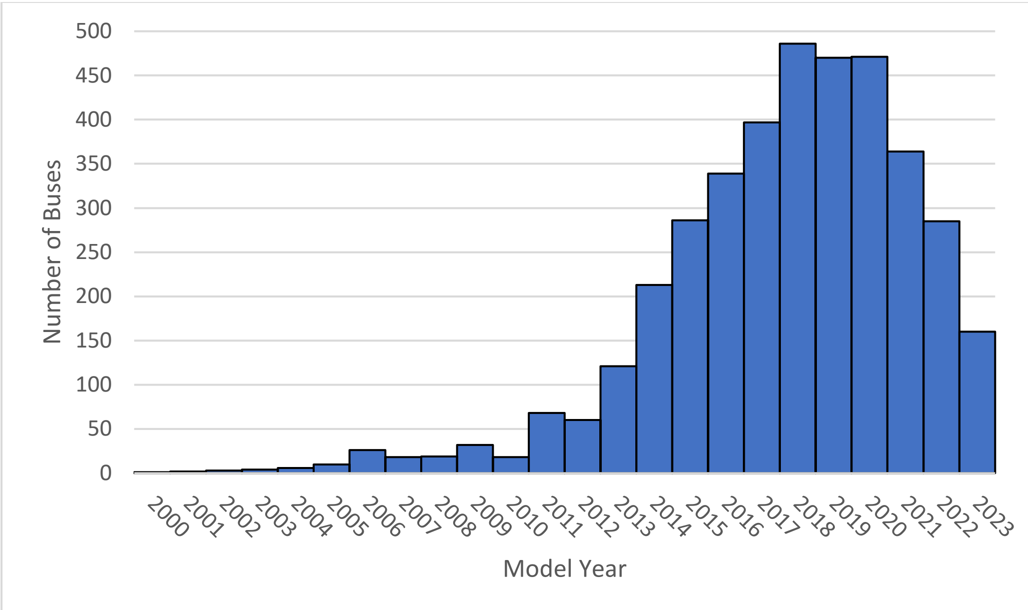


Table B-2. Average Number of Buses per District by Area Type

Area Type	Average
Rural	24
Suburban	51
Urban	41
All Areas	**31**

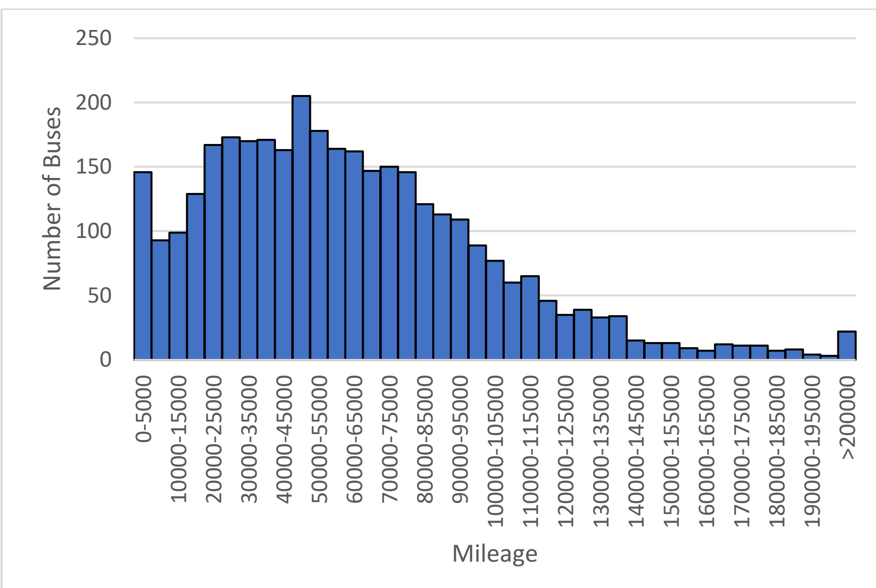
- Approximately 90% of reported buses are Type C (66%) or Type A (24%), with small numbers of Type B and D buses making up the remainder.
- About 64% of buses are diesel fueled, 34% gasoline fueled, with the remainder being liquified petroleum gas (LPG) (2%), compressed natural gas (CNG) (< 1%), hybrid (< 1%), and electric (< 1%).
- Ninety-two percent of buses were owned by either the districts or their contractors, while 8% were leased.
- Bus model years range from 2000 to 2023, with a survey average of 2018. The distribution is skewed toward newer vehicles, with only a small number of buses greater than 10 years in age. Newer school buses may be good candidates for retrofitting. See Section 1.2.2 for further discussion of potential benefits (Figure B-3).

Figure B-3. Bus Model Year Distribution



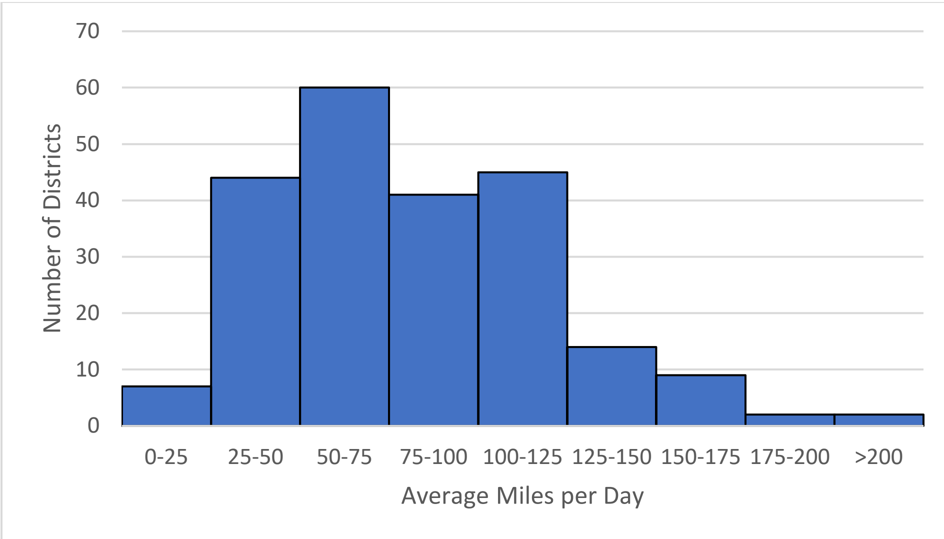
- Bus odometer readings range from 100 to 581,661 miles, with a survey average of 61,484 (Figure B-4).

Figure B-4. Bus Odometer Distribution



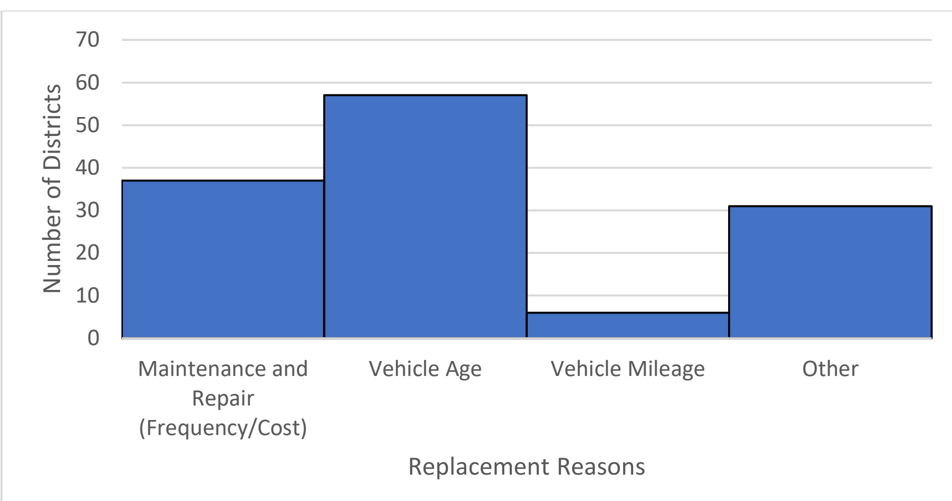
- Reported values for the average daily miles per bus range from 1 to 250, with an average of 80 miles per day. The mileage distribution tails off quickly above 125 miles per day. See Figure B-5.

Figure B-5. Average Daily Miles per Bus



- Bus replacement timing is usually based on vehicle age, most frequently set at 10 years, although there is some variation depending upon geographic region and fleet size. The survey average replacement age is 8.9 years. Other common reasons for bus replacement include high-maintenance and repair frequency and costs, high mileage, lease expiration, rust accumulation, available budget, and a combination of one or more of these factors (Figure B-6.

Figure B-6. District Basis for Bus Replacement



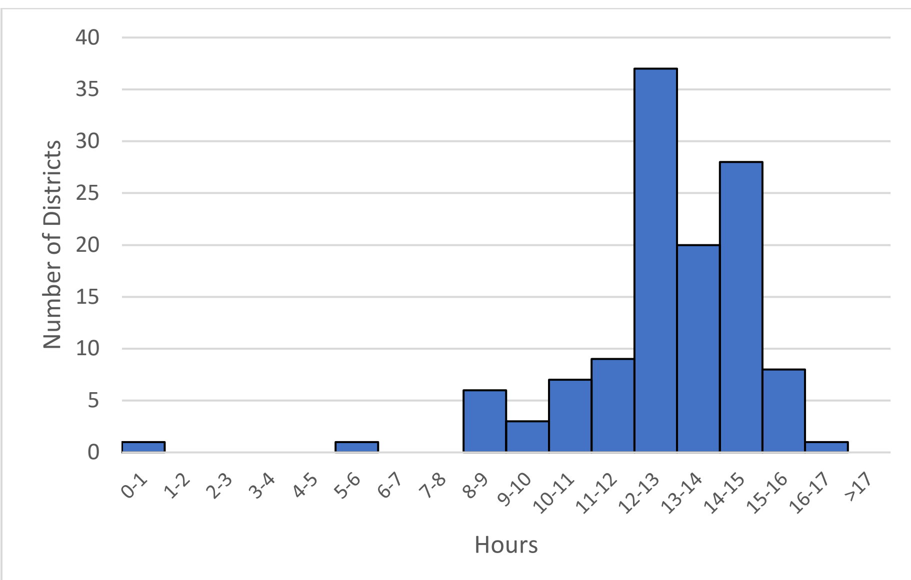
Route Descriptions: Information was collected on the number, length, and type of bus routes run by the districts.

- Over 70% of reporting districts average two or fewer routes per day per bus. Approximately 8% of buses run four or more routes per day.
- The number of routes run per day is relatively steady.
- The estimated (round trip) route length ranges from a low of 0.25 miles to 325 miles, with an average of 68 miles, roughly equivalent to the estimated average daily miles per bus (80 miles).

Operations Information: Detailed information about the operation profile of buses operated by each district was requested.

