DEPLOYING BATTERY ELECTRIC BUSES AT SCALE

A TOOLKIT FOR NEW YORK STATE TRANSIT AGENCIES

DECEMBER 2021

Glossary of Terms

APTA – American Public Transportation Association

BEB – Battery Electric Bus

Block – a schedule unit for bus operators, usually consisting of several trips on one route

CaaS – Charging-as-a-Service Model

CMAQ – FHWA Congestion Management Air Quality Program

CNG – Compressed Natural Gas

Low-No Grant – FTA Low or No Emission Vehicle Program

FHWA – Federal Highway Administration

FTA – Federal Transit Administration

NYPA – New York Power Authority

NYPTA – New York Public Transit Association

NYSDOT – New York State Department of Transportation

NYSERDA – New York State Energy Research & Development Authority

NYTVIP – New York Truck Voucher Incentive Program

SaaS – Software-as-a-Service Model

PPA – Power Purchase Agreement

TCRP – Transit Cooperative Research Program

VW Funds – Volkswagen Settlement Funds

ZEV – Zero Emission Vehicle

Further questions about BEB transition in New York State

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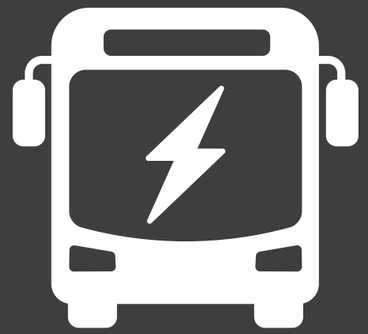
NEW YORK STATE | NYSERDA

RMI ENERGY TRANSFORMED

NELSON NYGAARD

Overview



The New York Battery Electric Bus (BEB) Toolkit is designed to provide New York State transit agencies with information and resources to guide decision making from planning through implementation. The research-based toolkit includes strategies and guidance to help both transit agency staff and transit stakeholders target their planning efforts effectively and make fleet electrification easier.

While each transit system's approach to fleet electrification will be based on specific local needs and conditions, experience shows fleet transitions are incremental.

This toolkit provides a step-by-step process for electrification, from identifying the key questions to address to developing a funding and action plan. It is intended to be useful for agencies just getting started to plan and design their first phase of BEB deployment; it is also designed to be a resource for agencies moving towards full scale bus electrification.

Throughout this toolkit, transit agency staff can find action steps, guidance, and resources to help agencies address the challenges of converting public transit fleets to cleaner battery electric technology to meet the State's climate change goals.

Our three-stage approach reflects funding, operational needs, facility capacity, and utility requirements. Phasing the transition to BEBs must also consider staff capacity to successfully deploy new vehicle technology.

Key questions this toolkit addresses include:

- **How does a transit agency begin to consider** bus electrification?
- **How can an initial deployment be designed** to collect data and develop internal practices?
- **What is the best approach** to move from an initial deployment towards full fleet transition? What are the risks and opportunities?
- **What funding is available** for a BEB pilot and beyond at the federal, New York, and local level?
- **What factors**, such as cold weather, impact battery range, and what is the best way to approach assignment of vehicles?
- **When and how should a transit agency coordinate** with New York utility providers?
- **What tools and resources exist** to support BEB deployments in New York State?

This toolkit is organized around the way transit agencies approach electrification:

- Strategic Planning and Funding
- Operations and Planning
- Procurement and implementation
- Facilities and Utility Coordination

Each section offers key action steps and external resources to help support agencies on how to make more informed decisions when planning their BEB programs.

Individual sections are designed to stand alone, so agencies and stakeholders can jump directly to the relevant stage and find helpful guidance and resources.

