



Skaneateles Central School District

NYSERDA Flexible Technical Assistance Program



Fleet Electrification Plan

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Prepared for:



Skaneateles Central
School District

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Acronyms

A	amperage
AC	alternating current
BESS	battery energy storage system
CLCPA	Climate Leadership and Community Protection Act
DC	direct current
DCFC	DC fast charger
EaaS	electrification-as-a-service
ESB	electric school bus
EV	electric vehicle
EVSE	electric vehicle supply equipment
FEP	Fleet Electrification Plan
GHG	greenhouse gas
HVAC	heating, ventilation, and air conditioning
ICE	internal combustion engine
kW	kilowatt
kWh	kilowatt-hour
kVA	kilovolt-amperes
MDB	main distribution board
MVA	megavolt-amperes
MW	megawatt
NOAA	National Oceanic and Atmospheric Administration
NYSBIP	New York State Bus Incentive Program
NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority
O&M	operations and maintenance
PPA	power purchase agreement
SOC	state of charge
tCO ₂ e	tons of carbon dioxide equivalent
V	voltage

Definitions

Amperage	The rate of flow of electrons through a circuit, a.k.a. current
Demand Charge	Utility charges based on the highest level of power a customer draws at one time during the billing period and the time of day it is needed by the customer
EV Ready	A state of infrastructure preparedness where a site or facility is equipped to support electric vehicle (EV) charging with minimal additional upgrades; this typically includes the installation of sufficient electrical capacity, conduit, wiring, and appropriate electrical panels to accommodate EV chargers
Internal Combustion Engine	Automobiles that use fossil fuels like gasoline or diesel to power their engines
Feeder	A utility power line that transmits electricity from a substation or generating station to distribution points
Future Proof	In the context of EV infrastructure, future proofing means to design the service and/or electrical equipment to be oversized, capable of handling additional electrical load in the future
Kilowatt	The rate at which power is consumed or delivered
Kilowatt-hour	A unit of measure for electrical energy or the amount of electricity used; 1 kWh is the energy delivered by 1 kW of power for 1 hour
Kilovolt-Amperes	A unit of measurement for apparent power, which is the total amount of power in use in an electrical system
Megawatt	A unit of power equal to one million watts, especially as a measure of the output of a power station
State of Charge	The percentage of energy the battery currently has compared to its capacity
Substation	A set of electric equipment that reduces high voltage power to a voltage suitable for distribution to customers
Transformer	A device that changes electricity from one level of voltage to another
Voltage	Pressure created by a difference in electrical charge between two points

1. Objectives and Key Concepts

1.1 Project Objectives

This project provides a conceptual framework for Skaneateles Central School District (Skaneateles CSD) to guide the transition of its 24-count school bus fleet to electric vehicles (EVs). Located in a mountainous region with cold weather conditions, Skaneateles CSD faces unique challenges, including higher power demands for its fleet. By incorporating worst-case scenario inputs into the route and charging analysis, this study will estimate the power requirements for each route and determine the maximum range of new battery electric vehicles (BEVs) to account for the district's dynamic routing needs.

Additionally, this Fleet Electrification Plan (FEP) outlines the necessary infrastructure upgrades to support BEV charging. Through comprehensive site assessments and utility engagement, the district will gain insight into the feasibility, timelines, power requirements, and costs associated with retrofitting its facilities for an electrified fleet. This strategy equips SKANEATELES CSD with the critical information needed for effective planning and implementation.

1.2 Vehicle Classifications

Type A EV Bus: A small school bus, typically built on a cutaway van chassis with a passenger capacity of 10-30 students. Type A buses are commonly used for shorter routes. Due to their smaller size, they generally require less battery capacity and may be more energy efficient on low-mileage routes.

Type C EV Bus: A standard-sized school bus with a capacity of 50-77 passengers widely used for general student transportation. They are suitable for medium- to long-range routes and typically require larger battery capacities.

Type D EV Bus: A large, transit-style school bus with a passenger capacity of 66-90 students. Type D buses are commonly used on high-capacity routes or longer trips. Due to their size, they require significant battery capacity and are well-suited for districts with large numbers of students or for long-distance routes.

1.3 Charging Types

Level 2: Level 2 chargers operate at 208 to 240 volts AC and can deliver up to 80 amps of power. These chargers typically require between 12 and 30 hours to fully charge a vehicle, depending on the battery size and state of charge (SOC). The hardware for Level 2 chargers is relatively affordable, with costs ranging from \$1,000 to \$10,000, while installation costs typically fall between \$8,000 and \$20,000 per charging port.

Level 3: Level 3 chargers, also known as DC fast chargers, provide significantly faster charging speeds. They operate on 200 to 500 volts DC and can deliver up to 500 amps, enabling a full charge in approximately 1 to 8 hours. This rapid charging capability comes with higher costs, as hardware prices range from \$20,000 to \$100,000, and installation expenses typically range from \$20,000 to \$100,000 per port.

Related Legislation

In 2022, as a part of the effort to reduce greenhouse gas emissions and improve the health of students, New York State passed legislation requiring the electrification of school buses. New York's 2022-23 budget set the following mandates:

- **2027:** All school buses purchased after July 1, 2027, must be zero-emission.
- **2035:** All school buses in operation after July 1, 2035, must be zero-emission.

2. Executive Summary

This Fleet Electrification Plan for Skaneateles CSD serves as a comprehensive guide to achieving a full transition to electric school buses (ESBs), aligning with New York State’s zero-emission vehicle mandates. The plan offers a phased approach to electrification, addressing operational challenges, infrastructure requirements, and long-term sustainability.

Electrifying the fleet presents significant benefits for Skaneateles CSD, including improved air quality for students and the community, reduced greenhouse gas emissions, and lower long-term operating costs. ESBs eliminate tailpipe emissions, creating healthier environments around schools and neighborhoods, particularly benefiting children who are more vulnerable to air pollution. Financially, electric buses offer lower fuel and maintenance costs compared to diesel counterparts, with the potential for further savings through strategic charging management and the use of off-peak electricity rates.

Key elements of this plan include a detailed route analysis that accounts for Skaneateles CSD’s unique challenges, such as mountainous terrain and cold winter conditions. These factors are critical in determining vehicle energy demands and battery performance under real-world conditions. The proposed charging infrastructure strategy ensures sufficient power for daily operations while minimizing costs through efficient site planning and phased implementation of utility upgrades.

The plan also emphasizes workforce readiness as a cornerstone of successful implementation. Driver training programs are designed to maximize vehicle efficiency through techniques like regenerative braking and pre-conditioning, while maintenance teams are prepared to address the specific needs of ESBs. Additionally, safety protocols, including fire prevention measures and emergency response coordination, are integrated into the transition plan.

Beyond operational improvements, fleet electrification aligns Skaneateles CSD with broader environmental and social goals, contributing to state and national efforts to combat climate change. It also positions the district as a forward-thinking leader in sustainable transportation, with the potential to inspire other school systems to follow suit.

By adopting this plan, Skaneateles CSD can confidently navigate the transition to an electric fleet while ensuring reliability, sustainability, and long-term cost savings. The phased approach provides flexibility to adapt to advancements in EV technology and district-specific needs, ensuring a successful and scalable transition that benefits the entire community.

2.1 Key Data

Fleet Information

Skaneateles CSD has an owned fleet of 24 buses housed at their transportation office (819 West Genesee St, Skaneateles, NY 13152). The fleet is currently operated by First Student and consists of 3 Type A buses, including 1 spare, and 21 Type C buses, including 9 spares. Most of this fleet (22 / 24 buses) are Blue Bird buses. Additional key details regarding the electrification plan are outlined below:

Table 1: Fleet Electrification Specifications

Number of Routes that Can Electrify with Current Technology	23 / 24
Number of EV Chargers	9 dual port 60 kW chargers 3 dual port 120 kW chargers
Type and Quantity of Buses	2 Ford e-sprinters 1 Blue Bird Micro Bird 21 Blue Bird Vision

Table 2: Electric Utility Requirements Summary

Utility Requirements	
Daily Peak Demand without Charge Management:	510 kW (active fleet only) 900 kW including spare buses/chargers
Daily Peak Demand with Charge Management:	360 kW (active fleet only)
% Reduction in Peak Demand with Charge Management:	29%
District-side Infrastructure Upgrades:	New service equipment sufficient for 2 utility upgrades (totaling 1000+ MW of utility equipment). Trenching from new service equipment to distribution equipment and chargers.
Utility-side Infrastructure Upgrades:	New service for EV fleet. No substation or feeder upgrades are needed currently.
Timeline for Upgrades:	12-24 months

Cost Breakdown

Table 3: Cost Summary*

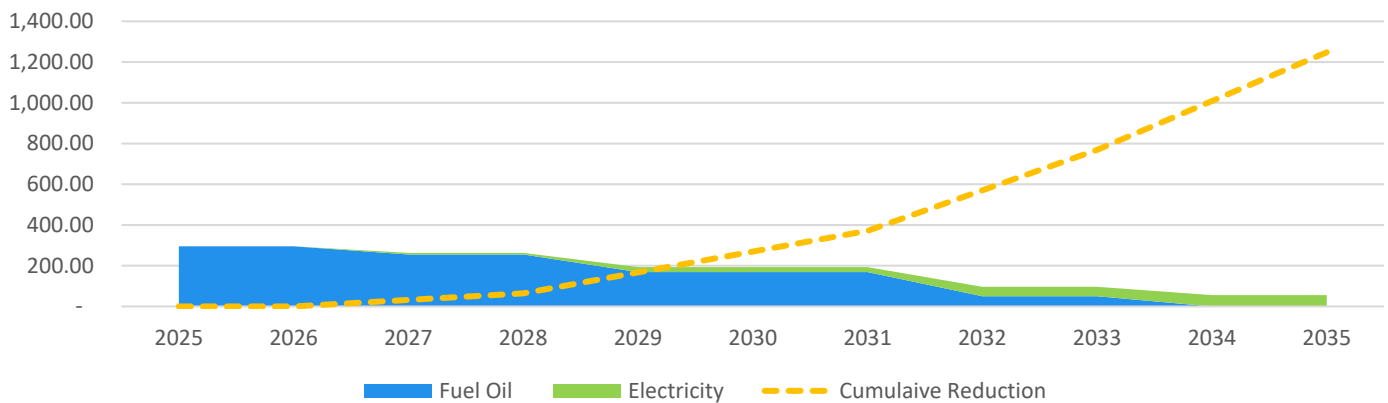
Estimated Total Project CapEx	
Total Project CapEx (Without Incentives):	\$12.2 M
Total Project CapEx (With Incentives):	\$9.5 M
Estimated Annual OpEx of Fully Electrified Fleet	\$211,000 (year 2035)
Incentive Information	
NYSBIP Bus Voucher:	Van: \$0 Type A: \$114,000 Type C: \$147,000
NYSBIP Charging Voucher	\$55,000 / bus
National Grid Make Ready Incentive for Utility Upgrades:	90% Utility-side cost
Estimated School Bus Costs	
Bus Unit Cost:	Van: \$55,000 Type A: \$350,000 Type C: \$440,000
Total Cost for Buses (Without Incentives)	\$10.7 M
Total Cost for Buses (With Incentives)	\$9.3 M
Estimated Electric Vehicle Charger Installation Costs	
Charger Unit Costs:	60 kW dual port: \$40,000 120 kW dual port: \$80,000
Total Charger Costs (Without Incentives)	\$664,000
Total EVSE Infrastructure Cost (Without Incentives):	\$590,000
Total Utility Upgrade Costs (Without Incentives):	\$250,000
Total Installation Costs (Without Incentives): (Chargers, Utility Upgrade, Installation)	\$1.5 M
Total Installation Costs (With Incentives): (Chargers, Utility Upgrade, Installation)	\$226,600
Estimated Operational Costs	
Electricity Costs:	Energy rate: \$0.05 / kWh

	Demand: \$17.31 / kW
Maintenance Costs:	ESB: \$0.24 / mile Charger: \$1,000 / port
Software Costs:	\$1,000 / port

*Total costs summarized based on current market price and do not reflect depreciation or escalation assumptions shown in TCO Appendix

Environmental Impact

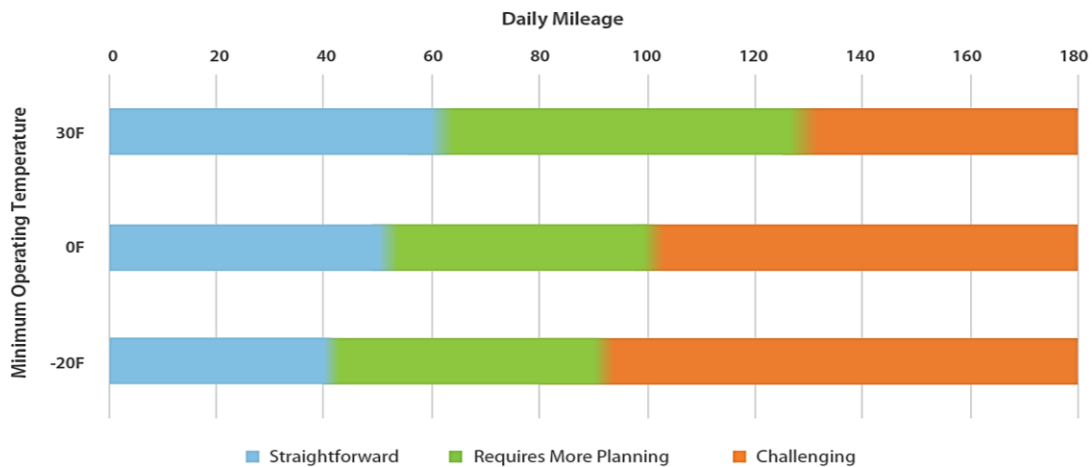
Graph 1: Projected Annual Greenhouse Gas Emissions of Fleet



2.2 Phasing Overview

To comply with New York State’s 2035 electrification mandates, Skaneateles CSD must transition all 24 school buses to electric. The initial phases are recommended to serve as pilot programs, focusing on electrifying shorter, less demanding routes. This approach allows for the establishment of new driver habits and operational procedures, providing a foundation for the broader transition.

Graph 2: Electric School Bus Suitability in 2024¹



¹ <https://afdc.energy.gov/guides/electric-school-bus>

Given the size of the fleet and that many of Skaneateles CSD’s routes are classified as complex or requiring additional planning, the implementation strategy has been divided into four distinct phases. This phased approach ensures a systematic and manageable transition, allowing the district to address specific challenges incrementally while optimizing operational efficiency and technology improvements occur.