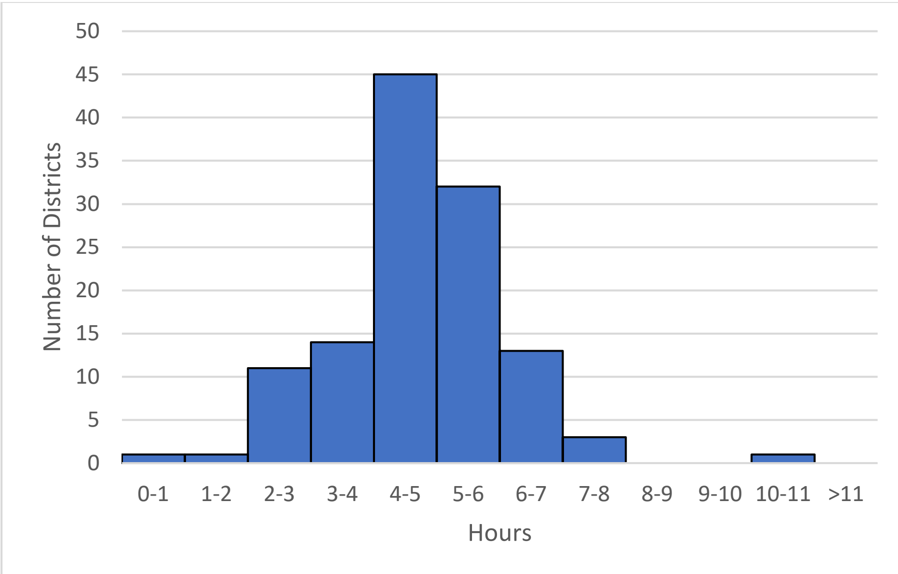
- The percentage of the bus fleet used during summer ranges from 1 to 100, with a survey average of 34%.
- The hours of downtime when buses are available for evening/overnight charging during the school year range from 0 to 16, with a survey average of 12 hours (Figure B-7).

Figure B-7. Average School Year Evening/Overnight Downtime Hours



- Ninety-six percent of districts have their buses return to the depot during the evening/overnight period.
- The hours of downtime when buses are available for midday charging (between runs) during the school year range from 0 to 10, with a survey average of 4 hours (Figure B-8).

Figure B-8. Average School Year Midday Downtime Hours

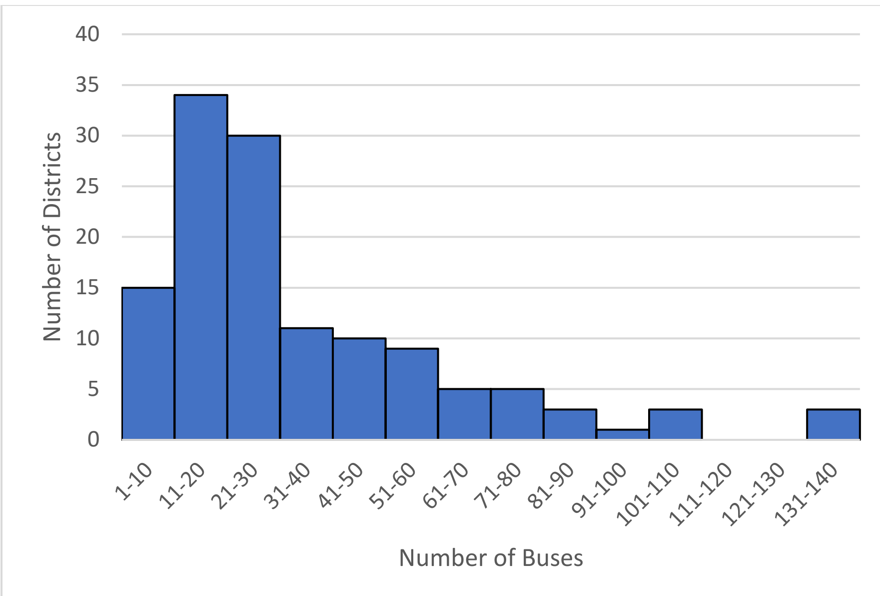


- The majority of districts (68%) have all of their buses return to the depot during the midday period.
- Most districts (72%) manage their own routing using software. Another 19% conduct routing in-house but without routing software.
- Sixty-two percent of districts reported fueling all of their buses at the transportation depot, while 30% fuel their entire fleet offsite. The remainder of districts reported some combination of on and offsite fueling.
- Sixty-five percent of districts reported using district technicians for their bus maintenance, 15% using outside contractors, and 19% using a combination of both.
- For districts that employ bus drivers directly, the number of drivers ranges from 3 to 150 with a survey average of 27.
- Districts reported directly employing between 0 and 11 bus maintenance repair technicians, with a survey average of 2.5.
- Districts reported directly employing between 0 and 12 facilities maintenance repair technicians, with a survey average of 2.0.
- Districts reported directly employing between 0 and 3 fleet managers, with a survey average of 0.6.
- Districts reported directly employing between 0 and 3 transportation directors, with a survey average of 1.1.

Depot Information: The following information was obtained regarding bus depots outside of New York City.

- Ninety-six percent of reporting districts maintain only one bus depot for their fleet. Three percent operate two depots, and 1% operate three depots.
- Approximately 85% of depots are district owned.
- The number of buses parked at the depots ranges from 3 to 135, with a survey average of 35, with the distribution skewed toward lower numbers of buses (Figure B-9).

Figure B-9. Number of Buses Parked at Depot



- Over 95% of depots reported having electrical service, with 64%of these having 240 V connections and the remaining with 120 V connections.
- Over 78% of respondents identified National Grid or NYS Electric and Gas as the depot utility provider.
- Only 11% of respondents indicated that a fleet and/or site electrification assessment had been conducted for their district. Most of these assessments determined the existing facilities will be able to serve EVs.
- The most common perceived challenges to bus electrification included lack of space on the existing electrical service panel, layout limiting access to power connections, difficulty accessing existing conduit or laying new conduit, and physical obstructions on the lot.

Several respondents described specific concerns and uncertainties about the upcoming adoption of ESBs, including:

- Range limitations under extreme cold and operation across hilly terrain
- Long routes in certain rural districts
- lack of charging during long trips
- Uncertain ability to provide reliable power onsite
- uncertain bus downtime
- Useful life concerns due to accelerated rusting
- Battery fire risk and degradation
- Depot space constraints
- Capital and installation costs
- Uncertainty around funding sources

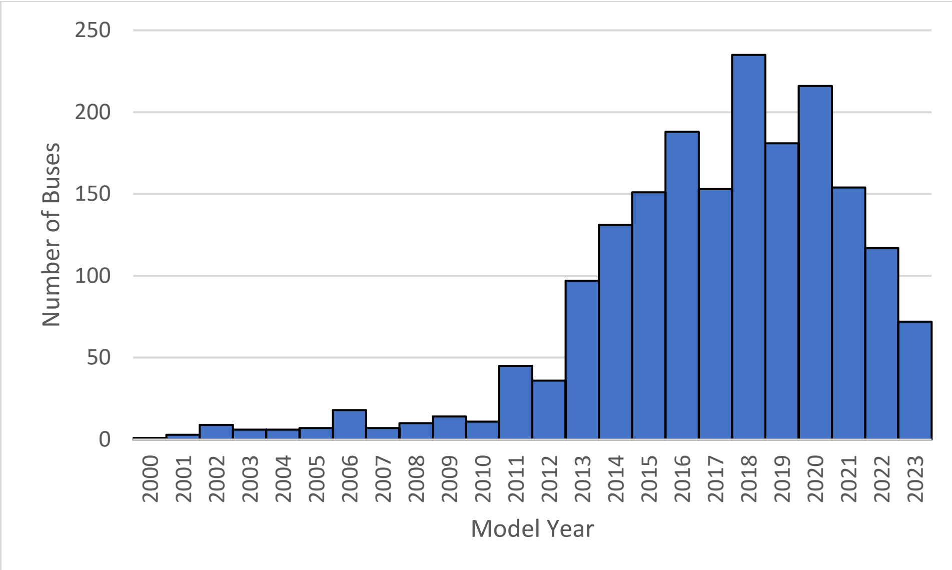
B.2 Survey Findings: New York City

The New York City Department of Education provided a consolidated response for New York City's school district fleets, excluding depot information. Accordingly, concerns about limitations on new and expanded depot space and access to other charging locations cannot be assessed from the survey response.

Bus fleet information: Details about the bus fleet for New York City are summarized below.

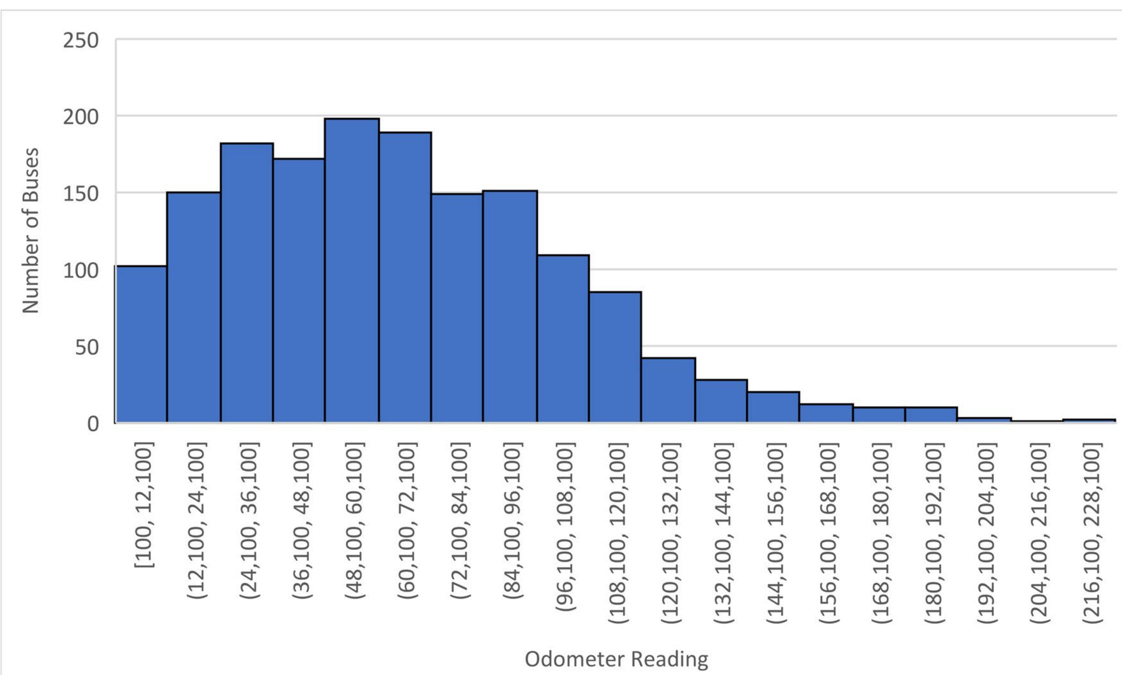
- 10,470 buses were reported by DOE, all but three of which (3 ESBs) are operated by contractors.
- Approximately 65% of these buses are Type A and 35%Type C, roughly a reversal of the percentages reported for the rest of the State (66% and 24%).
- Specific information was provided for between 1,556 and 1,868 buses (roughly 15% to 18% of the total fleet), depending on the data field.
    - Ninety-one percent of buses are owned by contractors, while 9% are leased, almost identical to the percentages reported for the rest of the State (92% and 8%).
    - Sixty-one percent of buses are diesel fueled, 37% gasoline fueled, and 2% LPG fueled—again almost identical to the rest of the State (64/34/2, with less than 1% CNG, hybrids, and electric).
    - Bus model years ranged from 2000 to 2023. The distribution is skewed toward newer units, with an average of 2017 and very few units older than 10 years. Once again, this distribution is almost identical to that reported for the rest of the State (Figure B-10 below).