Stages of Battery Electric Bus Deployment

	Stage 1: **Getting Started**	Stage 2: **Initial Deployment**	Stage 3: **Commitment to Full Scale**
Strategic Planning & Funding	Make the Case and Set Expectations for Bus Electrification ..... page 4 Expand Funding Options ..... page 5 Plan for Stages of Electrification ..... page 6 Consider Hiring a Consultant ..... page 6	Secure Funding for Initial Deployment ..... page 16 Set Key Metrics for Success Based on Stakeholder Input ..... page 16 Dedicate Staff Time to Electrification Efforts ..... page 16	Work Towards Full Scale BEBs Mostly Through Ongoing Transit Revenue Streams ..... page 24 Think About Total Cost of Ownership ..... page 24
Operations Planning	Establish Baseline Knowledge of BEB Operations ..... page 8 Establish Comprehensive Inventory of Existing Bus Operations and Fleet ..... page 8 Understand Garage Capacity Needs ..... page 8	Determine the Scale of Initial Deployment .... page 17 Determine Which Blocks to Deploy BEBs ..... page 17 Update Yard Management Plan ..... page 17	Determine the Rate at Which to Scale Up BEBs ..... page 25 Deploy BEBs on More Blocks ..... page 25
Procurement & Implementation	Gain a Baseline Understanding of BEBs and their Manufacturers ..... page 9 Review Existing Fleet Replacement Program ..... page 9 Explore Charging Options ..... page 9	Procure Initial BEBs and Chargers ..... page 18 Train Operators and Maintenance Staff ..... page 18 Collect Performance Data ..... page 18 Collect Charging Data ..... page 18	Procure BEBs in Line with Vehicle Replacement Schedules ..... page 26 Explore More Efficient Charging Options ..... page 26
Facilities & Utilities	Begin Conversations with Utility Providers ... page 10 Understand Existing Grid Capacity At Site(s) ..... page 11	Make Initial Electrical Upgrades ..... page 19 Optimize Charging Schedule Given Utility Tariff Structure ..... page 19	Expanding Garage Capacity for BEBs ..... page 27 Upgrade All Facilities to Charge Fully Electric Fleet ..... page 27
Case Studies, etc.	NY Case Study: Central District Transportation Authority (CDTA) ..... page 12 NY Case Study: Rochester-Genesee Regional Transportation Authority (RTS) ..... page 13 Innovative Deployments Outside New York (Part 1) ..... page 14	NY Case Study: Metropolitan Transit Authority (MTA) ..... page 20 NY Case Study: Tompkins Consolidated Area Transit (TCAT) ... page 21 Innovative Deployments Outside New York (Part 2) ..... page 22	Tool Provider Appendix ..... page 28

Stage 1: Getting Started

New York's Climate Act sets a series of aggressive electrification goals, including a target of reducing greenhouse gas emissions by 85% by 2050 and achieving 100% zero-emission electricity by 2040. While some New York transit agencies have begun planning and deploying ZEV vehicles, others are not as far along. Lessons learned from New York transit agency staff helped inform the key considerations in this toolkit for agencies getting started.

Photo from CDTA

While state climate goals are motivating a transition to BEBs, it is helpful for individual agencies to have a clear set of their own priorities and expectations.

In addition to state or future federal mandates, agencies may be motivated to lower operational costs, improve the customer experience, seize an opportunity for workforce development, or meet a local desire to achieve local environmental and health benefits. Clear goals help build a business case with Board members, elected officials, and others. It also helps engage agency staff to identify resources they will need and determine how to measure success. Early agency and stakeholder buy-in will motivate staff towards successful implementation and generate external support for future funding needs.

This stage guides transit agencies through considerations for starting a BEB program.

Action Steps for Stage One

- **Gain a baseline understanding** of BEBs, BEB vs. diesel operations, garage capacity needs, and different charging options
- **Make the case for bus electrification** with local and regional decision makers and stakeholders, and set realistic but ambitious expectations
- **Consider hiring a consultant**
- **Explore federal, state, and local funding options**
- **Begin conversations with utility providers** about utility rates and potential facility upgrades
- **Plan at a high level** for stages of electrification

Photo from NYCT

MAKE THE CASE AND SET EXPECTATIONS FOR BUS ELECTRIFICATION

Embarking on bus electrification requires substantial changes to agency operations, so getting buy-in and setting expectations among decision makers and staff is crucial. Motivations for electrification may vary for each agency, but generally revolve around political mandates and climate goals. Conversations with stakeholders, decision makers, and staff about transitioning to BEBs may include the following:

Environmental Impact

Bus electrification eliminates the tailpipe emissions found in diesel, compressed natural gas (CNG), and hybrid buses, but it relies on electricity generated from existing energy sources. Ensuring that the grid is drawing from renewable energy as much as possible will help improve environmental impacts and strengthen the case for fleet electrification.

However, perhaps more important are the emissions reductions associated with improving public transit overall. Like increasing biking and walking, getting more people to ride public transit reduces private vehicle trips, which offers the greatest environmental benefits. When discussing the environmental impact of transit decisions, both operations and fleet should be considered.

Mandates and Goals

Most New York State transit agencies are mandated to transition to zero emission buses by 2040, or earlier for some agencies. Local entities may also set their own goals as long as they are more aggressive than state goals. Due to vehicle replacement cycles and changes to operations, reaching these mandates requires staff to being preparing for the BEB transition now (2021).

Risk

Compared to diesel buses, BEBs are a much newer technology. Implementing them into transit operations has some risks, such as range limitations and grid resiliency. These risks should not prevent agencies from transitioning to BEBs, but rather being aware of the risks earlier on helps one plan for them and set realistic expectations.