Table 4: Conceptual Phased Implementation Plan

Phase	Year(s)	Buses Electrified	New Utility Service	Cumulative Max Power Demand*	Electric Fleet Capital Expenditure**	Electric Fleet Operational Expenditure
Phase 1	2027	4	+ 360 kW	35 kW	\$1.1 M	~\$24,500 / yr
Phase 2	2029	6	No new service	135 kW	\$1.9 M	~79,000 / yr
Phase 3	2032	8	+ 540 kW	185 kW	\$3.5 M	~\$142,000 / yr
Phase 4	2034	6	No new service	360 kW	\$3.1 M	~\$209,000 / yr

* With charging management and not including spare chargers

**Includes available funding

3. Route Analysis

The route assessment was conducted to evaluate the current fleet operations and their compatibility with battery electric vehicle (BEV) alternatives. The findings from this analysis will inform critical decisions, including the number and type of electric vehicle chargers needed and the development of a phased implementation plan for fleet electrification.

3.1 Route Analysis Inputs

To ensure the simulation reflects real-world conditions, the route analysis incorporates a range of inputs and assumptions. The details of these inputs, which are critical to the accuracy and relevance of the study, are outlined below.

Route Data:

Route data for the school year was provided for 14 of the fleet’s 24 buses. The remaining 10 buses are currently used as spares. It is understood that routes change from year to year, so this analysis also includes generalized data that can be used for future and extracurricular trip planning. On average, Skaneateles CSD’s Type A buses have comparable routes to the Type C vehicles, with a 47 mile per day average (Standard Deviation (SD): 29) compared to a 47 mile per day average (SD: 12), respectively.

Table 5: Skaneateles CSD Route Data

Bus Number	Bus Type	AM			PM		
		Miles	Depart Time	Return Time	Miles	Depart Time	Return Time
140	A						
157	Van	75.7	6:30:00 AM	9:30:00 AM	63.3	1:30 PM	3:40 PM
166	Van	17.6	9:05:00 AM	9:52:00 AM	17.6	1:42 PM	2:30 PM
167	C	67.3	7:25:00 AM	3:01:00 PM			
168	C						
169	C	56.7	6:15:00 AM	9:10:00 AM			
170	C						
171	C						
172	C	37.9	6:30:00 AM	8:10:00 AM	37.7	1:30 PM	3:15 PM
173	C	65.9	6:20:00 AM	9:06:00 AM	70.9	1:47 PM	4:40 PM
174	C						
175	C						
176	C						
177	C	44	6:30:00 AM	9:10:00 AM	43.2	2:05 PM	4:45 PM
178	C	63.8	8:30:00 AM	3:21:00 PM			
179	C	42.3	6:30:00 AM	9:17:00 AM	43.6	2:00 PM	4:40 PM
180	C						
181	C						
182	C	37.2	6:50:00 AM	9:06:00 AM	29.3	2:10 PM	4:30 PM
183	C	24	7:55:00 AM	9:10:00 AM	26.2	2:10 PM	3:15 PM
184	C	46.3	6:15:00 AM	9:05:00 AM	43.9	2:00 PM	4:31 PM
185	C	48.7	6:30:00 AM	9:05:00 AM	43.5	2:00 PM	4:30 PM
186	C						
187	C	52.4	7:05:00 AM	11:05:00 AM	28.5	2:06 PM	4:15 PM

Electric School Bus Make and Model:

Currently, Skaneateles CSD uses Blue Bird buses for their Type A and Type C buses and Chevrolet/Dodge for their passenger vans. Informed by the current fleet makeup and average route lengths, the first bus models that were chosen for the bus route simulation were the Blue Bird Micro Bird G5 for Type A buses, Blue Bird Vision for Type C buses, and Ford E-Transit for vans. The secondary models chosen for the route simulation include the BYD Achiever for Type A buses, the BYD Creator for Type C buses, and Mercedes E-Sprinter for vans. After conducting outreach and market scans, these 6 vehicle types had comparable specifications to the current buses and best fit the demands of the routes. All vehicle inputs are detailed below.

Table 6: ESB Model Inputs

	Type A		Type C		Vans	
Bus Model	Blue Bird Micro Bird G5	BYD Achiever	Blue Bird Vision Electric	BYD Creator	Ford E-Transit	Mercedes E-Sprinter
Battery Size:	175 kWh	156 kWh	196 kWh	288 kWh	89 kWh	113 kWh
Useable Battery:	89%	89%	89%	89%	89%	89 %
Operating Efficiency:	0.88 kWh/mile	1.49 kWh / mile	1.31 kWh / mile	1.65 kW / mile	0.56 kWh / mile	0.41 kWh / mile
Nameplate Range:	200 miles	105 miles	150 miles	175 miles	159 miles	273 miles
Vehicle Curb Weight:	14,500 lbs.	21,500 lbs.	33,000 lbs.	35,000 lbs.	6,000 lbs.	9,370 lbs.

*Assumed

Appendix 1-6 contains the bus specifications for the bus models chosen.

Temperature:

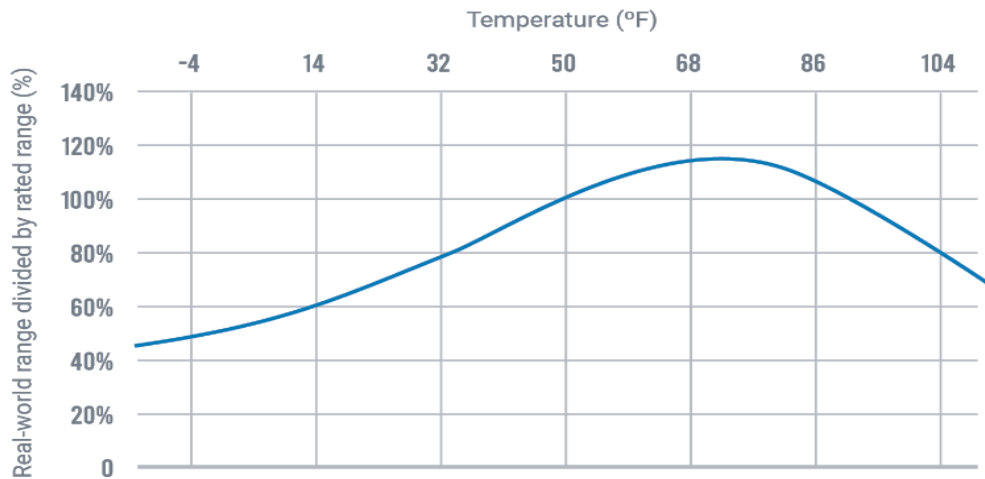
Historical temperature data was gathered from the National Oceanic and Atmospheric Administration (NOAA). The average high and average low temperatures for Skaneateles, NY were compiled and can be found in **Table 7** below.

Table 7: Average Temperatures in Skaneateles, NY (Source: NOAA)

Month	Average High (°F)	Average Low (°F)
January	31°	16°
February	34°	17°
March	43°	24°
April	56°	35°
May	77°	46°
June	79°	55°
July	81°	61°
August	79°	59°
September	72°	52°
October	60°	42°
November	48°	32°
December	37°	23°

Lithium-Ion batteries are less efficient in colder weather, therefore the routes simulated in this report use the lowest temperature conditions. This worst case-scenario was modeled to ensure that the routes can be completed by an ESB in the most demanding conditions presented. As seen in **Graph 3**, the range of an ESB reduces significantly in temperatures below freezing. This reduced range is attributed to less efficient battery function in colder weather as well as higher demand for HVAC.² The route analysis outlined in this study uses an assumed maximum range reduction of 30%.

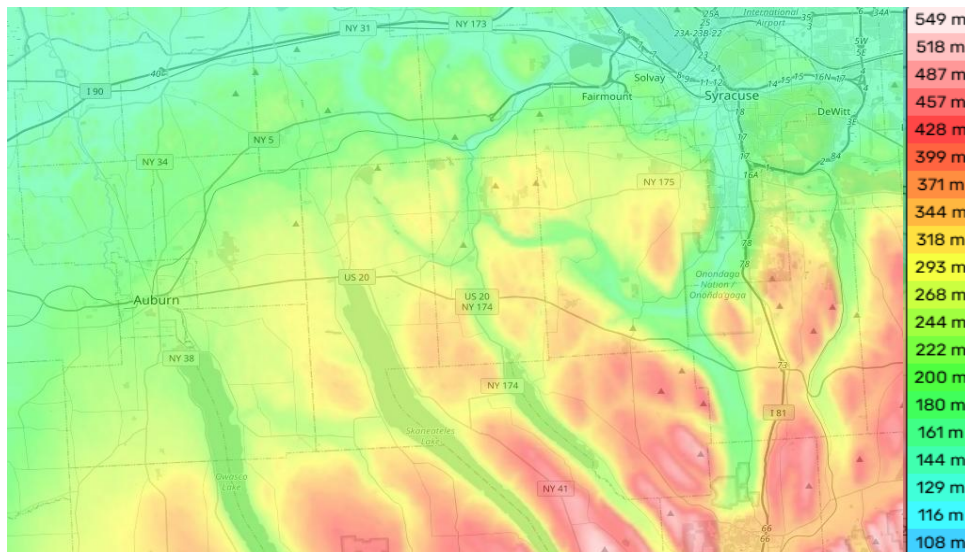
Graph 3: Temperature vs EV Battery Range²



Route Terrain:

Using an online topography database³ and turn-by-turn route data, the expected elevation changes along the fleet’s routes was determined. **Figure 1** shows the topographical map of the Skaneateles CSD area exported from the database and **Figure 2** shows the mapped turn-by-turn routes for the 14 active buses.

Figure 1: Topographical Map of Skaneateles CSD Area



² Geotab. *To what degree does temperature impact EV range?* <https://www.geotab.com/blog/ev-range/>

³ Topographic-map.com. <https://en-us.topographic-map.com/map-74mq6/Lake-Mohegan/?center=41.28503%2C-73.92906&zoom=12>

Figure 2: Turn-By-Turn Route Maps



Skaneateles Bus 166



Skaneateles Bus 183



Skaneateles Bus 172



Skaneateles Bus 157



Skaneateles Bus 173



Skaneateles Bus 185



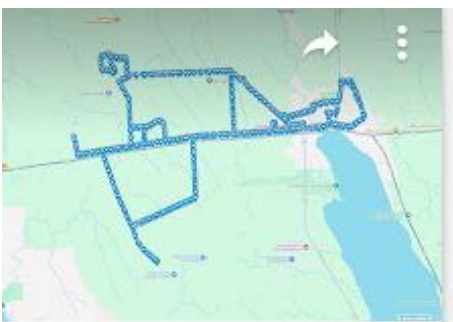
Skaneateles Bus 182



Skaneateles Bus 187



Skaneateles Bus 179



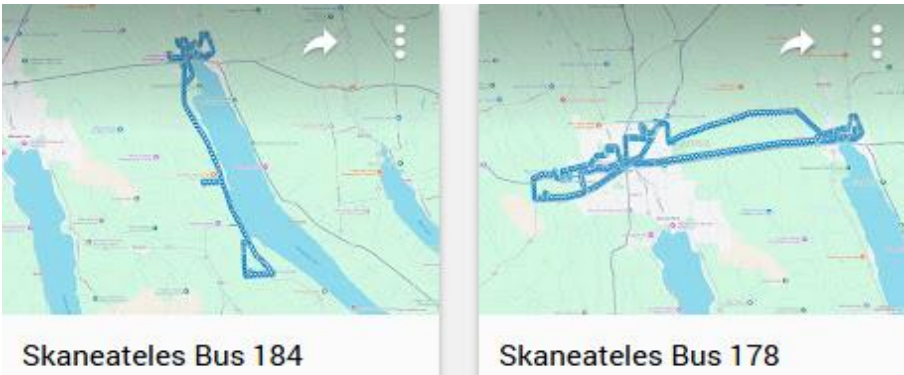
Skaneateles bus 177



Skaneateles Bus 169



Skaneateles Bus 167



Since Skaneateles CSD is between a mountainous region and a flat region, the topographical inputs used in the route simulation varied greatly for each route. These inputs are described below:

1. Average uphill road angle of 2°
2. Percentage through unlevel areas:
 - a) 80% of each route is through level areas (baseline efficiency), 20% of each route is through unlevel areas (10% uphill, 10% downhill)
 - Bus # 166, 167, 172, 177, 178, 179, 182, 183, 187
 - b) 60% of each route is through level areas (baseline efficiency), 40% of each route is through unlevel areas (20% uphill, 20% downhill)
 - Bus # 157
 - c) 30% of each route is through level areas (baseline efficiency), 70% of each route is through unlevel areas (35% uphill, 35% downhill)
 - Bus # 169, 184, 185
 - d) 10% of each route is through level areas (baseline efficiency), 90% of each route is through unlevel areas (45% uphill, 45% downhill)
 - Bus # 173
3. 30% recapture of kinetic energy during regenerative braking downhill

To calculate additional power required for uphill drives, the following calculation and inputs were used:

$$E_{vertical} = m \times g \times h$$

E_{vertical}: power required to move the BEV up an incline

m: mass of vehicle & ancillary loads

g: gravitational acceleration (9.81 m/s²)

h: height of the incline

3.2 Route Analysis Results

Summary

By integrating electric vehicle model specifications, route data, weather conditions, and topography inputs, the usable range and battery efficiency were calculated for operation in adverse weather and hilly terrain. These calculations formed

the basis for the route analysis results, offering insights into the performance and feasibility of BEVs under challenging conditions, as seen in **Table 8**.