Figure B-10. New York City Bus Model Year Distribution



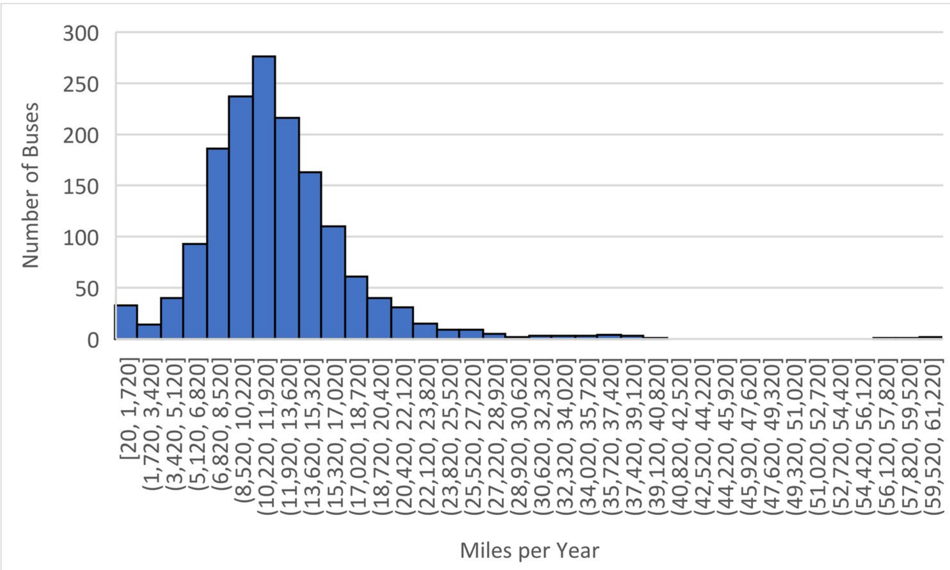
- Bus odometer readings range from 100 to 218,590 miles. The distribution is skewed toward lower mileage units, with an average of 64,463 miles and very few units with more than 120,000 miles. Once again, this distribution is almost identical to that reported for the rest of the State (average 61,484) (Figure B-11 below).

Figure B-11. New York City Bus Odometer Distribution



- Average miles per year range from 20 to 61,074 per bus. The distribution is skewed toward lower mileage units, with an average of 12,011 miles per bus and very few units with more than 20,000 miles per bus (Figure B-12 below).

Figure B-12. New York City Bus Average Miles per Year



Bus route information - Details about bus routes for New York City are summarized below.

- New York City runs approximately 9,000 regular routes per school day, and approximately 1,300 routes per school day for field trips, after school runs, and other runs.
- Approximately half the number of routes are operated during summer sessions.
- The average round trip route distance is estimated at 43 miles per day, significantly lower than the average for the rest of the State (68 miles per day).
- Buses are estimated to operate an average of four hours during morning runs and four hours in the afternoons, during the school year as well as in summer.
- Buses are estimated to be parked an average of 11 hours in the evenings, and 5 hours at midday, during the school year as well as in summer.
- Approximately 3,000 buses (roughly 30%) are estimated not to return to the depot overnight.
- All bus routing is managed in-house using software.
- Sixty percent of refueling is estimated to take place at the transportation depot, and 40% at commercial stations.

B.3 School Bus Fleet Telematics Data

Along with the school bus fleet and operations survey, ERG collected telematics data from Geotab USA to provide additional school bus fleet information to supplement and verify the data collected in the fleet and operations survey. The information covers operations between October 1 and October 30, 2022 for school buses using Geotab's telematics services across the State–excluding New York City–and were grouped into two primary analysis bins: geographic region, and bus type and age.[81] The analysis bins were further broken out into more specific areas of interest, including number of routes, route lengths, route geography, utilization rates, time-of-use, and vehicle miles traveled (VMT).

Evenly quintile percentage distributions were used to characterize the number of routes and distances traveled per bus. The following list provides a breakdown of the categories used in the telematics data analysis.

- Geography Type
  - City
  - Suburban
  - Rural
  - Town
- Bus Type[82]
  - Type A
  - Type C
- Time-of-use
  - Mornings
  - Afternoons
  - After School
  - Weekends
- Model Year
  - < 2010
  - ≥ 2010

School Bus Depot and Fleet Counts: The telematics data provided the total number of depots and the average number of school buses within each depot. Of the 3,536 school buses identified, 79% are within city and suburban geographic areas, while the remainder operate within town and rural areas. City and suburban depot fleet sizes are nearly twice the size of town and rural depots and represent 75%of the total number of depots in the telematics sample (Table B-3 below).

Table B-3. School Bus Depot and Fleet Counts by Geography Type

Geography Type	Depot Counts	Average Fleet Size	Total Vehicle Counts
City/Suburban	242	23	2,802
Town/Rural	82	12	734

The telematics data also provided a breakdown of vehicle counts by bus type and model year. Over 95% of both Type A and Type C buses are represented by model years 2010 or later, indicating that fleets are composed mostly of buses that are 13 years or younger. Additionally, 75% of all buses are Type C with a capacity between 54 and 78 passengers (Table B-4 below).

Table B-4. Vehicle Counts by Bus Type and Model Year

Bus Type	Model Year	Vehicle Count*
Type A	< 2010	50
Type A	≥ 2010	963
Type C	< 2010	60
Type C	≥ 2010	2,928

* Note the vehicle counts differ between Tables B-3 and B-4 due to confidential business information (CBI) restrictions being applied differently depending on the type of data aggregation.

School Bus Routes and Route Lengths - Table B-5 displays the number of routes each bus takes and the average length of each route by quintile. Daily route count quintiles range from 1 to 2 routes for city geographic areas, while suburban, rural, and town geographic areas range from 1 to 3 routes. The average bus route length ranges from 2.2 to 97.4 miles for city areas, 14.0 to 50.7 miles for suburban areas, 2.7 to 50.7 for town areas, and 18.8 to 53.5 miles for rural areas.

Table B-5. Bus Route Counts and Length Quintiles by Geography Type

Geography Type	Daily Route Count Quintiles	Route Length Quintiles (Miles)
City	[1, 1, 2, 2]	[2.2, 12.7, 38.8, 97.4]
Suburban	[1, 2, 2, 3]	[14.0, 24.9, 36.0, 50.7]
Town	[1, 2, 2, 3]	[2.7, 18.2, 28.3, 50.7]
Rural	[1, 2, 2, 3]	[18.8, 29.1, 38.8, 53.5]

School Bus VMTs – VMT for four different time-of-use categories are represented in Tables B-6 and B-7. Table B-6 breaks out the VMT based on the geography type, and Table B-7 breaks out VMT by bus type and model year. VMT quintiles across all geography types for morning and afternoon runs are similar in magnitude, as expected. However, VMT quintiles across all geographic types for after school and weekends have large variances.

Table B-6. Time-of-Use VMT Quintiles by Geography Type (miles)

Geography Type	VMT Weekday Morning	VMT Weekday Afternoon	VMT Weekday After School	VMT Weekend Daily
City	[9.2, 22.4, 43.4, 56.2]	[8.6, 17.0, 30.6, 45.2]	[7.5, 25.3, 39.6, 50.8]	[15.3, 42.6, 88.5, 138.7]
Suburban	[18.4, 28.2, 37.3, 49.6]	[18.4, 25.7, 33.7, 44.1]	[1.0, 4.6, 9.6, 18.8]	[0.4, 22.7, 43.9, 78.5]
Rural	[21.7, 34.1, 43.7, 56.7]	[23.1, 30.9, 40.3, 51.1]	[7.5, 16.1, 23.4, 37.9]	[29.3, 44.8, 67.5, 120.7]
Town	[17.3, 32.2, 44.7, 55.1]	[19.8, 28.9, 40.1, 53.5]	[2.3, 12.5, 24.8, 35.9]	[17.4, 43.7, 75.5, 111.5]

Table B-7. Time-of-Use VMT by Bus Type and Model Year (miles/day)

Bus Type	Model Year	Average VMT - Mornings	Average VMT - Afternoons	Average VMT - After School	Average VMT - Weekends
Type A	< 2010	17	15	11	23
Type A	≥ 2010	22	18	17	38
Type C	< 2010	18	16	8	18
Type C	≥ 2010	28	26	10	48
All	< 2010	21	18	10	36
All	≥ 2010	28	25	14	45

School Bus Utilization Rates: Tables B-8 and B-9 show school bus utilization rates by bus type and model year, and by geographic type. Generally, school buses with model years prior to 2010 are used less often than newer model year school buses during morning and afternoon time-of-use categories but not after school or on weekends. Similarly, morning and afternoon utilization rates for school buses across all geography types remain constant while after school and weekend utilization rates remain relatively low: between 5% and 7% for the weekend and 13% to 20% for after school.

Table B-8. Utilization Rates by Bus Type and Model Year

Bus Type	Model Year	Morning Utilization Rate	Afternoon Utilization Rate	After School Utilization Rate	Weekend Utilization Rate
Type A	< 2010	54%	48%	19%	19%
Type A	≥ 2010	65%	63%	27%	27%
Type C	< 2010	66%	63%	18%	3%
Type C	≥ 2010	78%	77%	18%	5%
All	< 2010	61%	56%	22%	16%
All	≥ 2010	75%	75%	21%	10%

Table B-9. School Bus Utilization Rates by Time-of-Use

Geography Type	Morning Utilization Rates	Afternoon Utilization Rates	After School Utilization Rates	Weekend Utilization Rates
City/Suburban	75%	74%	20%	7%
Town/Rural	69%	68%	13%	5%

Appendix C. Fleet Transportation As-a-Service Request for Information

On September 28, 2022, NYSERDA issued a Request for Information (RFI) for Fleet Transportation As-a-Service Business Models (RFI 5198), with responses due October 12, 2022. The RFI template (attached to this appendix) solicited information about as-a-service business models designed to accelerate medium- and heavy-duty truck and bus electrification. This RFI was intended to help inform NYSERDA's work in these fields and provide a forum for as-a-service (aaS) businesses to examine their strengths and barriers and for current and potential customers to inform NYSERDA of their concerns and expectations surrounding this business model. The RFI also offered a chance for the private sector to provide feedback on how NYSERDA's Clean Transportation team can help leverage new and evolving business models to enable maximum benefits, particularly with the prospect of additional financial assistance from the Environmental Bond Act and increased engagement from the New York Green Bank. Eastern Research Group's subcontractor CALSTART supported NYSERDA in compiling survey results and conducting follow-up interviews.