Table 8: Summary of Route Analysis Inputs

	Type A		Type C		Vans	
	Blue Bird Micro Bird G5	BYD Achiever	Blue Bird Vision Electric	BYD Creator	Ford E-Transit	e-Sprinter
Useable Range						
Nameplate Capacity (kWh)	175.00	156.00	196.00	288.80	89.00	81.00
Nameplate Range (miles)	200.00	105.00	150.00	175.00	159.00	150.00
Battery Efficiency (kWh/mile)	0.88	1.49	1.31	1.65	0.56	0.54
Usable Battery	89%	89%	89%	89%	89%	89%
Usable Capacity (kWh)	155.75	138.84	174.44	257.03	79.21	72.09
Usable Range (miles)	178	93.45	133.5	155.75	141.51	133.5
Useable Range in Cold Weather						
Efficiency Loss in Bad Weather	30%	30%	30%	30%	30%	30%
Efficiency in Bad Weather (kWh/mile)	1.25	2.12	1.87	2.36	0.80	0.77
Usable Range in Bad Weather (miles)	124.60	65.42	93.45	109.03	99.06	93.45
Useable Range in Hilly Areas & Cold Weather						
Additional energy going uphill (kWh/mile)	1.01	1.49	2.29	2.43	0.42	0.65
Regenerative Braking efficiency	30%	30%	30%	30%	30%	30%
Recouped energy going downhill (kWh/mile)	(0.30)	(0.45)	(0.69)	(0.73)	(0.12)	(0.20)
Efficiency in hilly areas (kWh/mile)	1.58	2.53	2.91	3.35	0.85	1.00
Eff. in hilly areas + bad weather (kWh/mile)	2.26	3.62	4.16	4.79	1.22	1.42
Range in Hilly Areas and Cold Weather (miles)	88.8	48.4	57.9	71.9	78.6	65.7

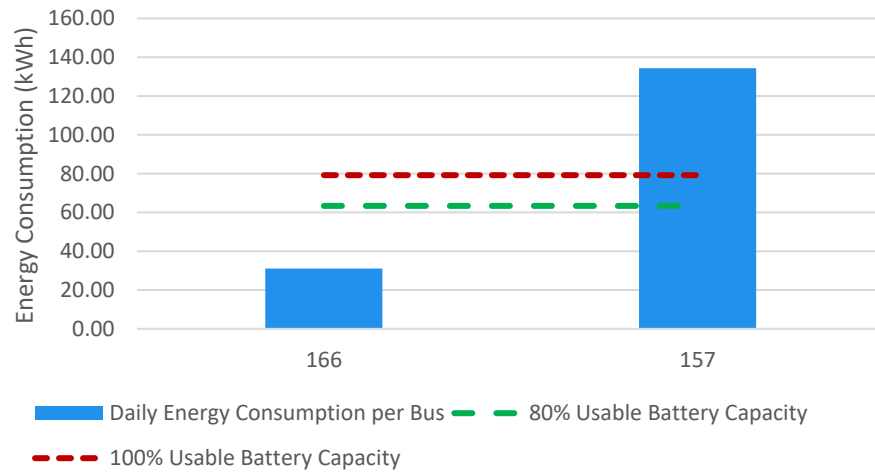
*Assumed

Results

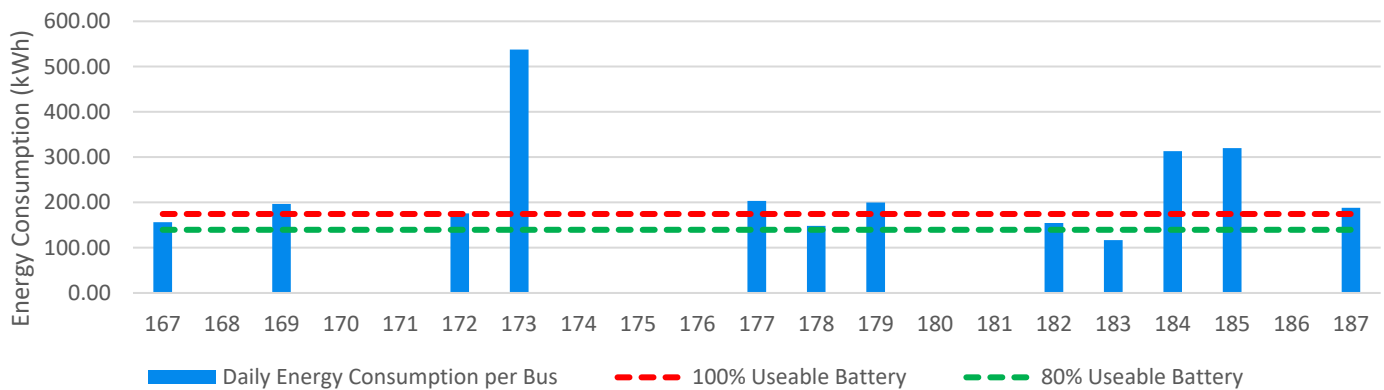
The results for the electric bus route analysis provide insights into the power consumption across different routes, highlighting the specific energy requirements for maintaining consistent service. By analyzing the factors described previously including route length, elevation changes, and cold weather conditions, this section offers a clear view of the power demands under worst-case operational conditions, helping to identify routes that may require additional charging infrastructure or adjustments to ensure sufficient range and battery longevity.

While the results presented below are for the Blue Bird Micro Bird, Blue Bird Vision Electric, and Ford E-Transit, the full results of the route analysis, detailing variations in power consumption during different weather conditions, can be found in **Appendix 7**. This should be referenced to understand the expected power demand of each route and how this may differ in various conditions.

Graph 4: Daily Energy Consumption – Vans



Graph 5: Daily Energy Consumption - Type C Buses



Graphs 4 and 5 illustrate the calculated daily power demand for the buses in cold weather and hilly conditions. Buses that fall under the green line, representing 80% of the usable battery, are predicted to meet their daily routes with over 20% SOC remaining without a midday charge. These buses are determined to be the most feasible for electrification and at least 1 should be electrified in the first phase of electrification.

Buses that fall in between the red line, representing 100% of usable battery, and the green 80% battery line are predicted to meet their daily routes without a midday charge, however, the SOC will fall under the 20% SOC threshold, so it is recommended to have a midday charge. These buses should also be prioritized in the electrification process, as they should only need a small midday charge to ensure their PM route is met. By utilizing charging management strategies, electricity costs can be minimized while ensuring the PM routes can be met with at least 20% of battery remaining. These strategies are detailed further within the Charging Strategy section.

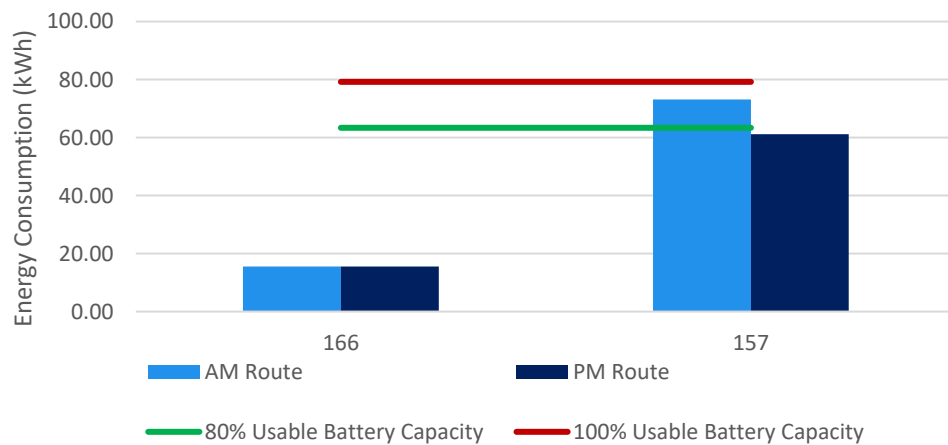
The buses that are above the red 100% battery line need a midday charge to meet their routes and are considered more complex, requiring more planning. While many only require a small amount of charging in the middle of the day, others

will require higher power chargers. The buses requiring higher power chargers should be included in the last phases of the transition, allowing more time for driver training and charging training as well as battery technology development. Furthermore, delaying the installation of higher power chargers needed for midday charges will minimize high capital and operating costs.

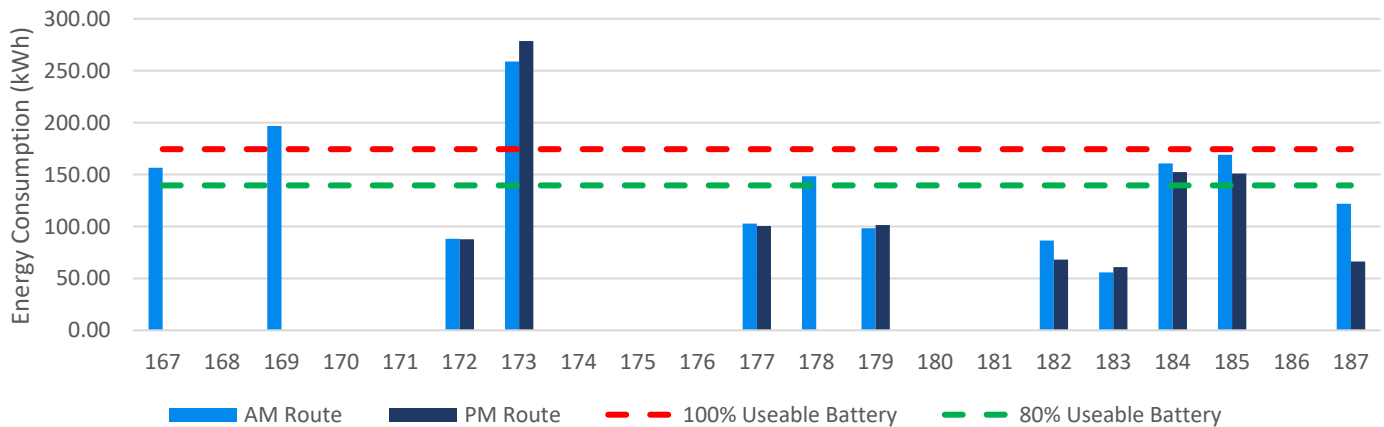
As seen in the graphs, 1 out of the 2 vans completes the daily route with 20% state of charge remaining (Bus # 166). Out of the 12 active Type C vehicles, only 1 (Bus # 183) is expected to meet its daily route without needing a midday charge during cold weather conditions. These 2 buses are the most feasible and should be prioritized for electrification.

Since a majority of the buses can't meet their daily routes without a midday charge, it is necessary to look into the morning and afternoon power demands separately for each bus to ensure that the buses are feasible for electrification. The graphs below show the power demands of each route. As stated previously, the full route analysis results for both models can be found in the Appendix.

Graph 6: AM & PM Energy Consumption - Vans



Graph 7: AM & PM Energy Consumption - Type C Buses



Graph 6 shows that the other van (Bus # 157) is expected to meet its afternoon route, but on cold days the morning route will exceed the usable battery of the bus. While still feasible, this bus is considered challenging and should be phased in during the later years of electrification. According to **Graph 7**, 5 additional Type C buses (bus # 172, 177, 179, 182, 187) are feasible for electrification but will require a midday charge to complete their routes. Furthermore, 4 Type C buses (bus # 167, 178, 184, 185) have routes that are expected to be completed with 0-20% state of charge remaining. While feasible,

it is not recommended to end a route in under 20% state of charge so these buses should be electrified in later years. The remaining 2 active Type C buses (bus # 169, 173) have routes that exceed the usable battery capacity of the bus and are considered infeasible using the current Blue Bird Vision model. These buses are categorized as challenging and should be the last buses electrified within the phased plan.

Challenging Routes

The 7 challenging buses (Bus # 157, 167, 169, 173, 178, 184, 185) each have a route that can't be met with 20% SOC remaining using these bus models and are, therefore, categorized as challenging and are not recommended for immediate electrification. Fortunately, there are multiple other models which can make all of the buses except bus # 173 feasible.

Table 9: Battery Requirements for Challenging Routes

Bus	Battery Size Needed to be Feasible*	Bus Technology Meeting Requirements
157 (Van)	105 kWh	Mercedes Benz e-Sprinter
167 (Type C)	220 kWh	BYD Creator, International CE Series, Thomas C2 Jouley
169 (Type C)	280 kWh	International CE Series
173 (Type C)	390 kWh	N/A
178 (Type C)	205 kWh	BYD Creator, International CE Series, Thomas C2 Jouley
184 (Type C)	225 kWh	BYD Creator, International CE Series, Thomas C2 Jouley
185 (Type C)	235 kWh	BYD Creator, International CE Series

*Using same inputs as described in **Table 8**

As battery technology improves and driver best practices are implemented, these more challenging routes will become more feasible to electrify. Studies conducted by Bloomberg suggest that, with a conservative assumption on technology development, electric school bus ranges will increase by 5% annually.⁴ Additionally, the efficiency in colder weather and hilly areas is expected to be a main focus of improvement within the EV industry. With these assumptions, the New York State Energy Research and Development Authority (NYSERDA) expects that technological advancements will lead to 400 kWh batteries for Type A vehicles and 600 kWh batteries for Type C vehicles becoming available by 2035. With this assumption in mind, Blue Bird buses are still recommended for Skaneateles since they are the preferred bus model.

In the meantime, Skaneateles CSD can consider pairing longer AM routes with shorter PM routes, using spare buses to split up longer routes, or switching buses in between AM and PM routes. Out of the 7 challenging buses, 3 have AM and/or PM routes that are infeasible. To reduce charging size and overall wear and tear of the vehicle, daily routes should be minimized as much as possible.

Future Route Planning

Given that many bus routes are dynamic and change year-to-year, the summary tables below will assist in electrification efforts for future route planning. Using the same inputs and assumptions described previously, the following data was

⁴<https://www.bloomberg.com/news/newsletters/2023-08-01/battery-bloat-could-backfire-on-electric-vehicle-manufacturers>

compiled for both average and cold temperatures. The model inputs were calculated for the Ford e-transit van, Micro Bird G5 Type A bus, and the Blue Bird Vision Type C bus (**Table 8**), using a 60 kW dual port charger and a 50% flat assumption.

The numbers in red indicate that the expected power demand is higher than the usable battery of the bus. This table clarifies the estimated power demand for unreported or changing routes and how it differs based on distance. Furthermore, this also gives insight into the required time to charge based on your route in both average and cold weather. These charging calculations are further explained in Section 4.

Table 10: Route Analysis for Range of Distances

Distance (mi)	Power Consumption Average Weather			Power Consumption Cold Weather			Time to Charge to Full in Bad Weather (30 kW Port) *		
	Van	Type A	Type C	Van	Type A	Type C	Van	Type A	Type C
10	7.06	12.27	21.09	10.08	17.53	30.12	0.7	1.2	2.0
20	14.11	24.55	42.17	20.16	35.07	60.25	1.3	2.3	4.0
30	21.17	36.82	63.26	30.24	52.60	90.37	2.0	3.5	5.9
40	28.22	49.10	84.35	40.32	70.14	120.50	2.7	4.6	7.9
50	35.28	61.37	105.43	50.40	87.67	150.62	3.3	5.8	9.9
60	42.33	73.64	126.52	60.48	105.21	180.74	4.0	6.9	-
70	49.39	85.92	147.61	70.56	122.74	210.87	4.6	8.1	-
80	56.45	98.19	168.69	80.64	140.27	240.99	-	9.2	-
90	63.50	110.47	189.78	90.72	157.81	271.12	-	-	-
100	70.56	122.74	210.87	100.80	175.34	301.24	-	-	-
110	77.61	135.01	231.95	110.88	192.88	331.36	-	-	-
120	84.67	147.29	253.04	120.95	210.41	361.49	-	-	-
130	91.72	159.56	274.13	131.03	227.95	391.61	-	-	-
140	98.78	171.84	295.21	141.11	245.48	421.74	-	-	-

*Time to charge not calculated for route demands that exceed usable battery

4. Charging Strategy

A comprehensive charging strategy is pivotal to fleet electrification success. This section outlines the charging stations required and the subsequent infrastructure plan developed from our route analysis, which assessed daily energy needs, vehicle dwell times, and optimal charging locations. Various chargers were evaluated to align with operational needs, focusing on charging speed, load management, cost-effectiveness, and scalability. The full results of the charging analysis can be found in **Appendix 8**.

Additionally, the infrastructure layout designed to support the chosen chargers is detailed, including electrical capacity, site readiness, and necessary upgrades. This integrated plan ensures immediate operational demands are met while accommodating future growth for a seamless transition to electrified operations.

4.1 Existing Conditions Assessment

Parking Area & Facility Assessment

Skaneateles CSD currently houses their transportation department and buses within the parking lots at 819 W Genesee Street Rd, Skaneateles, NY 13152. The electrical infrastructure and spatial arrangement of this parking area was assessed with the intention of installing electric vehicle chargers.

At the time of the site visit, Skaneateles was completing a generator installation that was not yet connected to the utility. Additionally, it was noted that every other parking row has a block heater between the parking spots. This will require careful planning of the charger installations and trenching routes to the chargers. The layout of the facility is detailed within **Figure 3** below.

Figure 3: Existing Conditions at 819 W Genesee Street Rd



Based on the layout, dual port chargers are recommended. Since the engine block heaters are between the buses, the chargers will have to be placed in the center of the parking spots and serve pairs of buses that are parked across from one another. Depending on the bus model chosen and location of the charging port, bus parking arrangements may have to be adjusted, and one bus may have to pull in headfirst while the other backs in. Dual port chargers with long charging cables and charging cable management systems are recommended as well.

Electrical Capacity Assessment

Skaneateles CSD provided electrical diagrams for the transportation building as well as access to the electrical room during a site walk. The engineering assessment of the facility and diagrams shows an 800A 208V service feeding the facility. This 800A service feeds various panels around the facility and is planned to be connected to a 125 kW generator. The Main Distribution Board (MDB) is feeding multiple sub-panels, including LP-1D (225A 208V), PP-1D (225A 208V), PP-2D (100A 208V), and PP-4D (100A 208V), a 225A step-up transformer, and a 100A town office panel. Overall, there are switches totaling over 800A on the 800A MDB. While not all the sub-panels are full and there may be some spare power, it is likely not enough to feed more than 1 dual port DC fast charger. The spare power can only be confirmed when an official load request is submitted to the utility.

It is recommended that a new, separate service is requested for the EV chargers and placed near the new generator electrical equipment. This is recommended due to the constraints on existing building capacity, location of the electrical room versus utility equipment, and to allow monitoring of the electrical ‘fuel’ costs of the electric fleet. Early engagement with the utility is essential when installing EV chargers for your electric fleet.

4.2 Charger Selection

Charge Analysis Inputs

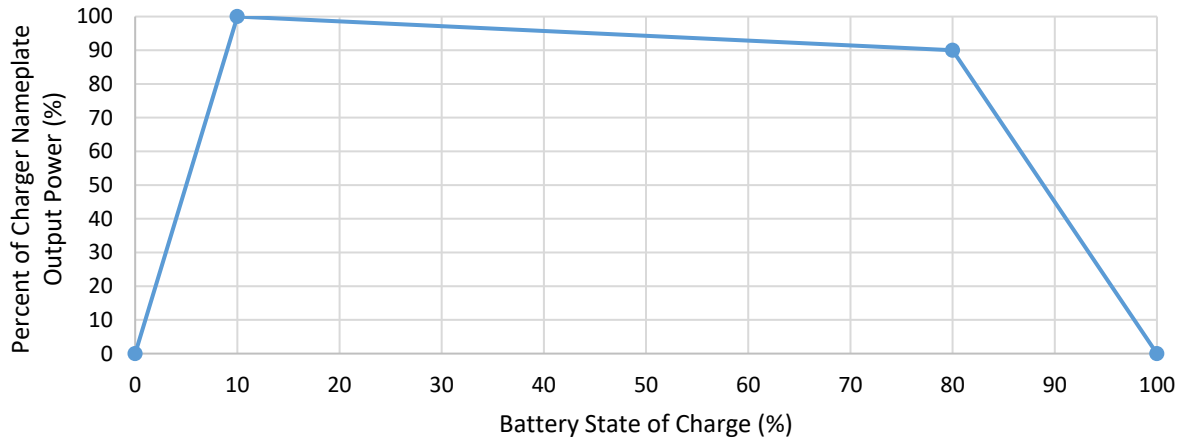
Using the results of the route analysis, the charge power needed for the AM and PM routes were determined. To calculate the resulting charger size required for each bus, various real-world inputs were considered. The inputs considered are listed below.

- 1. Efficiency loss due to weather conditions:** Cold weather conditions impact the flow of electrons, making chargers less efficient in colder weather, similar to EV batteries. Studies show that EV batteries take in less energy in cold weather⁵, which was applied to the charging analysis.
- 2. Charging curves:** EV charging curves generally consist of three phases: ramp-up, peak, and ramp-down. During the ramp-up phase, charging power gradually increases as the vehicle's battery management system assesses the battery's condition and thermal state. Once optimal conditions are met, the charger delivers maximum power during the peak phase, often reaching the advertised charging rate of the vehicle and station. As the battery approaches a higher SOC—typically 80%—the ramp-down phase begins, during which charging power tapers off significantly to prevent overheating and reduce stress on the battery. This tapering effect, critical for long-term battery health, can considerably extend the time needed to fully charge.

A typical charging curve is provided below which models the various charging speeds the ESB battery will accept, dependent on the battery's SOC. Using this typical charging curve, a 27.6% reduction in charging speed is calculated. This was accounted for when determining the required output power of charging stations for the ESB fleet.

⁵ <https://media.electrifyamerica.com/fivetips-charging-electric-vehicles-cold-weather>

Graph 8: Typical Charging Curve



- 3. Minimization of infrastructure requirements:** The model was created with the intention of minimizing infrastructure and power demand while still ensuring the fleet vehicles will meet their routes. The following assumptions were made within the charging analysis to minimize the power demand during peak hours and charger size required:
- a. Midday charge:** Since the dwell time for the fleet is much shorter than overnight charging, midday charges were limited to charge the ESBs only to the amount of power they need to end the PM route with 20% SOC. This reduces the max demand for midday charging as well as the size of charger required.
 - b. Overnight charge:** The overnight charge was modelled to charge the ESB battery to full for the start of the next day. With dwell times ranging from 12-16 hours, the ESB has more time to charge up to 100% at a lower output (with charging management systems). Charging to full overnight reduces the amount needed during the midday charge the next day, therefore reducing demand charges, size of charger required, and demand on the grid.

Results

Using these inputs, the charging load needed to meet each route was calculated. The results for the buses with route data are summarized in **Table 11** along with the subsequent recommended charger sizes. Charging for the buses whose routes exceed usable battery capacity was calculated as charging from empty to full using the assumption that there will be sufficient battery technology at the time of electrification.

It is important to note that Skaneateles CSD currently has a large number of spare vehicles. These buses are assumed to remain spare but should be in future route planning, so each one has been paired with a charger to support future operations.

Table 11: Charging Analysis Results & Recommended Charger Sizes

Bus #	ESB Type	Midday Charge Needed (kW)	Overnight Charge Needed (kW)	Recommended Charger Port Size (kW)
140 [SPARE]	A	0.00	0.00	60
157	A	35.00	8.43	30
166	A	0.00	3.30	30
167	C	0.00	16.79	30
168 [SPARE]	C	0.00	0.00	30
169	C	0.00	13.06	30

170 [SPARE]	C	0.00	0.00	60
171 [SPARE]	C	0.00	0.00	30
172	C	13.40	18.06	30
173	C	73.49	25.19	60
174 [SPARE]	C	0.00	0.00	30
175 [SPARE]	C	0.00	0.00	30
176 [SPARE]	C	0.00	0.00	60
177	C	25.54	20.03	30
178	C	0.00	16.06	30
179	C	25.17	19.91	30
180 [SPARE]	C	0.00	0.00	30
181 [SPARE]	C	0.00	0.00	30
182	C	5.86	19.21	30
183	C	0.00	13.82	30
184	C	64.49	21.89	60
185	C	67.83	21.28	60
186 [SPARE]	C	0.00	0.00	30
187	C	31.75	18.56	30

In summary, the total amount of chargers needed includes 9 dual port 60 kW DC fast chargers (30 kW per port) and 3 dual port 120 kW DC fast chargers (60 kW per port). When choosing a charger, be sure to engage with your contractor and bus provider to ensure the chargers and software are compatible with the bus models purchased.

It should be noted that a few of the buses that are paired with 60 kW ports have midday charge amounts that are higher than 60 kW. For these buses (bus # 173, 184, 185), it is suggested that they are not only phased in last to leave time for technological improvements, but also to switch buses to a spare bus for the afternoon route to minimize the midday charge demand. Furthermore, the BOCES buses (bus # 167, 178) do not have midday charge amounts listed because they do not charge at Skaneateles CSD’s transportation garage lot during the middle of the day. However, their round-trip routes are expected to end in under 20% SOC on cold days, so charging at the BOCES facility is recommended, if available.

In addition to installing chargers that meet the minimum requirements, it is recommended to include backup high-power chargers at the parking facilities. Backup fast chargers provide redundancy, ensuring continued charging availability if one or more chargers are out of service or if there is an unexpected need to charge buses assigned to lower-power chargers. Assuming the spare buses will remain idle in the future, their designated chargers can serve as backups, reducing or eliminating the need for additional chargers.

The site at 819 West Genesee St, in cold weather conditions and no charge management, anticipates a maximum demand of about 900 kW, driven by the charger sizes previously noted in **Table 11**. However, with charge management in place, the maximum demand can be reduced to about 350 kW. The full charging analysis found in **Appendix 8** provides further specifications on the levels of charge needed for midday and overnight charging.

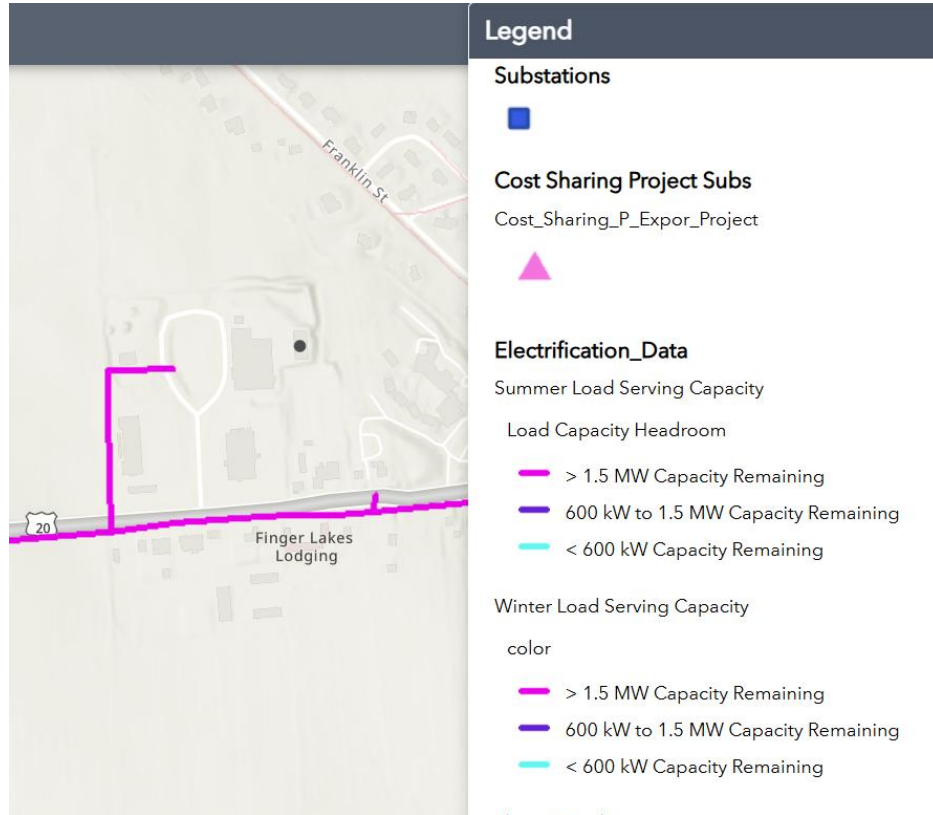
4.3 Electric Utility Analysis

In coordination with National Grid, the feasibility of delivering power to Skaneateles CSD’s school bus garage was evaluated. National Grid provided a utility assessment based on the charging requirements determined from the route and charging analysis. National Grid’s full evaluation can be found in **Appendix 9**, with key details highlighted hereafter.

The utility assessment for Skaneateles CSD’s fleet electrification project confirms that Skaneateles CSD currently has a 150 kVA pole-mounted transformer with around 75 kW of available capacity. While the available capacity in the existing padmount transformer can feed 1 dual port 60kW charger, a new or upgraded service will need to be installed for the remaining chargers. Rather than have 1 charger fed separately from the rest, a new EV-dedicated service is recommended.

In addition to the existing capacity, National Grid assessed the utility-side capacity. Their analysis determined that both the feeders and substation have sufficient capacity for the 900 kW load required for fleet electrification. This is supported in **Figure 4** below, which shows the substation has at least 1.5 MW remaining. Utility upgrades of this size typically take 12-18 months to compete, so early engagement with the utility is crucial.