Responses, insights, and trends from the RFI responses NYSERDA received are summarized and discussed below.

RFI responses span a range of service models that incorporate various elements of fleet electrification projects, including:

- Fleet/energy modeling
- Energy management
- EVSE procurement/installation
- DERs/microgrid
- Vehicle procurement
- Vehicle operation

C.1 Summary of RFI Responses

NYSERDA received 17 RFI responses. Fifteen were from vendors (including dealers), one was from a private school bus contractor, and one was from an industry association representing a non-zero-emission fuel type. The RFI response template included a question to indicate which services related to fleet electrification are in demand among fleet customers. Table C-1 shows the number of respondents indicating customer interest in a variety of services, from charging advisory and financing to full-service turnkey services.

Table C-1. Summary of Services Indicated by Respondents to Have Significant Interest Among Customers

Services	# Respondents
Charging Advisory	10
Vehicle Purchasing	3
Financing	8
Full-Service Turnkey Services	10
Sustainability Report, Benefits Reporting	2
Energy Infrastructure Sizing	7
Financial Advising	7
Fleet Assessments	7
O&M/Support Contracting	4
Route Analysis and Planning	4
Ongoing Managed Charging	9
Staff Training	6

RFI respondents highlighted cost planning and electrification assessments as essential tools to educate fleets and help them visualize the transition to ESBs. These tools can be used to educate not only the fleet operators, but also project stakeholders such as boards of education, parents, and voting community members.

Several RFI respondents highlighted simplicity as a driving factor for aaS models, leading to a faster and more comprehensive transition to EVs. AaS models offer a single point of contact for district operators, with one fixed annual fee per bus that encompasses not only vehicle purchase and operation cost, but also charging equipment, training, and maintenance. This model allows operators to outsource the complexity of the transition while ensuring that the vehicles will perform the needs of operators.

Many school districts and bus operators cited lack of understanding or awareness of the aaS model was cited as a barrier to adoption. Respondents acknowledged that aaS models require a shift from managing fleets as a capital expense to adopting the mindset of a fleet being an operational expense. Alternatively, aaS models may be more familiar to districts that already outsource bus ownership to third-party contractors. AaS models might also change the ownership structure for a fleet operator. which highlights another area in which education and awareness currently falls short. Innovative financing was cited as one of the easiest models to accelerate adoption.

ATTACHMENT A: FLEET TRANSPORTATION AS-A-SERVICE RFI RESPONSE TEMPLATE

FLEET TRANSPORTATION AS-A-SERVICE
Request for Information (RFI) 5198
No Funding is Associated with this Solicitation

Response Due Date: October 12, 2022, by 3:00 PM Eastern Time*

Response Submission Instructions: Please download a copy of this file, *Attachment A. Fleet Transportation As-A-Service RFI Response*. Fill out the document to respond to the RFI questions provided below. Once complete, please submit your response by email to fleets@nyserda.ny.gov with the subject line: 'RFI 5198 Response' and your organization name. Email submission is preferable. Responders may submit Word or PDF files. Individual files should be 100MB or less in file size. Response PDFs should be searchable and created by direct conversion from MS Word, or other conversion utility. Files should not be scanned. For ease of identification, all electronic files must be named using the responder's entity name in the title of the document. NYSERDA will also accept responses by mail or hand-delivery if email submission is not possible.

***All responses must be received by 3 p.m. Eastern Time on the date noted above.** Files submitted after 3 p.m. Eastern Time on the date above, will not be accepted. If changes are made to this solicitation, notification will be posted on the "Current Opportunities" section of NYSERDA's website (https://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities.aspx).

Fleet Transportation As-A-Service Follow-up Communications

The Clean Transportation team may do further outreach post RFI to Fleet As-A-Service related entities who would be willing to answer questions from NYSERDA on an ad-hoc or as needed basis related to potential future program design. Please indicate below if you are interested in being contacted by NYSERDA again.

A. I am interested in being potentially contacted post RFI by NYSERDA regarding As-A-Service transportation business models (please check yes or no):
☐ Yes
☐ No

B. If you checked yes, please provide your email address:

Why Participate in the RFI?

Responding to the RFI is an opportunity for the private sector to provide feedback on how NYSERDA's Clean Transportation team can in the future leverage new and evolving business models to enable maximum program benefits. The Clean Transportation team highly encourages As-A-Service companies that are interested in the NY medium- and heavy-duty fleet vehicles market to respond to this RFI.

Information Requested

NYSERDA seeks to learn more about business models that bundle several services to fleet vehicle operators. Please answer the following questions, keeping in mind the focus of Medium- and Heavy-duty vehicles in New York State. The questions will be broken up into two categories, one with questions for as-a-service vendors, and one with questions for both current and potential customers and fleet operators.

Questions for As-A-Service Vendors:

1. ***Briefly describe your as-a-service business model***

2. ***When offering as-a-service products, do you target a particular type of fleet and/or customer? Is there a minimum size fleet you aim to target?***

3. ***What aspects of the service have customers responded most favorably to?***

4. ***What have been some of the biggest obstacles to signing customers up for the service? Is there any part of the service that customers are especially wary of or hesitant about?***

5. ***What adjustments, if any, have customers had to make to their standard operating practices due to adopting this different business model?***

6. What type of tools or resources do you think tend to help fleet operators understand your service better or help them make the decision to choose your service?

7. Select the services your customers have the most interest in. Select all that apply. (Note – If ranking is needed, change field type)

- ☐ Charging Advisory (e.g., Infrastructure, Engineering, Grid Impact)
- ☐ Vehicle Purchasing
- ☐ Financing (of vehicle purchase and/or charging infrastructure)
- ☐ Full-Service Turnkey Services (everything)
- ☐ Sustainability Reporting, Benefits Reporting
- ☐ Energy Infrastructure Sizing (storage/PV + in front of meter/behind the meter analysis)
- ☐ Financial Advising (e.g., TCO analysis, tariff analysis, etc.)
- ☐ Fleet Assessments
- ☐ O&M/Support Contracting (incl. Technology such as vehicle telematics integration)
- ☐ Route Analysis and Planning
- ☐ Ongoing Managed Charging
- ☐ Staff Training
- ☐ Other (please specify)

8. ***What is the typical contract length or subscription duration for your service? Is there a minimum time commitment you expect? What are a customers' termination rights/obligations if they end the contract before the minimum?***

9. ***How do you work with fleets that have existing maintenance staff and do you offer trainings?***

10. What differentiating factors and/or policies make a market better for deploying vehicles through an as-a-service model?

11. What are the minimum requirements (with respect to fuel use/miles driven/operating costs/financial terms) for a fleet to realize savings compared to a diesel fleet using your model? If you have experience with these numbers across different fleet segments, please share multiple examples.

12. In as-a-service models, what are customers' most preferred pricing options and why? E.g. fixed annual/monthly fee, $ per operating mile, $ per vehicle, $/kWh, other (please specify)

13. In the as-a-service model, do you offer pay-to-own, or lease-to-own? Why or why not? Do you buy or lease from OEMs or from local dealers?

14. ***In the as-a-service model, how do you approach or plan for 'residual' vehicle value? Do you plan to monetize the batteries at the end of their useful life in the vehicles?***

15. ***In the as-a-service model, what battery life (in cycles, miles driven, or years) do you plan for? What battery life (in cycles, miles driven, or years) might be necessary for you to consider this business model?***

16. ***How would you describe your past experience leveraging government incentives for as-a-service offerings? Which incentives are easiest to access? Which are most difficult?***

17. ***What are some challenges to providing the as-a-service model in Disadvantaged Communities [Interim Definition is https://www.nyserda.ny.gov/ny/disadvantaged-communities]? Can you provide examples of how you have successfully addressed these challenges?***

18. General Comments / Feedback for NYSERDA on how to best support as-a-service business development across New York State.

Questions for Fleet Operators/Customers:

1. ***As a fleet operator, have you considered fleet electrification? Why or why not?***

2. ***If you have considered fleet electrification, what have been some of the biggest obstacles to electrification? Are there barriers that an as-a-service offering could help alleviate?***

3. As a fleet operator, what is the most attractive part of an as-a-service model?

4. Is there a specific part of the as-a-service model that you are wary of or hesitant about?

5. ***As a fleet operator, what tools or resources would you be interested in to help inform decision-making around electrification as-a-service business models?***

6. ***How much more would you be willing to pay to electrify your fleet compared to what you currently pay for gasoline/diesel vehicles?***

7. ***General comments/feedback on for NYSERDA on how to best support fleet operators considering using an as-a-service business model.***

Appendix D. Incentives for Zero-Emission School Buses and Associated Infrastructure

D.1 ESB Purchase Incentive Programs

There are a variety of Federal, State, and private funds available to support the purchase of ESBs. These programs are summarized below.

D.1.1 New York Truck Voucher Incentive Program (NYTVIP)

NYTVIP provides point-of-sale vouchers ranging from $60,000 to $220,000 per bus, depending on bus size, to qualifying public schools, private schools, and contractors. NYTVIP has an estimated $7 million in remaining funds, and its vouchers cover the full incremental cost of an electric bus over a comparable petroleum-fueled bus, up to defined limits. The amount awarded depends, in part, on vehicle class and fleet location; fleets that serve DACs receive greater incentives.[83] The voucher for a Type A electric bus is roughly $100,000-$120,000, while the voucher for a Type C or D electric bus is roughly $200,000-$220,000.

D.1.1.1 New York Environmental Bond Act

The Environmental Bond Act, which was passed by New York State voters in November 2022, includes $500 million to help school bus fleets transition to zero-emission buses. At this time, it is expected that the $500 million will primarily support the purchase of buses in a program similar to NYTVIP as well as funding the purchase of ESB chargers. New York will disseminate more details on ESB funding from the Bond Act and how to access it as programs are developed in 2023.

D.1.2 EPA Clean School Bus Program

This five-year, $5 billion federal incentive program is available for qualifying school districts in New York State, with priority given to high-need districts.[84] [85] [86] It provides incentives to replace school buses with low and zero-emission models. Half of the program's funding is dedicated to zero-emission school buses and half is dedicated to clean school buses (which can also include zero-emission models). ESBs qualify under both funding categories. EPA can make awards of up to 100% of the cost to replace buses and acquire charging or fueling infrastructure. EPA can award funding through rebates, grants and/or contracts. In 2022, the program provided incentives for zero-emission buses by vehicle size as shown in below. These award amounts are subject to change in 2023-2026.