Figure 4: National Grid Electrification Capacity Map at 819 W Genesee St

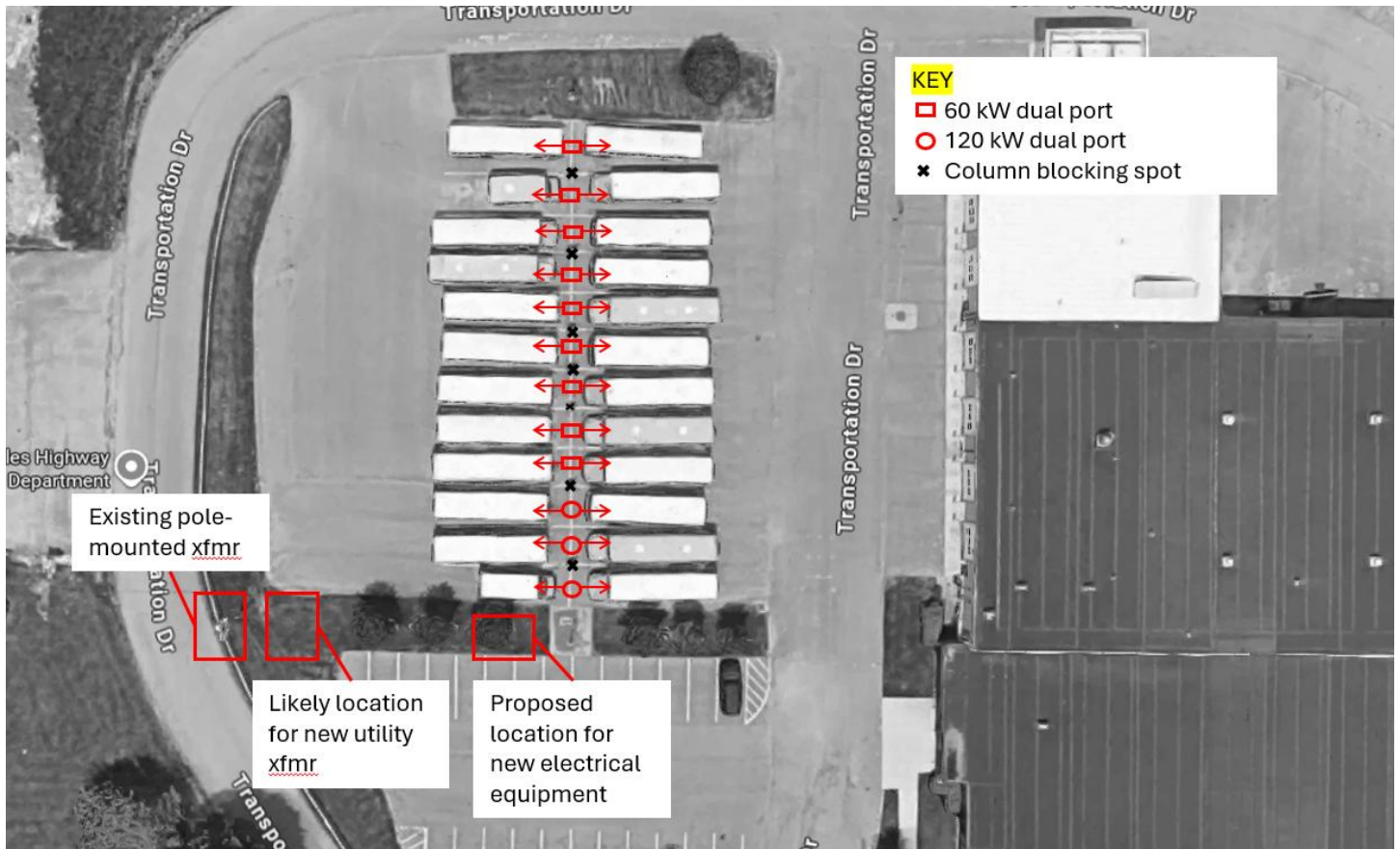


Finally, National Grid provided the expected utility rates during each phase of electrification. Using the managed charging scenario, Skaneateles CSD is expected to have an electric service rate of \$0.05 / kWh and a demand cost of roughly \$17.31 / kW. These rates are used within the total cost of ownership assessment and are only based on current available utility rates.

4.4 Proposed Charging Solution

Using the findings from the existing conditions assessment, charging analysis, and utility assessment, a preliminary charging design was developed for Skaneateles CSD’s parking lot. The proposed layout for all electrical equipment is illustrated in the site map below, with equipment placement optimized for spatial efficiency and minimized conduit and wire lengths to reduce overall costs. This site map and supporting single line diagrams can also be found in **Appendix 10**.

Figure 5: Proposed Charging Solution for Skaneateles CSD



As noted previously, a new service request is suggested for this fleet. The proposed location of the utility transformer and new electrical equipment are shown in **Figure 5** above. These areas were chosen to both minimize the cost of utility installation, and to centrally feed the EV chargers. Similarly, the higher power chargers are placed closer to the new service and distribution equipment because those chargers have the highest installation costs. Placing them closer to the distribution panel will minimize wire and conduit costs. More installation details, including when each charger should be installed and how future proofing measures are incorporated, are included in the Phased Implementation plan section.

5. Phased Implementation Plan

The phased implementation of Skaneateles CSD fleet electrification plan ensures a smooth transition, balancing operational reliability with long-term sustainability. Each phase builds upon the previous, incorporating vehicle replacement plans, electrical infrastructure upgrades, and future proofing plans to prepare the district for comprehensive electrification. In the first few years, training is key to the success of your fleet. It is important that operational personnel are trained on proper driving techniques, charge management strategies, and handling of EV chargers to ensure you are maximizing the benefit of EV technologies and optimizing operations.

To maintain adaptability, the following proactive measures should be integrated:

- **Energy Management Systems:** Advanced software will optimize charging schedules and minimize energy costs as the fleet grows.
- **Emerging Technology Integration:** Continuous alignment with advancements in battery and charging technology will ensure infrastructure remains cutting-edge.
- **Resilience Planning:** Backup power solutions and high-power chargers will enhance system reliability during unforeseen disruptions.

This phased strategy, underpinned by future-proofing and systematic infrastructure upgrades, ensures the district's successful transition to a sustainable and efficient electric fleet.

5.1 Phasing Plan Summary

Table 12 below gives an overview of the number of buses electrified each year along with the number of charging ports installed. This phasing plan was made using the results of the route and charging analysis and was based on the spatial arrangements of the parking lots.

Table 12: Phasing Overview

Phase	Year	Type A/Van Electrified	Type C Electrified	30kW Ports Installed	60 kW Ports Installed	Total kW Installed	Cumulative kW Installed
1	2027	1	3	4	0	120	120
2	2029	1	5	4	2	240	360
3	2032	1	7	6	2	300	660
4	2034	0	6	4	2	240	900

More details about which buses are recommended for electrification each year and what charging port they will be paired with are included in **Table 13** below. The order of bus electrification was prioritized using the power demand and, therefore, feasibility of the route as the main factor. When transitioning to electric buses and scrapping old ICE vehicles, it's important to note that the vehicles were chosen based on the power demand of their routes, not their age. To maximize efficiency, it's recommended to scrap the oldest vehicles first. If a newer vehicle is selected for electrification, the ICE vehicle should be reassigned to an older vehicle's route to facilitate the retirement of the older vehicle. If Skaneateles CSD is going after the NYSBIP scrapping bonus, the retired vehicle must meet the usage and/or age requirements, see **Appendix 11**.

Table 13: Detailed Phased Implementation Plan

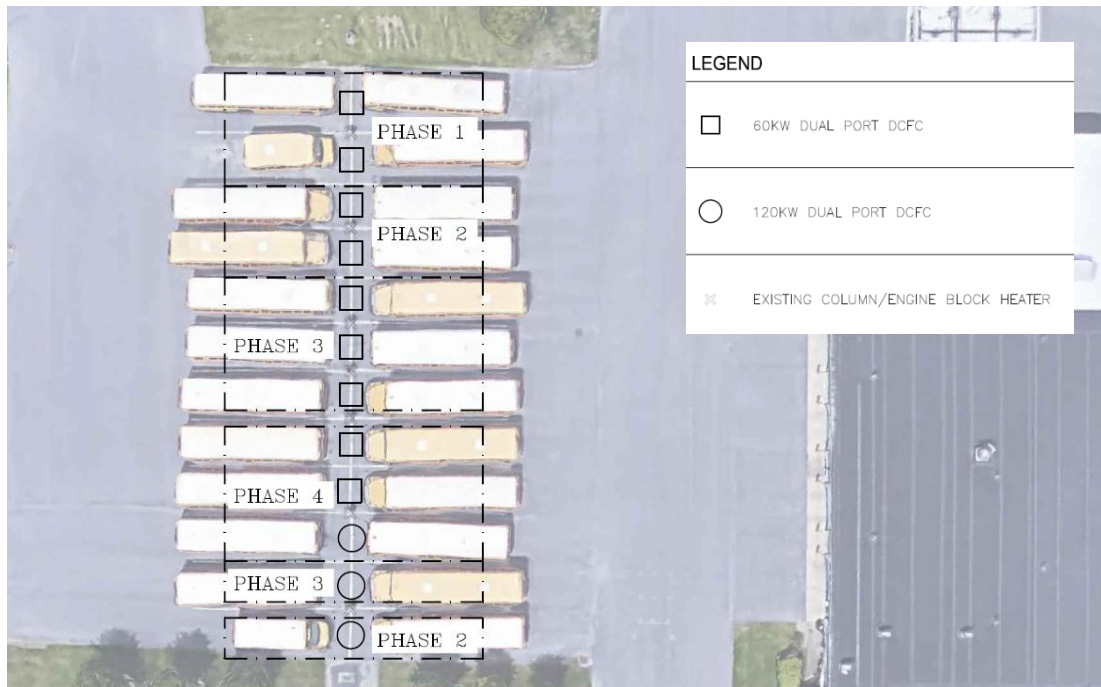
Bus Number	Type	Phase	Daily Mileage	Charging port	Notes / Recommendations
166	Van	1	35	30	
168	C	1	0	30	Spare
182	C	1	66	30	
183	C	1	50	30	
172	C	2	75	30	
177	C	2	87	30	
179	C	2	86	30	
187	C	2	81	30	
140	A	2	0	60	Spare
170	C	2	0	60	Spare
171	C	3	0	30	Spare
178	C	3	64	30	BOCES Route
184	C	3	90	60	Use spare bus to switch between routes
185	C	3	92	60	Use spare to switch between routes
157	Van	3	139	30	
167	C	3	67	30	BOCES Route
174	C	3	0	30	Spare
175	C	3	0	30	Spare
169	C	4	56	30	
173	C	4	137	60	Use spare bus to switch between routes
176	C	4	0	60	Spare
180	C	4	0	30	Spare
181	C	4	0	30	Spare
186	C	4	0	30	Spare

There are 3 buses that have a recommendation to use a spare bus to switch between routes. These buses have long morning and afternoon routes, so switching to a spare bus for the afternoon route can help minimize midday demand charge and overall wear and tear of the electric bus. However, by the time these buses are suggested for electrification, the Blue Bird bus technology may be improved enough to make both routes more feasible.

5.2 Phased Installation Details

The phased implementation plan recommended for Skaneateles CSD is described below, detailing when each vehicle and charger is suggested for replacement and installation. As stated previously, supporting phased diagrams and single line diagrams can be found in **Appendix 10**.

Figure 6: Phased Installation Site Plan



Phase 1 (2027)

The first phase focuses on deploying an initial set of ESBs to evaluate their performance and operational impacts. During this phase, 1 van and 3 Type C buses operating low-demand routes are suggested for replacement. These routes were selected due to their shorter distances, making them ideal for early implementation.

Training is a key component of this phase, with drivers and maintenance staff receiving comprehensive instruction on ESB operation, including regenerative braking and servicing. This initial phase is expected to gather baseline data on range, charging performance, and costs, while also building operational confidence in the district's transition to ESBs.

- **Buses Electrified:** 166, 168 (spare), 182, 183
- **Chargers installed:** 2 dual port 60kW DC fast chargers (including 1 spare port)
- **Utility upgrades:** New utility service required. Suggested to request service sufficient for phases 1 and 2 (360 kW), allowing time for technological advancements to inform service upgrade for phases 3 and 4. Utility will likely deliver a 500 kW padmount transformer, requiring 600A 480V new service and distribution equipment. Utility padmount and new service conduits should be future proofed for future upgrades, if applicable.
- **Infrastructure work:** In addition to the padmount and supporting equipment installation, a new 600A 480V panel should be installed to feed the chargers installed in phase 1 and 2. Trenching through grass from the utility equipment to the new service equipment and panel is required. From the panel, conduit and wire should be trenched through the first parking spot up along the east side of the engine block heaters to the 4 farthest charging spots where the 2 dual port chargers will be installed. Future proofed conduits should be installed within the trench for the 3 dual port chargers installed within Phase 2. Protective equipment also needs to be installed for the 2 dual port chargers, and for the future proofed equipment.

Figure 7: Phase 1 Installation Design



Phase 2 (2029)

The second phase expands the program by electrifying additional low-to-medium demand routes utilizing the existing power infrastructure. During this phase, 6 additional buses will transition to electric operation. These routes were selected based on route analysis, confirming sufficient charging downtime for midday charging.

This phase aims to expand the electric bus fleet while maintaining operational consistency across the district. Operational schedules should be optimized to align with charging times, ensuring efficiency and minimizing service disruptions.

- **Buses Electrified:** 172, 177, 179, 187, 140 (spare), 170 (spare)
- **Chargers installed:** 2 dual port 60kW DC fast chargers, 1 spare dual port 120 kW DC fast charger
- **Utility upgrades:** Utilize existing utility service installed within Phase 1. It is suggested that engagement with the utility for the second utility upgrade is started so that all work is completed by the start of Phase 3.
- **Infrastructure work:** Utilize future proofed conduit to run wire to the 3 dual port chargers installed within Phase 2.

Figure 8: Phase 2 Installation Design



Phase 3 (2032)

In Phase 3, medium demand routes and challenging routes will be electrified. Charge management systems should be optimized during this phase to minimize peak demand costs, and logistical challenges related to route demands should be closely monitored and addressed.

When planning Phase 3, the results of Phases 1 and 2 should be analyzed to inform infrastructure needs. Emerging battery technologies may reduce midday and overnight charging requirements, so work closely with contractors to ensure the infrastructure remains flexible and optimized for updated fleet demands. Utility planning should begin well in advance, as National Grid estimate 1+ year timelines for installing new transformers. Early engagement with utility providers is crucial to avoid delays in implementation.

- **Buses Electrified:** 171 (spare), 178, 184, 185, 157, 167, 174 (spare), 175 (spare)
 - **Note:** 2 spares suggested to be used for afternoon routes on cold days
- **Chargers installed:** 3 dual port 60 kW DC fast chargers (including 3 spare port), 1 dual port 120 kW DC fast charger
- **Utility upgrades:** Upgraded utility service required. Suggested to request service upgrade sufficient for phases 3 and 4 (+ 540 kW), bringing the total charging load to 900 kW. This scope of work assumes the utility will deliver a separate 750 kW padmount transformer, but they may opt to upgrade the existing transformer to a 1000 kW (1 MW) transformer. This can only be confirmed with a formal load request to the utility. For a new 750 kW transformer, 1000A 480V new service and distribution equipment is required.