Table D-1. EPA Clean School Bus Program Initial Funding Under the Bipartisan Infrastructure Law

Prioritization Status	ZE Class 7+	ZE Class 3-6	ZE Infrastructure
School District that Meets One or More Prioritization Criteria	$375,000	$285,000	$20,000 per bus
Other Eligible School Districts	$250,000	$190,000	$13,000 per bus

2022 EPA Clean School Bus awards were allocated via a lottery system. For the initial round of funding (application period closed in August of 2022), EPA allocated rebates, providing $965 million for recipients to adopt new buses and infrastructure. For the second round, EPA will allocate funding through a grant solicitation in 2023 followed by additional rounds of funding alternating between the two distribution types through 2026. For the most recent solicitation, EPA awarded $67 million of the nearly $1 billion total to 20 school districts in New York State. This funding will support the deployment of 174 ESBs and corresponding infrastructure. In 2023 the Clean School Bus Program includes a competitive grant program and will likely include a rebate program later in 2023. The 2023 award amounts are similar to 2022. However, one amount is being provided so that awardees have flexibility on spending toward buses and infrastructure. The ZE Class 7+ amount is $395,000 for priority districts and $250,000 for other districts. For Class 3-6 buses the amounts are $315,000 and $195,000 for priority and other districts, respectively.

D.1.3 EPA Diesel Emission Reductions Act Grants

Administered by EPA, the Diesel Emission Reduction Act (DERA) National Grants Program[87] funds projects that provide significant reduction in diesel emissions and exposure with an emphasis on fleets operating in areas with poor air quality. Awards may reach up to $100 million annually through 2024. However, the historical average funding per year has ranged from $20 million to $50 million.

New York State is within EPA's Region 2, which also includes New Jersey, Puerto Rico, and the U.S. Virgin Islands. Historically, Region 2 receives about 10% of EPA's annual DERA National Grant funding. For example, in 2021, EPA's DERA National Grants Program was allocated $46 million, and EPA Region 2 was allocated $4.6 million to award to eligible applicants from the region.

D.1.4 Inflation Reduction Act Tax Credits

President Biden signed the Inflation Reduction Act[88] into law on August 16, 2022. Section 13403 of the Act creates a new tax credit for qualified commercial clean vehicles, including some ESBs. The credit can be applied to vehicles purchased after December 31, 2022, through December 31, 2032. For EVs, the potential tax credit is the lesser of 30% of the purchase cost or the incremental costs increase for the new vehicle compared to a comparable internal combustion vehicle. It also proposes a limitation of $40,000 for vehicles weighing greater than 14,000 pounds and $7,500 for vehicles weighing less than 14,000 pounds that are assembled in North America.[89] While other federal subsidies are not stackable with the rebates or grants under the EPA Clean School Bus Program, this tax credit may be applied in addition to receipt of EPA rebate/grant funds.

Using the following assumptions, the total potential aggregate savings associated with the tax credit could equal approximately $1.8 billion dollars (see below).

Table D-2. Total Potential Aggregate Tax Credit Savings

Tax credit/ESB	$ 40,000[90]
Estimated Number of Units to Be Replaced in NYS	44,711
Potential Aggregate Savings	$ 1,788,440,000

D.1.5 ESB purchase incentive program requirements

The funding programs listed above have differing eligibility requirements which are summarized below:

Table D-3. ESB Funding Programs and Requirements

	New York Truck Voucher Incentive Program	Environmental Bond Act Funding	EPA Clean School Bus Program	EPA Diesel Emission Reduction Act Grants	Inflation Reduction Act Tax Credits
Fleet Location	Fleet must be domiciled within 0.5-mile of a DAC to receive the highest voucher funding	TBD	High-need, low-income, rural, tribal school districts receive priorities	Not specified	Low-income communities, air quality non-attainment zones, or non-urban areas[a] Primarily used in the United States
Eligible Applicants	Public school districts, private schools, third-party contractors	TBD	Public school districts, tribes, private fleet operators	Public school districts and municipalities, as well as selective private entities	Tax-exempt entities, such as school districts; states, local, and Tribal governments; tax-exempt entities can receive direct/cash payment from IRS

Table D-3 continued

	New York Truck Voucher Incentive Program	Environmental Bond Act Funding	EPA Clean School Bus Program	EPA Diesel Emission Reduction Act Grants	Inflation Reduction Act Tax Credits
Buses Eligible for Replacement	Diesel-powered Class 4-8 school buses with an engine model year of 2009 or older	TBD	1. Be vehicle model year 2010 or older diesel-powered school buses 2. Have a GVWR of 10,001 lbs. or more 3. Have provided bus service to a public school district for at least 3 days/week on average during the 2022/2023 school year	1. Diesel school buses powered by a 2006 or older model year engine 2. Have a GVWR of 10,001 lbs or more 3. Owned by the applicant or state government without any liens on the title 4. Owned by the applicant or state government without any liens on the title 5. Have accumulated at least 10,000 or more miles transporting students	Class 6 and 7 school buses[b] There is currently no replacement requirement
Buses Eligible for Purchase	1. Class 3-8 BEV or Class 4-8 FCEV 2. Purchase from approved contractors 3. Final assembly of vehicles must take place in the U.S. 4. Repowered vehicles allowed	TBD	1. Be EPA certified vehicle model year 2021 or newer 2. Have a GVWR of 10,001 lbs. or more 3. Be purchased, not leased or leased-to-own	1. Powered by a 2017 or newer model year engine, or fully electric 2. Not funded with any other federal funds 3. Meet federal safety standards 4. Fuel types can be electric, diesel, gasoline, propane, or CNG buses meeting current emission standards	Light to Heavy-Duty Battery electric powered vehicles; fuel cell
Scrappage Requirements	Scrappage requirements apply, with certain exceptions for repowered vehicles and fleet locations	TBD	Model year 2010 and older buses must be scrapped	Old vehicles must be scrapped, with engine and chassis disabled	N/A

Table D-3 continued

	New York Truck Voucher Incentive Program	Environmental Bond Act Funding	EPA Clean School Bus Program	EPA Diesel Emission Reduction Act Grants	Inflation Reduction Act Tax Credits
Purchase Mechanism	Leased vehicles are eligible if vehicle lease is at least 5 years from the voucher approval date	TBD	New replacement buses must be purchases, not leased or leased-to-own	New ESBs must be purchased, not leased or leased-to-own	New ESBs must be purchased
Usage Requirements	1. ≥8,000 miles annually on average during the five-year in-service period 2. Operate 95% within NYS and 70% within the identified school district(s) 3. Submit Semi-Annual Usage Reports		Serve the school district for at least 5 years from the date of delivery	Meet the Ownership, Usage and Remaining Life requirements; submit quarterly reports	N/A

[a] Lashof, D, Gander, S (2022) "The Electric School Bus Revolution Has Begun – Here's How We Keep it Going" Retrieved from https://thehill.com/opinion/energy-environment/3709448-the-electric-school-bus-revolution-has-begun-heres-how-we-keep-it-going/#:~:text=The%20IRA%20included%20multiple%20such,pay%20provision%20which%20enables%20tax-

[b] Lyderson, K. (2022) "Inflation Reduction Act Offers Latest School Bus Electrification Funding Opportunities". Retrieved from https://stnonline.com/special-reports/inflation-reduction-act-offers-latest-school-bus-electrification-funding-opportunities/

D.1.6 EVSE Incentive Programs

There are a variety of federal, state, and private funds available to support the purchase of EVSE. These programs are summarized below.

D.1.6.1 EPA Clean School Bus Program

Level 2 and DCFC chargers and related services are eligible for EPA Clean School Bus grants. Districts that replace diesel buses with zero-emission vehicles are eligible for additional charging infrastructure rebates.

D.1.6.2 *Alternative Fuel Vehicle Refueling Property Credit*

EVSE for electric vehicles are eligible for a tax credit of 30% of cost, or 6% if property is subject to depreciation. There is a $100,000 cap for this tax credit. To apply for the tax credit applicants may use IRS Form 8911 (https://www.irs.gov/pub/irs-pdf/f8911.pdf).

D.1.6.3 Joint Utilities of New York: Medium- and Heavy-Duty EV Make-Ready Pilot

The Joint Utilities of New York – comprised of Central Hudson Gas and Electric, Con Edison, New York State Electric and Gas (NYSEG), National Grid, Orange and Rockland Utilities, and Rochester Gas & Electric (RG&E)—offer incentives to fleets in their territories of up to 90% of utility-side infrastructure costs through their Medium- and Heavy-Duty EV Make-Ready Pilot program.[91] These incentives are capped at $1.2 million per participant. To be eligible, fleets must already participate in either NYTVIP or the New York City Clean Trucks Program.

A 2020 order by the New York State Public Service Commission (PSC) allocated $15 million for the pilot, to be distributed across the five upstate investor-owned utilities. This funding built upon a separate $9 million budget for fleet make-ready incentives allocated over a three-year year period ($3 million per year) in a 2019 Con Edison rate case,[92]bringing the total program make-ready funding to $24 million across the State.

Note

Eligible costs include traditional distribution infrastructure, such as step-down transformers, overhead service lines, and utility meters. This incentive covers utility-side and some customer-side costs (depending on the utility provider) but does not offer awards for the charging equipment itself.

Utility-side costs include the utility service and utility transformer, while customer-side costs include the meter pan and wiring, step up transformer, electric panel, and charging port.[a]

[a] Con Edison, (n.d.) "POWERREADY Electric Vehicle Program" Retrieved From: https://www.coned.com/en/our-energy-future/electric-vehicles/power-ready-program

The PSC initiated a mid-point review for the statewide Make-Ready Program in August 2022, assessing all elements of the program—including the Medium- and Heavy-Duty EV Make-Ready Pilot. Department of Public Service (DPS) staff filed the Midpoint Review Whitepaper in March 2023 recommending modifications to the Medium- and Heavy-Duty Make-Ready Pilot to increase the budget by $30 million, make customer-side costs eligible for funding, and add the EPA Clean School Bus Program to the list of qualifying voucher programs for fleets to be eligible for funding. The Midpoint Review Whitepaper also recommends that utilities should identify existing load serving capacity at school bus depots, and that existing Fleet Assessment Services be adapted to a standardized program to serve needs of school transportation operators.

D.1.76.4 PSEG Long Island

PSEG Long Island, which operates the electric distribution system on Long Island on behalf of the Long Island Power Authority (LIPA), provides funding to support EVSE with incentives that may cover up to 100% of eligible make-ready costs for light-duty vehicles, including utility-owned equipment (step-down transformers, overhead service lines, utility meters) and customer-owned equipment (conductors, trenching, panels for stations, and other customer-side equipment).[93] Expansion of PSEG's make-ready program to medium- and heavy-duty vehicles is under consideration pending guidance from the Public Service Commission.

School Districts with Municipal Utilities

The Joint Utilities and PSEG Long Island provide electrical service to most of the school districts in NYS. Approximately 25 school districts are served by Municipal Utilities who locally distribute electricity generated by NYPA. These publicly owned utilities do not participate in programs run by the Joint Utilities or PSEG Long Island and have individual approaches to managing service requests. NYSERDA is working with a few of these school districts already and targeted efforts to engage these school districts and their utilities are underway.