- Infrastructure work:** In addition to the padmount and supporting equipment installation, a new 1000A 480V panel should be installed to feed the chargers installed in phase 3 and 4. Trenching through grass from the utility equipment to the new service equipment and panel is required. From the panel, conduit should be trenched up along the west side of the engine block heaters to the remaining parking spots. 4 dual port chargers should be installed within the spots specified in **Figure 9** below, while the remaining spots will be future proofed. Protective equipment also needs to be installed for the 2 dual port chargers, and for the future proofed equipment.

Figure 9: Phase 3 Installation Design

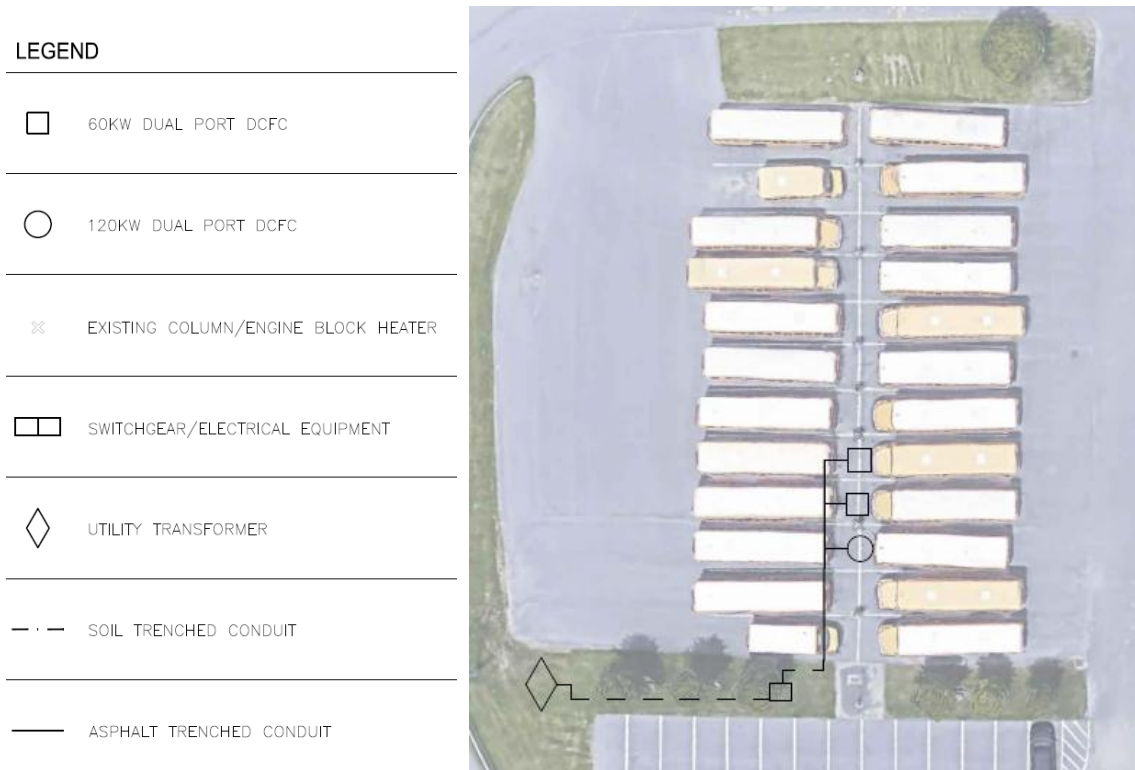


Phase 4 (2034)

The final phase of the plan completes the transition to an all-electric fleet. This phase includes replacing the remaining buses with the most challenging routes. Advanced fleet management tools should be enhanced to monitor performance, energy usage, and costs, ensuring the fleet operates efficiently and cost-effectively.

- Buses Electrified:** 169, 173, 176 (spare), 180 (spare), 181 (spare), 186 (spare)
- Chargers installed:** 2 dual port 60kW DC fast chargers (3 spare ports), 1 spare dual port 120 kW DC fast charger (1 spare port)
- Utility upgrades:** Utilize existing utility service installed within Phase 1. It is suggested that engagement with the utility for the second utility upgrade is started so that all work is completed by the start of Phase 3.
- Infrastructure work:** Utilize future proofed conduit to run wire to the 3 dual port chargers installed within Phase 4.

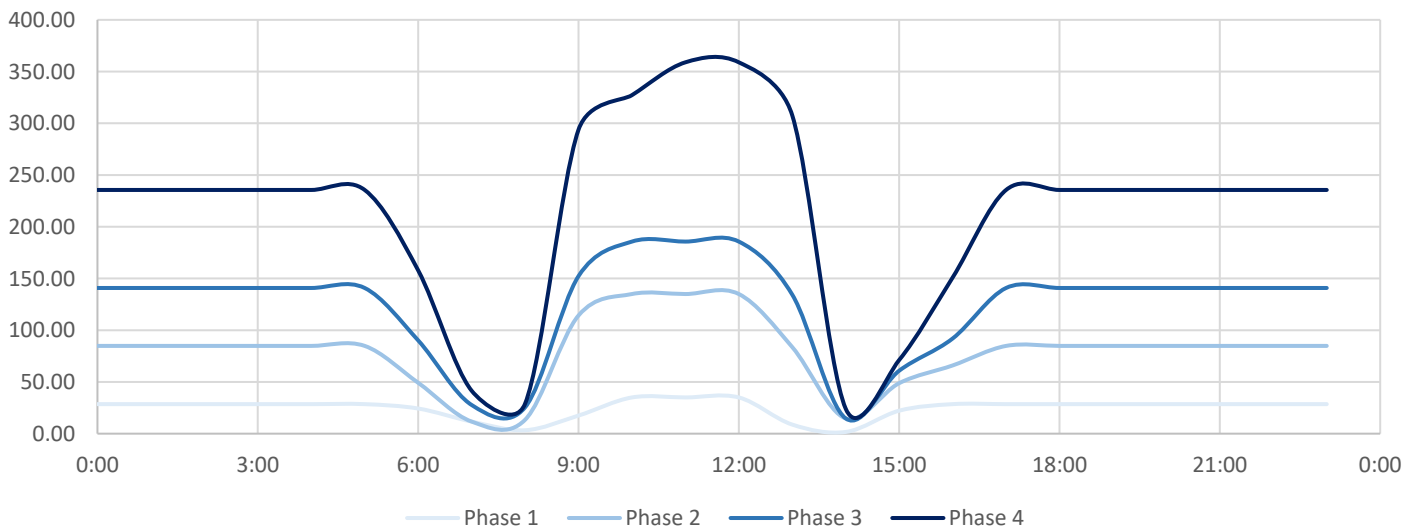
Figure 10: Phase 4 Installation Design



5.3 Charge Management & Load Prediction

Effective charge management is essential for ensuring the seamless operation of an electrified school bus fleet. Without proper planning, uncoordinated charging can lead to excessive energy costs, increased strain on depot infrastructure, and reduced fleet availability during critical operational periods. Charge management helps optimize energy usage, align charging schedules with bus availability, and prevent costly peak demand charges. The graph below shows the expected load profile of Skaneateles CSD’s EV fleet, assuming charge management is utilized to maintain minimum required charging output.

Graph 9: Predicted Load Profile for Skaneateles CSD



Key benefits of charge management are described further below.

1. **Operational Efficiency:** Charge management ensures buses are charged and ready for service when needed, minimizing delays and disruptions to routes.
2. **Cost Control:** By limiting charger output, staggering charging sessions, and therefore reducing peak demand, districts can decrease energy costs and avoid penalties from demand charges. **Table 14** below shows how charge management can be utilized to evenly spread charging during your dwell periods and decrease peak demand.

Table 14: Projected Peak Demand with and Without Charge Management

Phase	Daily Peak Demand Without Charge Management (kW)	Midday Peak Demand with Charge Management (kW)	Overnight Peak Demand with Charge Management (kW)	Daily Peak Demand with Charge Management (kW)
1	120	35	28	35
2	360	135	85	135
3	660	185	141	185
4	900	360	235	360

Demand with charge management calculated for active vehicles only

3. **Infrastructure Longevity:** Reducing simultaneous charging sessions prevents overloading depot infrastructure and extends the life of charging equipment.
4. **Scalability:** Charge management ensures infrastructure can handle a growing fleet without requiring excessive upgrades.
5. **Integration with Renewable Energy:** Advanced systems can align charging schedules with on-site solar production or energy stored in batteries, reducing dependency on grid power and lowering carbon emissions.

6. Transition Plan Cost Estimates

This section provides a detailed schedule of capital expenditure (CapEx) required to complete each phase of the transition, along with the ongoing operational expenditures (OpEx) incurred throughout the duration of each phase. This comprehensive breakdown is designed to facilitate accurate budgeting for each stage of the planned transition. The analysis spans from 2025 to 2035, encompassing the entire EV transition period. By including both upfront investment needs and recurring costs, this schedule ensures that all financial aspects of the transition are accounted for, enabling effective financial planning and resource allocation. Additionally, the phased approach allows for adjustments based on real-time operational data and funding availability, ensuring a sustainable and scalable transition over the long term. This structured plan provides stakeholders with a clear understanding of the financial trajectory, supporting informed decision-making and alignment with funding opportunities, such as grants and incentives, to optimize cost efficiency.

6.1 Inputs

Capital and Operating Expenditures

When estimating transition plan costs, both capital and operating expenses must be considered. A significant portion of capital costs include the purchase of ESBs and the necessary charging infrastructure. These expenses can be partially offset through utility, state, and federal grant programs, which are further evaluated in the Funding Opportunities section. Operational costs primarily consist of energy requirements for each route and the associated energy replenishment costs, and ongoing software and maintenance costs on the ESBs and EV charging stations.

Key assumptions underpinning these calculations include an estimated ESB maintenance rate of \$0.24⁶ per mile and an EV charging station maintenance rate of \$1,000 per port. Another important assumption includes the cost of utility upgrades. These costs are extremely variable and are dependent on an official utility ruling, which is only obtained after a formal load request submission. The utility assessment determined feeder and substation upgrades are not necessary, so a \$200/kW rule of thumb was applied for the cost of the utility service. Finally, the current cap to the NYSBIP charging vouchers is set to expire in December of 2025. These cost projections assume that the current caps of \$2 million per district for charging vouchers and 10% of the fleet for the vehicle voucher will remain in place. Cost projections without incentives are included since they frequently fluctuate and are not guaranteed.

To ensure accuracy in forecasting, a year-over-year escalation schedule was applied to bus and charger costs as well as energy and maintenance rates, accounting for inflation and the expected increase in maintenance needs as the internal components of vehicles and equipment age. A discount rate of 6% and a utility escalation rate of 2% are included. A comprehensive breakdown of the annual cost projections is available in **Appendix 12**, offering detailed insight into the financial aspects of the transition plan.

Funding Opportunities

Transitioning to an electric fleet involves significant expenses, but various funding programs and models can help offset costs. The EPA's Clean School Bus Program, funded with \$5 billion under the Bipartisan Infrastructure Law, provides rebates and grants for purchasing electric buses and installing charging infrastructure. In New York, the New York School Bus Incentive Program (NYSBIP), administered by NYSERDA, offers vouchers to reduce costs for electric bus acquisitions and charging infrastructure, accelerating clean vehicle adoption. Similarly, National Grid's Medium- and Heavy-Duty

⁶ Levinson, M. (2025). *Recommended total cost of ownership parameters for electric school buses: Summary of methods and data* (Technical Note). World Resources Institute. <https://doi.org/10.46830/writn.22.00024.v2>

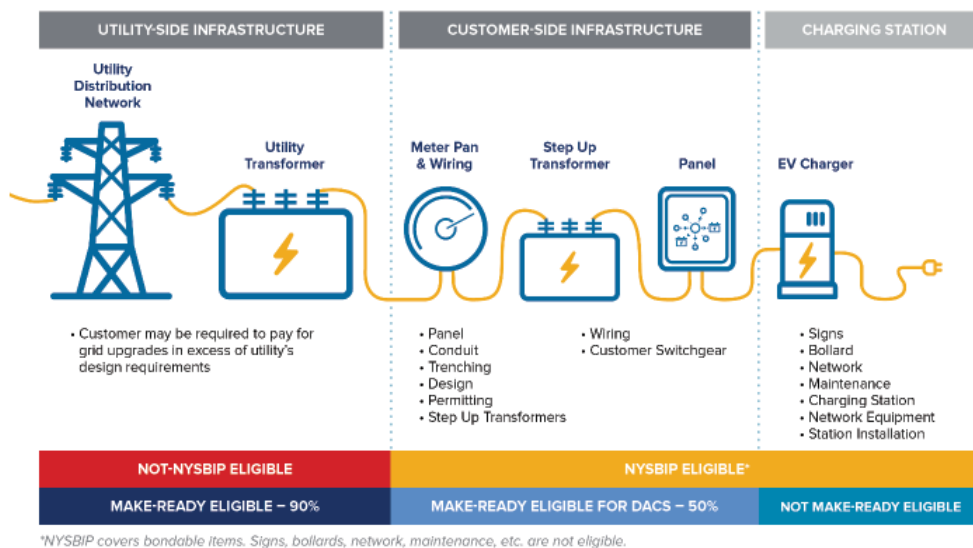
(MHD) EV Infrastructure Make-Ready Program funds up to 90% of utility-side infrastructure costs, easing the financial burden of charging station installations. The Transportation Department at 819 W Genesee St is not located in a disadvantaged community, making them ineligible for National Grid’s Make-Ready incentive funding up to 50% of customer-side costs. NYSERDA’s NYSBIP vouchers and National Grid’s MHD Program funds are accounted for in the Phased Cost Projections and can be seen in the comprehensive breakdown of the annual cost projections in **Appendix 12**.

In addition to the baseline NYSBIP charger and vehicle vouchers, there are additional add-ons that can increase your funding amounts. Some of these add-ons are detailed below, and it is encouraged to become familiar with the NYSBIP manual which outlines the various requirements of the program⁷.

Table 15: NYSBIP Bonus Vouchers

School Bus Type	Percentage of Incremental Cost Covered	Base School Bus Voucher Dollar Amount	Priority District Bonus Amount	Scrapage Bonus Amount	V2G Add-On Amount	Wheelchair Add-On Amount
New Type A	60%	\$114,000	\$28,500	\$47,500	\$9,500	\$8,000
New Type C	60%	\$147,000	\$36,750	\$61,250	\$12,250	\$8,000
New Type D	60%	\$156,000	\$39,000	\$65,000	\$13,000	\$8,000
Repowered Type A	75%	\$105,000	\$21,000	N/A	\$7,000	N/A
Repowered Type C	75%	\$135,000	\$27,000	N/A	\$9,000	N/A

Figure 11: NYSBIP Eligibility



Another funding option is an Electrification-as-a-Service (EaaS) model which provides a streamlined approach by bundling vehicle procurement, maintenance, charging infrastructure, and energy management into a single service, minimizing upfront costs. Instead of requiring large, up-front expenditures for EVs and charging infrastructure, EaaS providers often operate on a subscription or service agreement basis. This shifts expenses to predictable operating costs, allowing organizations to electrify their fleets without significant budgetary strain. Additionally, EaaS providers manage the design, installation, and commissioning of charging stations, ensuring that the infrastructure is optimized for the fleet's specific needs. It is important to note that in an EaaS model, a third party will own the assets, not Skaneateles CSD.

⁷<https://www.nyserdera.ny.gov/-/media/Project/Nyserda/Files/Programs/Electric-School-Bus/NYSBIP-Implementation-Manual.pdf>

Similarly, if pursuing alternative energy options, a Power Purchase Agreement (PPA) can reduce the upfront CapEx. Under a PPA, a third-party provider finances, installs, and maintains energy assets such as PV solar or BESS, while the district purchases the generated electricity at a fixed or variable rate over a specified period. This arrangement helps the district benefit from lower, predictable energy costs for EV charging, while avoiding the financial and operational burdens of ownership. Additionally, PPAs enable the district to leverage private investment and take advantage of available incentives, resulting in long-term cost savings and a more affordable transition to electric buses.

6.2 Results

The total projected capital expenditures (CapEx) and operating expenditures (OpEx) for Skaneateles CSD’s fleet electrification transition are summarized below. **Table 16** presents cost projections for the electric fleet only, including bus purchases, charging infrastructure and electrical upgrades, as well as ongoing operational expenses. This table provides a baseline for understanding the costs of both adopting and maintaining an electric fleet.

With incentives applied, cumulative CapEx through the final phase of electrification in 2035 is projected at **\$9.5 million**, while the fully electrified fleet’s annual OpEx is estimated at **\$211,000**. **Graphs 10-11** provide more detail on the CapEx and OpEx per year.

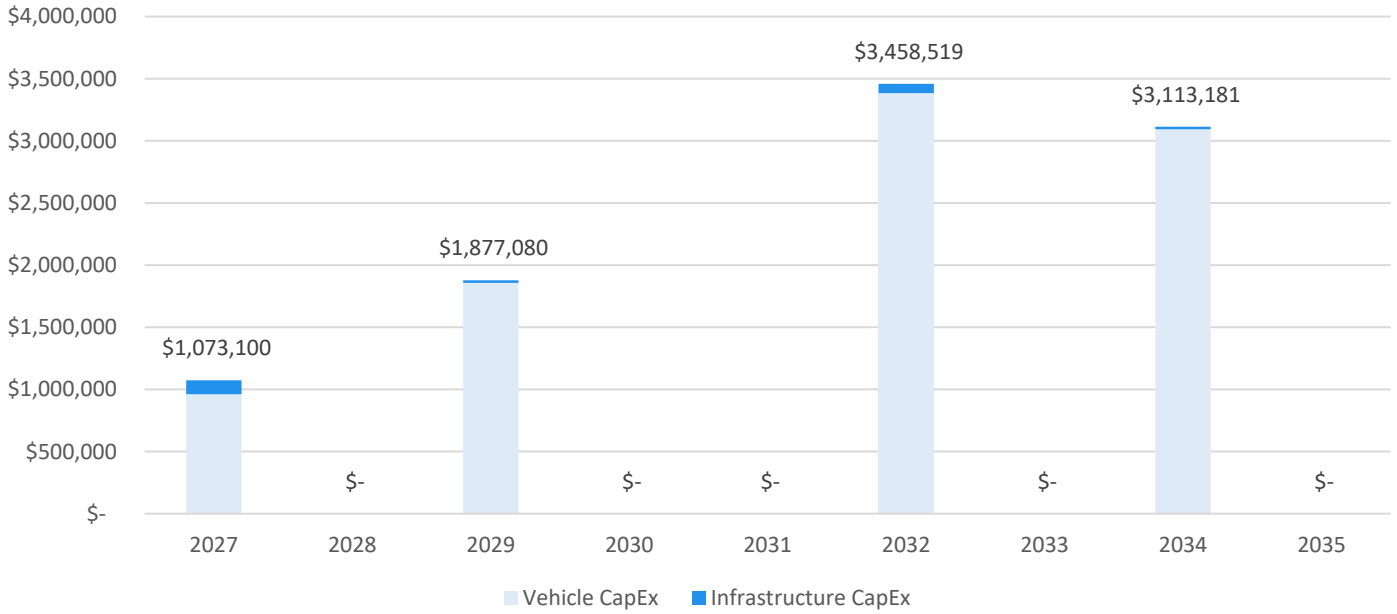
Table 16: Phased Cost Projections for Electrification of Fleet

General				
Year	2027	2029	2032	2034
Phase	1	2	3	4
ESB In Fleet	4	10	18	24
CapEx				
Vehicle Costs	\$1,402,500	\$2,706,080	\$3,530,519	\$3,093,181
Charger Hardware Costs	\$81,600	\$169,793	\$225,232	\$187,466
Charger Infrastructure & Installation Costs	\$160,000	\$45,000	\$140,000	\$45,000
Utility Upgrade Costs	\$100,000	\$-	\$150,000	\$-
CapEx Funding				
NYSBIP Vehicle Vouchers	\$(441,000)	\$(849,000)	\$(147,000)	\$-
NYSBIP Charger Vouchers	\$(220,000)	\$(214,793)	\$(365,232)	\$(232,466)
National Grid Customer-Side Make Ready	\$-	\$-	\$-	\$-
National Grid Utility-Side Make Ready	\$(90,000)	\$-	\$(135,000)	\$-
Total CapEx Without Incentives	\$1,814,100	\$2,935,874	\$4,105,752	\$3,340,646
Total CapEx with Incentives	\$1,063,100	\$1,872,080	\$3,458,519	\$3,108,181
OpEx				
Energy Costs	\$19,529.50	\$111,115.90	\$120,705.71	\$207,554.68
Software Costs	\$16,000.00	\$60,000.00	\$72,000.00	\$96,000.00
Maintenance Costs	\$13,529.41	\$67,625.34	\$91,885.66	\$115,330.88
Total OpEx*	\$49,059	\$238,741	\$284,591	\$418,886
Total Cost Without Incentives	\$1,863,159	\$3,174,615	\$4,390,343	\$3,759,532
Total Cost with Incentives	\$1,112,159	\$2,110,822	\$3,743,111	\$3,527,066
Cumulative Without Incentives	\$1,863,159	\$5,037,774	\$9,428,117	\$13,187,649
Cumulative With Incentives	\$1,112,159	\$3,222,981	\$6,966,091	\$10,493,157

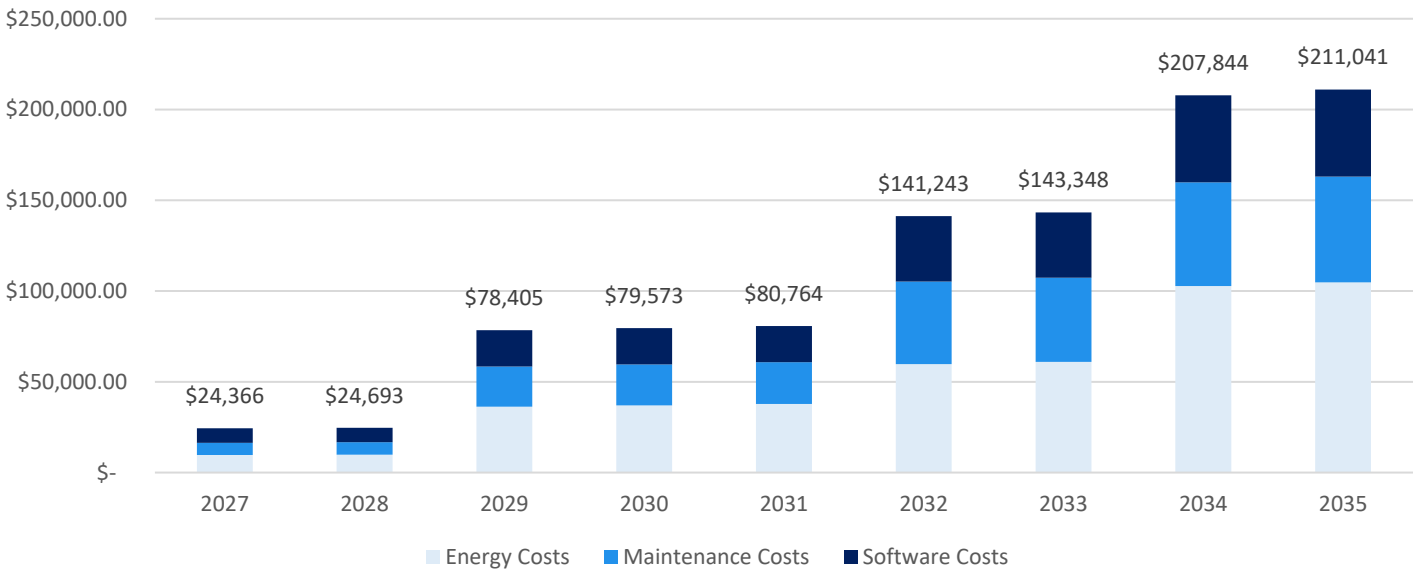
ESB = Electric School Bus, ICE = Internal Combustion Engine (current fleet vehicles)

*OpEx listed as total across the number of years in that Phase (Phase 1: 2 years, Phase 2: 3 years, Phase 3: 2 years, Phase 4: 2 years)

Graph 10: Electrification CapEx Breakdown (with Incentives)



Graph 11: Electrified Fleet OpEx Breakdown

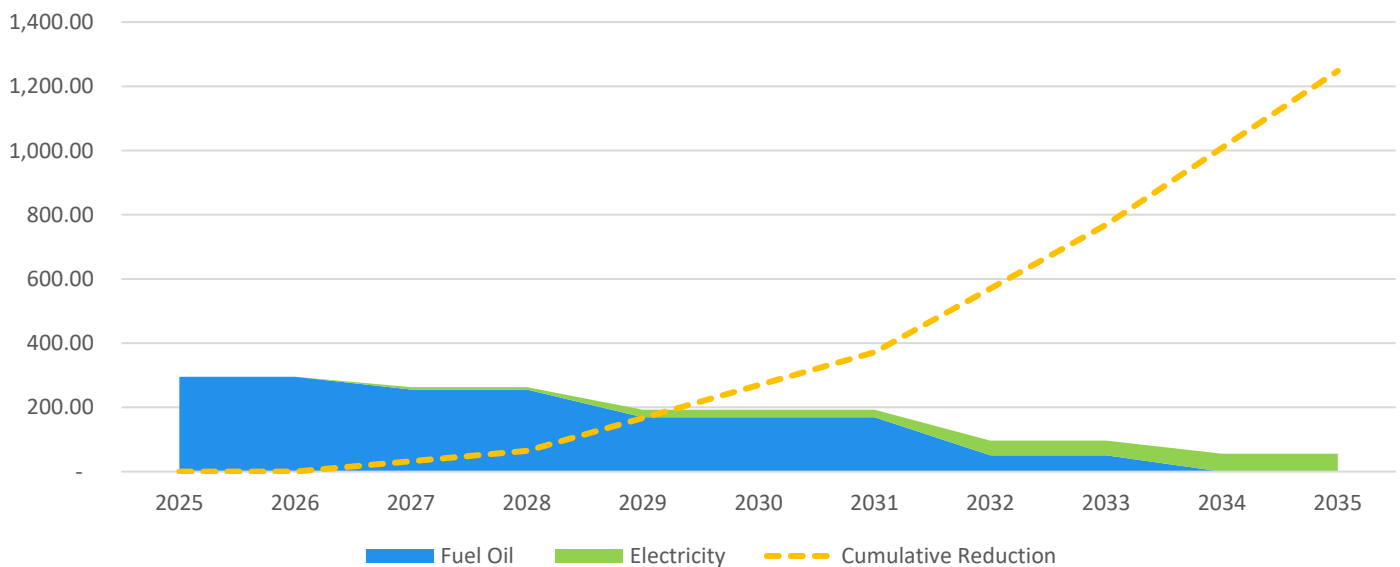


7. GHG Emissions Impact

Transitioning to an electric school bus fleet significantly reduces greenhouse gas emissions and improves energy efficiency compared to diesel-powered vehicles. Electric buses produce zero tailpipe emissions, contributing to cleaner air quality for students and the community, while also aligning with state and federal sustainability goals. The grid powering Skaneateles CSD's facility is currently 'clean' and are additional statewide efforts in creating cleaner power plants which will reduce emissions. The transition also lowers the district's reliance on fossil fuels, promoting long-term energy resilience and cost stability. This shift not only supports Skaneateles CSD's environmental objectives but also positions the district as a leader in sustainable transportation.

As shown by **Graph 12**, implementation of the FEP strategy will reduce total fleet GHG emissions by a cumulative total of 1,248 metric tons of carbon dioxide equivalent (mtCO₂e) during the transition through 2035 using the current and projected grid emission intensity. This is equivalent to the emissions from consuming 2,900 barrels of oil and the carbon sequestered by over 20,600 tree seedlings grown for 10 years. The NY Climate Leadership and Community Protection Act of 2019 (CLCPA) commits to a 100% zero-emission electricity by 2040, at which time the annual fleet emissions will drop to zero assuming successful implementation of the FEP.

Graph 12: Annual Fleet Greenhouse Gas Emissions Through 2035



8. Alternative Energy Options

With a fleet of 24 buses, Skaneateles CSD will incur significant costs in the transition to electric vehicles, particularly in charging infrastructure and energy management. To mitigate these expenses, a suggested option is to explore distributed energy resources such as linear generators, battery energy storage systems (BESS), and solar photovoltaics (PV). These technologies can supplement grid capacity, provide backup power, and help manage demand charges, potentially reducing long-term operational costs. By incorporating on-site energy generation and storage, districts can improve energy resilience and optimize charging strategies while navigating the financial challenges of fleet electrification.