D.1.6.5 EVSE purchase incentive program requirements

Infrastructure purchase incentive programs may have different requirements for fleet and investment eligibility. These are summarized below:

Table D-4. EVSE Funding Programs and Requirements

	Alternative Fuel Vehicle Refueling Property Credit	Joint Utilities: Medium- and Heavy -Duty Make Ready Program	PSEG Long Island[a]	EPA Clean School Bus Program
Fleet and/or Charger Location	Non-urban, low-income areas	Disadvantaged communities receive priorities	TBD	High-need, low-income, rural, tribal school districts receive priorities
Eligible Applicants				Public School Districts with a NCES District ID, Tribal Applicants
Eligible Charger Types	Not specified; bidirectional charging equipment/V to G allowed[b]	L2 or DCFC	L2 or DCFC	Selective L2 or DCFC chargers
ESB Procurement Pairing	N/A	EVSE is part of the EV Make-Ready Program, which also includes conversion to EVs	EVSE funding is part of the PSEG EV Make Ready program	EVSE funding is paired with ESB procurement
Eligible Infrastructure Components	Permitting and inspection fees are not included[c]	Soft costs are eligible to be covered	Cost components include utility-side infrastructure, customer-side infrastructure, EVSE hardware and other soft costs. Eligible equipment excludes the charging stations and ports themselves	Costs associated with EVSE installation, utility-side distribution upgrades, customer-side electrical service installation, charge management software are covered
Usage Requirements	See charger location requirements	Projects must meet the five-year operating requirements from the date of post-construction approval	1. Station data collection for <5 years 2. 95% Up-Time annually per port 3. 99% Up-Time 4. public sites must accept a universal form of payment	
Workforce development/training requirements	prevailing wage requirements apply to ensure fair wages for laborers who help build charging infrastructure	Work with utilities and Approved Contractor to build charging infrastructure	Developer (from customer's side) constructs/energizes EV station	EPA evaluates applicants based on their extent of workforce development/training for the project

[a] DC Fast Charge - PSEG Long Island (psegliny.com)

[b] Instructions for Form 8911 (01/2023) | Internal Revenue Service (irs.gov)

[c] Alternative Fuels Data Center: Alternative Fuel Infrastructure Tax Credit (energy.gov)

D.1.7 ESB and EVSE Funding Sources Available in New York State

The following table summarizes available funding streams in New York State:

Table D-5. Summary of Available Funding Streams in New York State

Program Name	Maximum Funding Available	Available Funds (2023)	Maximum Vehicle Funding	Max Infrastructure Funding
2022 Inflation Reduction Act Clean Heavy-Duty Vehicles	$1 billion*	$1 billion*	Under Development	Under Development
EPA Clean School Bus Program 2023 Funding - Grant	$386 million*	$386 million*	$375,000	$20,000
EPA Clean School Bus Program 2023 Funding - Rebate	$579 million*	$579 million*	$375,000	$20,000
EPA Diesel Emission Reduction Program	$100 million*	$100 million*		NA
Joint Utilities of NY: Medium- and Heavy-Duty EV Make-Ready Pilot	$3 million	$1 million	None	90% of utility-side make ready
NY Direct Current (DC) Fast Electric Vehicle Supply Equipment (EVSE) - ConEd	$6.4 million	$2.13 million	None	100%
NY Direct Current Fast Charging (DCFC) Program PON 4509	$16 million	$16 million	None	80%
NY Electric Vehicle Charging Station Make-Ready Program	$9 million	$9 million	None	100%
NY Environmental Bond to Support ZE School Buses	$500 million	$500 million	Under Development	Under Development
NY National Grid Medium-Heavy Duty EV Make Ready Pilot	$6 million	$2 million	None	90% of utility-side make ready costs
New York Truck Voucher Incentive Program	$6.3 million	$3.15 million	$3.15 million	NA
PSEG Long Island Direct Current Fast Charging Program	Variable	No Maximum	None	Variable
PSEG Long Island EV Make Ready Program	$12.84 million	$4.28 million	None	$4.28 million

* national figure

D.1.8 ESB and EVSE incentive programs in other states

Other states have their own ESB and EVSE purchase incentive programs, summarized in Table D-6 and table D-7, which offer ideas and lessons learned for New York State in designing future programs. As detailed below, some infrastructure incentive programs outside of New York State provide funding for charging ports in addition to make-ready infrastructure, unlike the Make-Ready pilot program. Some even provide funding for charger installation (e.g., the Portland General Electric [PGE] School Bus Fund).

Table D-6. Examples of Vehicle Purchase Incentives in Other States

Jurisdiction	Program Name	Incentive Structure	Program Notes
California	School Bus Replacement Program	Grants funded through state budget appropriations and California Energy Commission (CEC) support	Grants are available for public school districts, county offices of education, and joint power authorities with priority given to low-income and DACs.
California	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) Public School Bus Set-Aside	Vouchers offered through California Air Resources Board (CARB)	Vouchers are available for public and charter schools located in small and medium air districts
Colorado	ALT Fuels Colorado	Grants funded initially by the Federal Highway Administration's Congestion Mitigation and Air Quality Improvement (CMAQ) program; future funding will be managed by the Colorado Department of Public Health and Environment (CDPHE)	Provides grants to scrap and replace pre-2009 diesel vehicles with electric or natural gas vehicles for public, private, and non-profit fleets[94]
Massachusetts	MOR-EV Trucks	Vouchers and rebates provided by the U.S. Department of Energy (DOE) Resources	Provides funding for the purchase or lease of electric and fuel-cell EV by public and private entities. Funding amount increases with vehicle classification level. Extra funding is available for fleets that serve environmental justice communities

Table D-7. Examples of EVSE Incentives in Other States

Jurisdiction	Program Name	Financial Incentive	Eligible Investments	Program Notes
California	EnergIIZE Commercial Vehicles	Grants funded by the CEC "Clean Transportation Program"	Level 2 and DCFC chargers	Program is not focused specifically on school bus fleets, but school districts located in low-income or DACs that meet other equity criteria may qualify
Colorado	ALT Fuels Colorado	Grants funded initially by the Federal Highway Administration's CMAQ program; future funding will be managed by CDPHE.	Level 2 and DCFC chargers	Provides infrastructure funding for public, private, and non-profit fleets that are converting to electric[95]
Oregon	PGE School Bus Fund	Grants funded by Portland General Electric (PGE)	Level 2 and DCFC chargers and installation	In addition to providing funding towards ESB purchases, PGE provides funding for qualified charging ports[96]

Appendix E. Procurement and Operational Models

To help avoid the cost premiums associated with fleet electrification and transfer the responsibility associated with ESB operation and maintenance to qualified parties, school districts have a range of deployment model options to consider. In these scenarios third-party private companies provide procurement and operational assistance in exchange for ownership and payments These include:

- **Traditional-** School district owns and operates all buses and equipment.
- **Lease.** A third party owns the ESBs, while the school district owns the chargers and charging infrastructure and manages operations.
- **Turnkey.** A third party owns the ESBs, chargers, and charging infrastructure, while the school district manages operations.
- **Transportation-as-a-Service (TaaS).** A third party owns the ESBs, chargers, and/or charging infrastructure and manages operations.[97]
- **Contractor service-** A third party school bus contractor owns the school buses and any associated charging infrastructure and provides a comprehensive service, including drivers, operation of buses, and all other aspects of student transportation, to the school district. The contractor may engage another third party for a Turnkey or TaaS contract for electrification and charging support.
- **Contractor operation.** The school district maintains ownership and maintenance responsibilities, while the contractor operates the buses. Private companies typically offer many of these services via a fee-based subscription model where school districts pay a fixed rate that covers the cost of the buses and infrastructure as well as operation and maintenance (when applicable).[98] As a part of their service packages, these companies commonly offer fleet advisory services, such as site assessment and design, funding opportunity identification, operating and maintenance training, and more. In some instances, providers may partner with other private entities (e.g., OEMs, distributed energy resources (DERs), battery storage companies, and/or utilities) to provide V2G services. Some companies may provide their own operation staff, hiring and deploying its own drivers, mechanics, and dispatchers.[99]

TaaS in Action: Montgomery County, MD

Montgomery County Public Schools (MCPS) has added 86 ESBs to its fleet as of October 2022, with deployment of 326 vehicles planned by 2025. The district plans to have an entirely electric fleet within ten years under an agreement with transportation-as-a-service firm Highland Electric.

Highland and its project partners Thomas Built Buses, Proterra, and American Bus will electrify all five of MCPS' bus depots, supplying ESBs and charging infrastructure along with services including managed charging. The ESBs will also lend their batteries to deliver stored electricity to local electricity markets, interconnected through the local energy utility, Pepco (the Potomac Electric Power Company). Highland coordinates ESB procurement and financing, infrastructure installation, and managed charging. The firm internalizes each of these variable costs while school districts see a predictable fee structure.

Alternative fleet ownership and operation structures offer key benefits. Under these models, a private entity owns or operates ESBs and/or charging infrastructure components and shoulders some of the costs associated with ESB deployment. For example, Charging-as-a-service companies, make it easier for fleets to deploy charging infrastructure, thereby reducing fleet managers' O&M burden. In other instances, utilities own and manage charging stations on the behalf of fleets. This approach enables utilities to provide startup capital for charging infrastructure while leveraging the demand response benefits discussed above.

Charging-as-a-service companies have emerged as an option to address needs in the ESB landscape. As a part of their packages, companies such as ChargePoint and BP Pulse include cloud-based charging applications that allow fleet operators to remotely manage and monitor real-time charging status and schedule charging based on bus routes and availability.[100] These charging models make it easier for fleets to deploy charging infrastructure, thereby reducing the burden of O&M from fleet managers. In other instances, utilities own and manage charging stations on the behalf of fleets. This approach enables utilities to provide startup capital for charging infrastructure while leveraging the demand response benefits discussed above.

In September 2022, NYSERDA issued an RFI for Fleet Transportation As-a-Service business models (RFI 5198). The RFI template (provided in appendix C) solicited information from the private sector about aaS business models designed to accelerate medium- and heavy-duty truck and bus electrification to help inform policy and program planning. appendix C provides details about the RFI administration and methodology.

Note

TaaS-based solutions are frequently referenced as "x-as-a-service," where x denotes the type of solution(s) offered by a vendor. There are a range of as-a-service (aaS) models that address various elements of fleet electrification, including energy modeling, charge management, vehicle procurement, and more. In these offerings the TaaS-provider generally deploys private capital to fund fleet electrification projects and recovers their costs over time through ongoing service payments.

Benefits. These deployment services offer significant benefits. For example, they can help school districts avoid the initial high costs of fleet electrification and they can streamline the overall process—schools need to contract with only one company for all their transportation and fleet electrification needs. They also take "new" elements off the school bus fleet operator's plate by handing them over to an entity that specializes in these services; in this way, the fleet operator can focus on what it does well already. TaaS models in particular can offer opportunities for school districts and contractors to transition to ESBs more quickly and with lower costs than traditional procurement models. TaaS may be especially attractive to and relevant for school districts in less resourced communities that cannot easily purchase new vehicles and charging infrastructure because of the high upfront capital costs.