8.1 Linear Generators

As fleet operators transition to electric vehicles (EVs), the challenge of reliable and scalable charging infrastructure remains a key concern. Linear generators offer a flexible and efficient solution by providing on-site power generation that can supplement grid capacity or serve as a primary energy source in areas with limited electrical infrastructure. Unlike traditional combustion engines or turbines, linear generators use a direct linear motion of magnets within coils to generate electricity, eliminating the need for rotating parts. This design improves efficiency, reduces maintenance, and allows for rapid response to fluctuating power demands.

One of the key advantages of linear generators for EV fleet charging is their fuel flexibility. They can operate on various fuels, including natural gas, hydrogen, biogas, and other renewable sources, making them adaptable to evolving clean energy goals. This capability enables fleet operators to implement charging solutions that align with sustainability initiatives while ensuring reliability, even in locations where grid expansion is costly or impractical. Additionally, linear generators can function as distributed energy resources, supporting microgrids or peak shaving strategies to mitigate demand charges and reduce overall energy costs.

For fleets operating in remote or off-grid environments, linear generators provide a dependable alternative to traditional diesel generators, offering cleaner and quieter power generation. Their modularity allows for scalable deployment, ensuring that charging capacity can grow alongside fleet electrification goals. By integrating linear generators into EV charging strategies, fleet operators can enhance energy resilience, optimize costs, and accelerate the transition to zero-emission transportation without being constrained by grid limitations.

8.2 Distributed Energy Resources

Solar-powered microgrids and/or battery energy storage systems (BESS) provide another scalable and sustainable solution for EV charging. By integrating solar photovoltaics (PV) with battery storage and intelligent load management, microgrids can generate and store renewable energy on-site, reducing reliance on the traditional grid while lowering operational costs. Solar energy offers a zero-emission power source that can be optimized for daytime charging when sunlight is abundant, while battery storage ensures energy availability during nighttime or cloudy conditions. When combined with other distributed energy resources, such as linear generators, solar microgrids enhance resilience by diversifying power generation sources and reducing exposure to fluctuating utility rates.

Battery energy storage systems provide a crucial solution for managing energy demand and ensuring reliable EV charging, especially in areas with grid constraints. By storing electricity during off-peak hours or when energy prices are low, BESS allows fleets to reduce demand charges and avoid costly peak-period electricity rates. Additionally, BESS enhances grid resilience by providing backup power during outages and stabilizing energy supply in the event of fluctuations. Whether used as a standalone solution or in combination with other distributed energy resources, battery storage enables fleet

operators to optimize energy costs, improve charging reliability, and accelerate electrification without relying solely on grid upgrades.

While the benefits of BESS and solar-powered microgrids are clear, the upfront capital investment can be a significant barrier for fleet operators. Partnering with a third-party owner-operator can alleviate these costs by utilizing private capital to finance, build, and maintain the microgrid. Through power purchase agreements (PPAs) or energy-as-a-service models, fleets can access clean and reliable charging infrastructure without the financial burden of ownership. This arrangement allows operators to focus on fleet management while benefiting from predictable energy pricing, reduced demand charges, and long-term sustainability advantages. By leveraging third-party ownership, fleet operators can accelerate their transition to solar-powered charging, ensuring a cost-effective and resilient electrification strategy.

9. Maintenance and Training Considerations

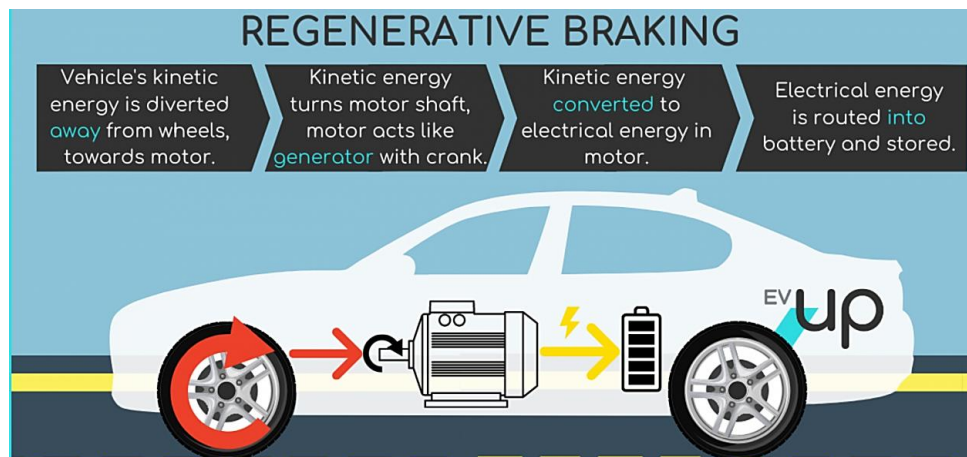
Successfully integrating EVs and charging infrastructure into fleet operations requires more than just the initial installation and deployment. To ensure long-term reliability, safety, and performance, a comprehensive approach to maintenance and training is essential. By prioritizing maintenance and training in the following areas, Skaneateles CSD can improve operational efficiency, reduce downtime, and enhance safety protocols, helping to maximize the benefits of their electric fleet investments. Guidelines and resources on ESB workforce training can also be found in **Appendix 13**.

9.1 Driver Training:

Training school bus operators in new driving habits is essential in increasing the efficiency of the ESBs. There are certain driving behaviors that maximize the regenerative braking capabilities of the vehicle and minimize power demand, extending the range of the school bus.

It is important to understand how regenerative braking works to properly operate the system. **Figure 12** below provides a high-level description of this process⁸.

Figure 12: Regenerative Braking Technology



ESB routes typically have many stops, causing drivers to brake frequently and therefore giving many opportunities to regenerate energy. Furthermore, SKANEATELES CSD is in a hilly area allowing for regeneration downhill, if operated properly.

The list below⁹ includes driver habits that minimize power usage and allow for regeneration during braking:

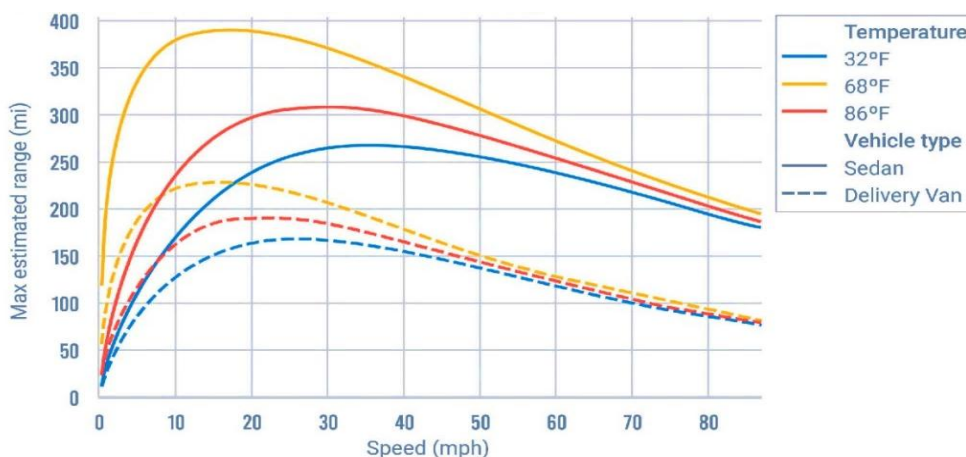
- **Cabin pre-conditioning:** Heat or cool the interior of the vehicle before you get in while the vehicle is still plugged in to the charger. This draws power from the grid rather than the battery to condition the interior temperature, preserving battery health and maximizing range.
- **Minimize HVAC usage:** Avoid excessive heating or cooling of the vehicle, when possible. While HVAC use in extreme conditions is considered in the route analysis, range can be extended by combining pre-conditioning strategies with minimization of heating and cooling systems.

⁸ <https://www.evup.com.au/about-evup/ev-news/how-does-regenerative-braking-work>

⁹ <https://driveelectric.gov/webinars/electric-school-bus-operators>

- **Avoid excessive speed:** Where allowable, avoid driving at speeds over 60mph and try to maintain speeds of under 20 mph. Driving at faster speeds drains battery faster, as displayed in **Graph 13** below¹⁰.

Graph 13: The Effect of Speed and Temperature on Range



- **Minimize frequent and aggressive acceleration:** Reduce use of accelerator and coast on kinetic energy of the bus as much as possible, while still maintaining speed limit and safe driving practices. Ease into driving from stopped points, having a ‘heavy foot’ uses up the EV battery at an accelerated rate.
- **Modulate accelerator pedal:** Rather than hitting on the brake right away, lessen the pressure on the accelerator first to utilize the regenerative brake to slow down.
- **Use hilly routes to your advantage:** Drive over hills at a speed that will allow you to coast all the way down. This permits movement downhill at ‘negative’ energy, regenerating power the whole way down.

9.2 ESB Maintenance:

While electric buses typically require less maintenance than diesel and gasoline-fueled buses, there are still routine maintenance considerations that school districts should be aware of to reduce maintenance costs, extend the lifetime of the vehicle, and maintain fleet operations. Currently, New York State Department of Transportation (NYSDOT) has the same requirements for all buses, regardless of fuel type. **Appendix 14** is a NYSERDA resource which outlines the NYSDOT maintenance requirements and their importance to ESB operations.

It is important to highlight that any maintenance that engages high-voltage systems requires extra caution. Common practice includes disengaging battery connectors and waiting at least 15 minutes before performing any maintenance. If maintenance is conducted in-house, they should be trained in new ESB practices and ensure that they reference the ESB service manuals from the manufacturer¹¹.

¹⁰ <https://www.geotab.com/blog/ev-range-impact-of-speed-and-temperature/>

¹¹ <https://www.nyserdera.ny.gov/-/media/Project/Nyserda/Files/Programs/Electric-School-Bus/Electric-School-Bus-Operations-and-Maintenance.pdf>

9.3 Charger Operations and Maintenance:

In addition to charge management strategies, proper maintenance and operation of the charging equipment is an important consideration for ESB operators. When purchasing and installing charging equipment, ESB operators should reference the charging station's operating manual. **Appendix 15** includes key details for a charger O&M plan¹².

Preventative measures that can extend the lifetime of the charger include purchasing a charge management system with your charger as well as protective bollards. The bollards will block the charger from being hit and allow for proper storage of the charging cables, avoiding damage to the equipment.

9.4 Fire Safety:

While the risk of ESBs catching fire is significantly less than a school bus with a combustion engine, it is still important for ESB operators to understand the risks associated with ESBs and the mitigation strategies for these risks. If Skaneateles CSD decides to house any buses indoors, it is important that fire prevention and ventilation systems are installed or upgraded within the facility. Additionally, engaging with your fire department during your transition to ESBs allows them to be familiar with the electrical layout of the facility. NYSERDA's Electric School Bus Guidebook contains a section on Fire Safety that details fire prevention measures and is in **Appendix 16**¹³.

¹² <https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Electric-School-Bus/Electric-School-Bus-Charging-Equipment-Operations-and-Maintenance.pdf>

¹³ <https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Electric-School-Bus/Electric-School-Bus-and-Charging-Safety.pdf>

10. Final Summary

The Fleet Electrification Plan for Skaneateles CSD provides a structured approach to transitioning its school bus fleet to EVs in alignment with New York State's zero-emission mandates. The plan outlines a phased strategy that addresses operational needs, infrastructure requirements, and financial considerations, tailored to the unique challenges of Skaneateles CSD's mountainous terrain and cold climate.

The plan proposes a phased transition, beginning with electrification of 4 buses in 2027 and culminating in a fully electric fleet of 24 buses by 2035. Through detailed route and charging analyses, the study identifies operational demands, factoring in worst-case scenarios like a 30% reduction in battery efficiency during cold weather. The Ford E-Transit, Blue Bird MicroBird and Blue Bird Vision Electric buses were simulated for their compatibility with Skaneateles CSD's needs, offering usable ranges of 79 miles, 89 miles, and 58 miles, respectively, in cold weather and hilly conditions. With these inputs, it was found that only 1 route can't be met with current EV models. If battery and bus technology continue to advance at the current predicted rate, it is predicted that there will be bus models capable of completing the currently infeasible route.

Charging infrastructure recommendations include the installation of 12 dual port chargers over 4 phases. An upgraded utility service capable of handling up to 900 kW of extra power will support these upgrades. Advanced charge management systems are expected to limit peak demand to roughly 360 kW by 2035, reducing operational costs and grid strain, if utilized. It is recommended to begin conversations with your contractor and utility early in the transition process to avoid any unwanted delays.

Training programs for drivers and maintenance staff are highlighted as critical components to ensure operational readiness. Driver education focuses on optimizing ESB efficiency through practices such as regenerative braking and minimizing HVAC usage, while maintenance protocols address the unique requirements of EVs and associated charging equipment. Safety considerations, including fire prevention measures and facility upgrades, are integrated into the report to inform on and mitigate potential risks.

The financial framework provides a comprehensive overview of both capital and operating expenses. The plan forecasts cumulative capital expenditures, including vehicle procurement and charging infrastructure, of approximately \$9.5 million and full fleet ESB operational expenditures of \$211,000 by the end of the transition. It incorporates funding opportunities such as NYSERDA's New York School Bus Incentive Program (NYSBIP), and National Grid's Medium-Heavy Duty Program to offset costs. The plan also mentions Electrification-as-a-Service (EaaS) models as an alternative funding mechanism, enabling fleet electrification through predictable operational expenses rather than upfront capital investments.

This plan equips Skaneateles CSD with a clear path to electrifying its fleet, addressing logistical and financial challenges while ensuring compliance with state mandates. By providing detailed analysis, phased implementation, and funding strategies, the plan supports a sustainable transition that is both practical and adaptable to future advancements in electric vehicle technology.

Appendix:

1. Ford E- Transit
2. Mercedes E- Sprinter
3. Blue Bird MicroBird Specifications
4. BYD Achiever Specifications
5. Blue Bird Vision Specifications
6. BYD Creator Specifications
7. Route Analysis Results
 - a. Ford E-Transit & Blue Bird Micro Bird
 - b. Mercedes E-Sprinter & BYD Achiever
 - c. Blue Bird Vision
 - d. BYD Creator
8. Charge Analysis Results
9. NYSEG Utility Assessment
10. Engineering Diagrams (Phased Site Diagrams and Single Line Diagram)
11. NYSBIP School Bus Voucher Requirements and Amounts
12. Annual Cost Projections
 - a. CapEx
 - b. OpEx
 - c. Total
13. NYSERDA ESB Workforce Training Guide
14. NYSERDA ESB O&M Guide
15. NYSERDA ESB Charger O&M Guide
16. NYSERDA ESB Safety Guide