Considerations. Some of these models might also present tradeoffs for school districts. In a TaaS model, districts do not own ESBs, chargers, and/or charging infrastructure and, as a result, may have to continually pay for their services. The lack of bus and charger ownership may be attractive to school districts but can also constrict their ability to make fleet management decisions. The initial setup of these models may bring administrative hurdles, though these would be alleviated once the new model is established. In addition, private deployment models may restrict a district's eligibility to receive grants and other incentives to pay for new buses or may require additional steps to qualify, as some private firms may not be eligible depending upon program guidelines.

As shown in below, a few firms offer turnkey and TaaS solutions for school bus fleets. Some companies, such as Zum, have already contracted with thousands of fleets, whereas others, such as Levo Mobility, are still in the process of developing these services.

Table E-1. Examples of deployment models

Company	Overview	Model Type	Examples
Highland Electric Fleets	Highland has over 330 ESBs under subscription and has deployed V2G technology in Massachusetts and Vermont	Turnkey	Beverly MA; Montgomery County, MD; South Burlington, VT[101]
Levo Mobility	Levo is a relatively new joint venture create by Nuuve and Stonepeak Partners LP[102]	Turnkey	Levo has yet to deploy fleets but recently entered a contract with the Troy Community Consolidated School District in Illinois[103]
Zum	Zum services over 4,000 schools and districts	TaaS	Bay Area, CA (San Francisco, Oakland, Menlo, Nueva)[104]

Appendix F. Centralized Purchase Models

This appendix describes initiatives in which a central entity organizes the procurement of vehicles, charging infrastructure, and/or related services on behalf of individual fleets. The coordinating entity does not provide direct funding but uses collective buying power to procure equipment or services at the lowest cost. Fleets have several centralized purchase options to consider, including, among others, the New York State OGS's bus purchasing contract and charging contract with ChargePoint to procure EVSEs and network services.

F.1 Centralized Purchase Types

School fleets can take advantage of centralized purchase agreements to procure a wide range of goods and services, including but not limited to ESBs and EVSE procurement, O&M services, charging-as-a-service (CaaS), telematics, and other services such as site planning and prep, consulting, utility coordination, equipment installation and project management.[105] These agreements are generally organized by public entities, and can assist fleet electrification at any stage in the process. New York State and the federal government have general service offices that handle such agreements.

In contrast, the Metropolitan Area Planning Council in Massachusetts is a regional planning agency composed of representatives from cities and towns in the Boston metropolitan area.[106] Sourcewell, a quasi-governmental organization founded by the Minnesota legislature, is another organization type. While it is based in Minnesota, Sourcewell allows organizations (public, private, and nonprofit) from across country to participate in their agreements.[107] South Carolina does not have formal centralized purchasing agreement, but handles all in-state school bus purchases, enabling the State the to realize bulk purchase discounts.

A few factors vary across centralized purchase agreements, including:

- **Eligible organizations:** Some agreements only allow public entities to participate, whereas others will also allow private companies and nonprofits.
- **Eligible fleet locations**: Some agreements only allow in-region or in-state fleets to participate, whereas others allow fleets from across the country.
- **Eligible equipment:** Different procurement opportunities may focus on a small number or even a single make and model of equipment in the order. If the equipment offered under centralized purchases is limited to specific makes or models, there may be opposition to a public-sector agency "picking winners" amongst competing technologies.

F.2 Examples of Centralized Purchase Arrangements

New York State school districts have several centralized purchase arrangements to consider. They include:

F.2.1 The New York State Office of General Services (NYSOGS)

OGS uses Sourcewell's contract with ChargePoint to procure EVSEs and network services.[108] These products include Level 2 and DCFC chargers; site assessment, preparation, installation, and maintenance costs; monitoring, reporting, billing, support, and training services, amongst other products. In addition, Sourcewell generally allows nonprofit organizations and private schools to apply for its contracts.

F.2.2 Other Centralized Purchase Agreement Opportunities

The U.S. General Service Administration (GSA) Blanket Purchase Agreement (BPA) for EVSEs offers a similar array of products as Sourcewell.

The New York Power Authority (NYPA) also solicits bids to procure various products and services, although, these products are generally not applicable to ESB fleets.[109]

New York State school districts can also take advantage of BOCES offerings, which include shared services to school districts (e.g., bus maintenance and transportation services) as well as energy cooperatives. However, BOCES membership is not available to school districts in these cities: Buffalo, New York City, Rochester, Syracuse, and Yonkers. Table F-1 below lists examples of centralized purchase arrangements.

Table F-1. Examples of centralized purchase arrangements

Jurisdiction	Initiative	Coordinating Entity	Applicable Product/Service	Program Notes
New York State	Electric Vehicle Supply Equipment and Network Services	New York State Office of General Services (OGS)	Level 2 and DCFC chargers and related site services (e.g., installation, maintenance, repair); Network services[110]	OGS handles contracts for commodities, services, and technologies on the behalf of state agencies, local governments, school districts, and nonprofits[111]
New York State	BOCES	New York State Legislature	Energy cooperatives, bus maintenance and transportation services, and more	BOCES provides a variety of shared services to the State's school districts, however, schools located in New York City, Buffalo, Rochester, Yonkers, and Syracuse are not eligible for participation[112]
Boston Metropolitan Area	Green Mobility Purchasing Group	Metropolitan Area Planning Council	Level 2 and DCFC chargers	MAPC submits Request for Quotes on a statewide Contract for the equipment with the most municipal demand to obtain purchase discounts and lowest prices available
Federal Government Fleets	BPA	U.S. GSA	Level 2 and DCFC chargers; O&M plans; power management and metering; CaaS; and more	U.S. GSA has 60-month contracts with an array of EVSE providers to help streamline the purchasing process for federal fleet electrification
Nationwide	Sourcewell	Sourcewell	ESBs, EVSEs, and related services	Sourcewell is a government agency based in Minnesota that allows all education and government agencies, nonpublic schools, and nonprofit organizations to participate in various cooperative purchasing agreements[113]
South Carolina	n/a	South Carolina Department of Education (SC DEC)	ESBs	The SC DEC handles all in-state school bus purchases, potentially obtaining bulk purchase rates

Appendix G. Fleet Advisory and Grid Coordination Services

This appendix describes initiatives that can smooth the process of fleet electrification, including a wide range of analyses and coordination programs. The table below describes fleet advisory and grid coordination services available to fleets interested in electrification. These services are typically provided by utilities, dealers, third-party contractors, and/or engineering firms (sometimes with government support) and span the various stages of the ESB fleet electrification process, from preliminary site assessments and costs savings analyses to ESB and EVSE procurement and implementation guidance.

Table G-1. Fleet Advisory and Grid Coordination Services

Service	Service Description
Projected costs	Projects total and/or incremental costs of ESB purchases, EVSE hardware, EVSE installation and grid interconnection, ESB and EVSE maintenance and operation, electricity rates, operator and maintenance training, cost savings, TCO analysis
ESB and EVSE product options	Reviews vehicles and chargers to determine suitability for operational needs
Site assessments	Feasibility analysis, site/infrastructure review and needs assessment, site design
Rate Analysis	Rate analysis to determine costs of fleet electrification, utility tariff recommendations, economic best practices for fleet operators
Operations modeling	Emissions mitigation, fuel savings, maintenance cost/down time savings
Identification of financing/funding opportunities	Identifies federal, state, and/or local incentives for which a fleet is eligible, such as grants, vouchers, rebates, loans, and tax incentives
Energy analysis	Analyzes a fleet's potential to incorporate managed charging, renewables, battery storage, and V2X programs
Transition planning	Provides a recommended timeline and overview of the steps needed to install charging infrastructure and obtain ESBs, including guidance of processes such as sites assessments, permitting, utility coordination, workforce training, fleet replacement, etc.
Route analysis and projected operational needs	Analysis of current VMT per route for diesel fleet, projections on whether ESBs can complete current route without opportunity charging at destinations, modeling needed to assign multiple ESBs to a diesel bus route due to range, modeling anticipated pupil school housing needs, as well as assumptions on range impacts due to cold weather days, snowstorms, traffic, and elevation, and possibility of route efficiency analysis to determine if fewer buses can complete required pupil transportation needs
Utility programs	Develops charging plans, reviews time of use charging rates and demand response mechanisms, and investigates the potential of V2G/V2X

G.1 Program variations

Fleet advisory services are commonly provided by utilities and public agencies, often in partnership with private contractors who specialize in this work. These programs are available only to fleets within a utility's service area. While the services included in these assessments often vary, they commonly include analyses that cover various stages of electrification, such as site assessments, vehicle and infrastructure recommendations, operation and maintenance analyses, procurement plans, and financial assistance identification.

G.2 Key examples

The six utilities that form The Joint Utilities of New York—Central Hudson, Con Edison, National Grid, NYSEG, RG&E, and Orange and Rockland—currently offer Fleet Assessment Services to their customers as a part of their overarching make-ready incentive program[114]. While each utility's program varies, most include some or all of the following components:

- Site feasibility
- Rate analysis
- Estimated billing impacts
- Charging recommendations
- ESB suitability assessment
- TCO analysis/operation cost and savings projection
- Multiyear procurement plan evaluation
- Emissions reductions analysis

Utilities in states such as Oregon, Michigan, and Massachusetts offer similar fleet advisory services. Some programs include analyses that are not currently offered by the New York State utilities, such as current fleet performance analysis, preliminary site design and costs estimates, and financial assistance identification.

NYSERDA's P-12 Schools: Clean Green Schools Initiative and its Flexible Technical Assistance program provide funding for fleet transition studies provided by third parties. below highlights fleet advisory and grid coordination programs offered within New York State and beyond.

Table G-2. Example Fleet Advisory and Grid Coordination Services

Service	Description	Applicable Programs	Service Providers
New York State	Fleet owners and operators in New York State are eligible to apply for assistance from their utility service provider to help prepare their fleet for EV charging	Charging infrastructure services, including site feasibility analysis, rate analysis, estimated billing costs, charging recommendations, TOC comparisons per vehicle, fleet-wide cost and savings analysis, procurement plan analysis	The Joint Utilities of New York[115]
New York State	The Clean Green Schools Initiative offers funding for professional services that aim to reduce energy loads and provide clean energy opportunities	Energy studies, clean transportation studies, energy performance contracting, energy master planning and decarbonation roadmaps, on-site energy managers, fiscal advisors, and more[116]	NYSERDA[117]
Oregon	The first stage of Portland General Electric's Fleet Partner program, which assists fleets from assessment to purchases, is the Fleet Partner Plan	BEV feasibility assessment, charging analysis, site assessment, preliminary designs and costs estimates, and more	PGE[118]
Michigan	The first stage of Consumers Energy's PowerMIFleet program is an "Electrification Assessment"	Performance analysis of current fleet, vehicle and charging station recommendations, cost savings analysis, and environmental benefits analysis	Consumers Energy[119]
Massachusetts	National Grid offers a free Fleet Advisory Program for fleet owners	Productivity and efficiency analysis, fuel costs, operation and maintenance costs, carbon footprint analysis, vehicle recommendations, financial assistance identification	National Grid[120]
Massachusetts	Massachusetts is developing a bus electrification fleet support program available to public school districts	This program recently began working with awardees and will include assessment of charging options and necessary site upgrades, vehicle replacement recommendations, and funding opportunity identification. Support will include advice and assistance coordinating with local utilities, review of draft bid documents, and construction project management	Massachusetts Clean Energy Center[121]

G.3 New York State program development

A variety of fleet advisory services are offered at the state level, the federal level (e.g., the EPA Clean School Bus Program), utilities, and from advocacy groups, including WRI's Electric School Bus Initiative. In addition to utility-led initiatives, under NYSERDA's Clean Transportation Prize program, the prize-winning New York City School Bus Umbrella Services (NYCSBUS), a school bus operator in NYC, is developing an "ESB Center of Excellence," with the goal of contributing to a state-wide knowledge base about ESB implementation. The Center will include ESB curriculum development and coordination, production of training videos and web animations, outreach to New York State school districts via a cohort program that uses materials from the Center of Excellence support school districts in the development of transition plans and share project findings and resources for their deployment planning and workforce training.

Appendix H. Vehicle to Everything Solutions

Vehicle to everything programs include any bidirectional charging functions allowing ESBs to discharge unneeded stored power from their onboard battery storage. The power can be used on-site in building applications known as vehicle-to-building or V2B, or, in more sophisticated arrangements, be fed back into the grid to generate revenue (via vehicle-to-grid or V2G). This latter option can provide an added revenue stream for operators, which could be further leveraged by giving the utility control over minute-to-minute fluctuation in charging load to assist in load smoothing.

ESBs represent a significant energy storage resource with the potential to assist in mitigating peak load. Because the typical ESB has a predictable duty cycle concluding in the early evening, any remaining state of charge in the vehicles once plugged into their charging terminals could be leveraged to address on-site power demand or even feed back into the grid. Such actions could help mitigate the early evening peak spike in power demand during warm months. Currently, V2G programs are in the early stages of development. Many projects are smaller efforts designed to demonstrate that V2G is a viable technology rather than implementing the technology at scale. For example, Highland Electric Fleet's project in Beverly, Massachusetts used one ESB to supply the energy grid with power for 50 hours. Con Edison also recently completed a three-year V2G pilot in White Plains, New York.[122] The utility retrofitted three ESBs with V2G technology that enabled them to feed energy back into the grid when at the charging depot and successfully demonstrated V2G capabilities in ESBs.[123] Both of these programs have proven their ability to successfully transmit energy back into the grid via school buses, but neither program reported a quantitative figure for cost savings, or for emissions savings. DPS's *Electric Vehicle Make-Ready Program Midpoint Review and Recommendations Whitepaper* (March 2023) recommends that the Public Service Commission direct the Technical Standard Working Group to convene a dedicated effort to address challenges to vehicle-grid integration.[124]

Because the ESB market is still in a developing stage, V2G services are often packaged alongside fleet electrification services (e.g., Dominion Energy's program in Virginia) and there are currently no standalone programs available for ESB fleets. In the future, these programs could be offered as standalone services by utilities, private fleet deployment firms, and/or charge managing firms.

Appendix I. ESB Workforce Training Needs and Options for Meeting Demand

I.1 ESB Workforce Training Needs and Options for Meeting Demand

The electrification of school bus fleets is likely to result in lower overall operating costs, due in part to reduced maintenance costs for ESBs. Fleets may rely on external contractors or vehicle manufacturers to handle maintenance specific to electric powertrains. Alternatively, with workforce development investments, fleets may continue to address these needs in-house. This appendix highlights pathways for workforce training necessary to meet new demands under school bus electrification. Because training programs aligned with EV support are still in the early stages of development, this appendix focuses on describing key workforce training needs for ESB fleets and points to example programs in other fleet segments (e.g., transit buses) as available.

I.1.1 "Upskilling"/Retraining Existing Technician Staff

Much of ESB maintenance and general operations support tasks can be performed by existing in-house fleet technicians, provided they receive training on the nuances of working on ESBs, such as high-voltage power control when operating on components connected to the battery pack. Incentive and other funding applications should incorporate workforce impact assessments, where fleet operators are guided through evaluating the impact of ESB deployment on their operators, maintenance technicians, and facility managers.[125] Enabling the upskilling of the existing fleet workforce can help limit local employment dislocation by ensuring a skilled local workforce.

ESB manufacturers currently provide the most robust workforce training resources. These programs are often designed to empower individuals to take on more highly skilled positions. For example, New Flyer, Inc. (NFI) launched an Electrical Technician Training Program at its Minnesota facility locations in 2021, an initiative that includes entry-level training in modules including electrical theory, component systems, bus maintenance trouble shooting, and high-voltage safety training.[126,127] Establishing and incentivizing programs like this with partners already within New York State or planning to open facilities in the State would help ensure that opportunities are accessible to the State's school bus workforce.

O&M training resources will be required to bring existing fleet staff up to date on the differences in working with ESBs. These resources include certification-oriented skills courses, digital training resources, on-the-job training and apprenticeships, and reference materials, provided by a range of entities (e.g., vehicle and charger manufacturers, third-party ESB service providers, state and federal agencies, nonprofits, and trade organizations). The following sections describe currently available resources and discuss the need for additional program development.

I.1.2 Existing Training Resources

The Electric Vehicle Infrastructure Training Program provides EVSE installation certification for all fleet types, and the DOE's Energy Management Program's EV Champion Series covers topics such as EVSE power and installation requirements, and BEV site assessments and operations[128,129]. Hudson Valley Community College offers an "Electric and Autonomous Vehicles" degree, which trains students to become vehicle technicians[130].

Federal initiatives funded under the 2022 Bipartisan Infrastructure Law are expected to provide accessible information and guidance to fleets and other entities involved in the operation and maintenance of ESBs. As an example, EPA's Clean School Bus Program is developing Clean School Bus Technical Assistance, focused on ESB planning and deployment, routing and maintenance, utility connections, and bus performance optimization; provided under a partnership between EPA, the Joint Office of Energy and Transportation, and the National Renewable Energy Laboratory.[131]

I.1.3 Existing New York State Programs

NYSERDA has created two programs aimed at developing the clean energy workforce which could be leveraged for ESB training: On-the-Job Training for Energy Efficiency and Clean Technology and the Energy Efficiency and Clean Technology Training Program RFP.

The On-the-Job Training for Energy Efficiency and Clean Technology program provides incentives to eligible businesses, at various levels of the supply chain, to hire and provide on-the-job training for workers. While eligible businesses can provide services in one or more energy efficient and clean technology area (e.g., smart grid, energy storage, heating, ventilation and air conditioning systems (HVAC)), only one category, EV charging stations, is directly applicable to school bus electrification.[132]

Additionally, through its Clean Technology Training Program RFP, NYSERDA is seeking proposals for technical training, experiential learning, job placement, and support services in the energy efficient and clean technology areas, including EV charging stations. Selected projects are intended to provide relevant training and experience for new and current workers so that their skills meet industry demands.[133]

As EV- and EVSE-oriented trade skills courses begin to appear on curricula (as is already the case at Hudson Community College), New York State could consider partnerships with colleges, community-colleges, and vocational school to develop courses that meet industry needs, such as those that cover EVSE equipment installation, ESB and EVSE O&M best practices, and ESB and EVSE-specific repair work and ongoing maintenance.

I.1.4 Ensuring Availability of Licensed Electricians

The *Jobs Study* projects an additional 10,000 jobs in the EV charging subsector by 2050.[134] Other sources indicate that ESB deployment alone will support career opportunities for thousands of electricians nationally.[135] The anticipated demand for electrician labor across sectors (including other vehicle segments, building electrification, DERs) suggests that a key priority for New York State in decarbonization is ensuring the availability of a skilled in-state workforce to meet this expanding need, including electricians with EVSE-specific training. In addition, training could also be provided to the technicians responsible for operating the software and communication systems that connect the charger to the network.

I.1.5 Leveraging New Opportunities to Ensure Workforce Benefits

As school bus fleet conversion progresses, the development of new manufacturing facilities, fleet locations, and supporting charging infrastructure may provide "organic" opportunities for ensuring that the workforce is trained and that it also provides additional benefits to employees and the broader economy. These benefits include training opportunities, fair wages and benefits, and health and safety systems.

Community binding agreements are legal agreements between companies and community coalitions, focusing on creating pathways to high-quality jobs for frontline and historically marginalized communities. A recent multistate community binding agreement with electric transit bus manufacturer New Flyer at facilities in Alabama and California requires that 45% of new hires and 20% of promotions benefit historically disadvantaged groups. The community binding agreement also specifies the development of apprenticeship and technical training programs, on-site independent safety trainings and debt clinics, increased Spanish bilingual capacity, and additional hiring protections and worker complaint systems. Community binding agreements with manufacturers Proterra and BYD offer similar benefits and protections to their manufacturing workforces.[136] The community binding agreement model could possibly be adapted to non-manufacturing contexts relevant to ESB deployment, such as new fleet facility locations or the installation of charging infrastructure. One example could be agreements for minimum local hiring targets to support local construction or facility operation.

Endnotes

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68 EEP (2022).

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78 Area type is consistent with National Center for Educational Statistics designations – see https://nces.ed.gov/programs/maped/LocaleLookup/.

79 Depot addresses were independently verified using Google Maps.

80 There are 734 districts total, with 32 residing in New York City. See https://data.nysed.gov/ and https://www.wnyc.org/schoolbook/guides/understanding/.

81 Due to confidentiality restrictions, the identity of fleet operators was masked so there are some limitations to the level of data disaggregation used in reporting.

82 Bus type assigned by number of passengers – 30 passengers or less designated as Type A, 54 to78 passengers designated as Type C – see https://www.trackschoolbus.com/types-of-school-buses/.

83 NYSERDA, (2022). "Truck Voucher Incentive Program" Retrieved From: https://www.nyserda.ny.gov/All-Programs/Truck-Voucher-Program

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86 Eligible Applicants Include state and local government entities that provide bus service (including public school districts and charter schools), contractors (for-profit, not-for-profit, and nonprofit), nonprofit school transportation associations, and tribal organizations responsible for the purchase of buses or bus services for a Bureau of Indian Affairs funded school. For prioritized fleets, EPA offers $285,000 per class 3-6 ESBs and $375,000 per class 7+ ESBs and offers $190,000 per class 3-6 ESBs and $250,000 per class 7+ ESBs for non-prioritized fleets. EPA also offers up to $20,000 per zero-emission bus for related infrastructure (maximum of $13,000 for non-prioritized fleets).

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