Photo from RTS

EXPAND FUNDING OPTIONS

BEBs have a higher upfront cost than diesel, CNG, or hybrid buses. They also require new fueling infrastructure, such as charging equipment and potentially investments in electrical transmission infrastructure. As a result, transitions require additional costs, making expanding funding options and sources for the BEB transition critical. Extra funding is especially helpful at the start of process, as agencies build/develop parallel systems as they test technologies without sacrificing current operations and capital dollars.

The New York agencies interviewed for this effort are funding BEB deployments primarily through federal and state grants, supplemented by existing operations and capital revenue. Federal grants include the FTA Low or No Emission Vehicle Program (Low-No), FTA Bus and Bus Facilities Program, and FHWA Congestion Management Air Quality (CMAQ) funds. New York State funding includes the Truck Voucher Incentive Program and other funding from NYSERDA and NYPA. Current funding opportunities are listed in the table below. Transit agencies should be mindful of funding cycles, particularly if they plan to mix and match programs. In addition, non-traditional sources of funding may include energy and energy efficiency grants, foundation funding, partnerships with energy providers, and if applicable, partnerships with tribal entities to access federal tribal funding programs.

Current BEB Funding Opportunities for NY State *(as of June 2021)*

Source	Funding Opportunity	Eligibility	Description
Federal[1]	**FTA Formula Funds**, including 5307 Urbanized Areas, 5311 Rural Areas, and 5339(a) Bus and Bus Facilities, plus COVID-19 relief funds distributed via formulas	All transit agencies	Primary source for existing operational and capital funding, which agencies may stretch to fund BEB deployments. Requires local match.
	FTA 5339(c) Low-No Grant Program	All transit agencies, through application	Funding for BEBs (or other low emissions buses) and associated infrastructure and facilities, which has been awarded to approximately one NYS agency per year for the last several years. Requires local match.
	FTA 5339 Bus and Bus Facilities Program	All transit agencies, through application	Funding for fixed route buses and associated infrastructure, which may be used for BEBs. Requires local match.
	FHWA Congestion Management Air Quality (CMAQ) Program	All transit agencies, through application to NYSDOT	Funding to help states meet Clean Air Act requirements apportioned to state DOTs via formula. May be used for transit improvements. Requires local match.
State	**NYSERDA New York Truck Voucher Incentive Program (NYTVIP)**, funded by Volkswagen Settlement	18 transit agencies, with earmarks for the five upstate/ suburban agencies, through application	Covers incremental cost for BEBs. $16.4 million earmarked for CDTA, NFTA, RTS, Suffolk County, and Westchester County.
	NYPA charging infrastructure funding, funded by Volkswagen Settlement	NYTVIP recipients	$6 million for charging infrastructure associated with BEBs.
	NYSDOT electrification assistance	Upstate transit fleets	$7 million in direct assistance to facilitate electrification
	NYSERDA and NYPA BEB Planning Grant	Five upstate/ suburban agencies	$1 million for creating BEB transition plans for CDTA, NFTA, RTS, Suffolk County, and Westchester County.

Source: Nelson\Nygaard

1 The Infrastructure Investment and Jobs Act and the Build Back Better Framework is not included in this analysis. New opportunities may arise for BEB funding in the near future.

Photo from TCAT

PLAN FOR STAGES OF ELECTRIFICATION

Transit agencies in New York State are mandated to transition fleets to ZEVs. There are generally two ways NY agencies are thinking about their first BEB order:

1. **Pilots** are useful for testing the viability of BEB technology through different operating conditions and may be useful for New York agencies who are unsure of if, how, and when to make the leap to BEBs.
2. **Initial deployments** are how many agencies, especially those with mandates in New York State, are viewing their first procurements. Agencies following an initial deployment approach seek to put these buses into service to replace diesel or CNG buses, but still consider them as a test case for future deployments.

For both of these options, as agencies begin to transition to ZEVs, they must continue to plan and consider later stages of implementation. The following factors influence the timeline for rolling out BEBs:

- **Funding** – procuring and implementing BEBs are initially dependent on grant funding cycles and when opportunities become available
- **Facility Capacity** – space and electrical constraints influence the size of an initial BEB deployment, and facility upgrades will most likely be required in order to expand the fleet
- **Vehicle Replacement Cycles** – fixed-route buses have a replacement cycle of approximately 12 years, so replacement schedules and policy mandates place constraints on the timeline of rolling out BEBs
- **BEB Range Technology** – Current BEB technology may not be able to deliver the ranges of an agency's longest routes, so agencies may have to wait for improved technology, change their deployments, or increase their fleet size

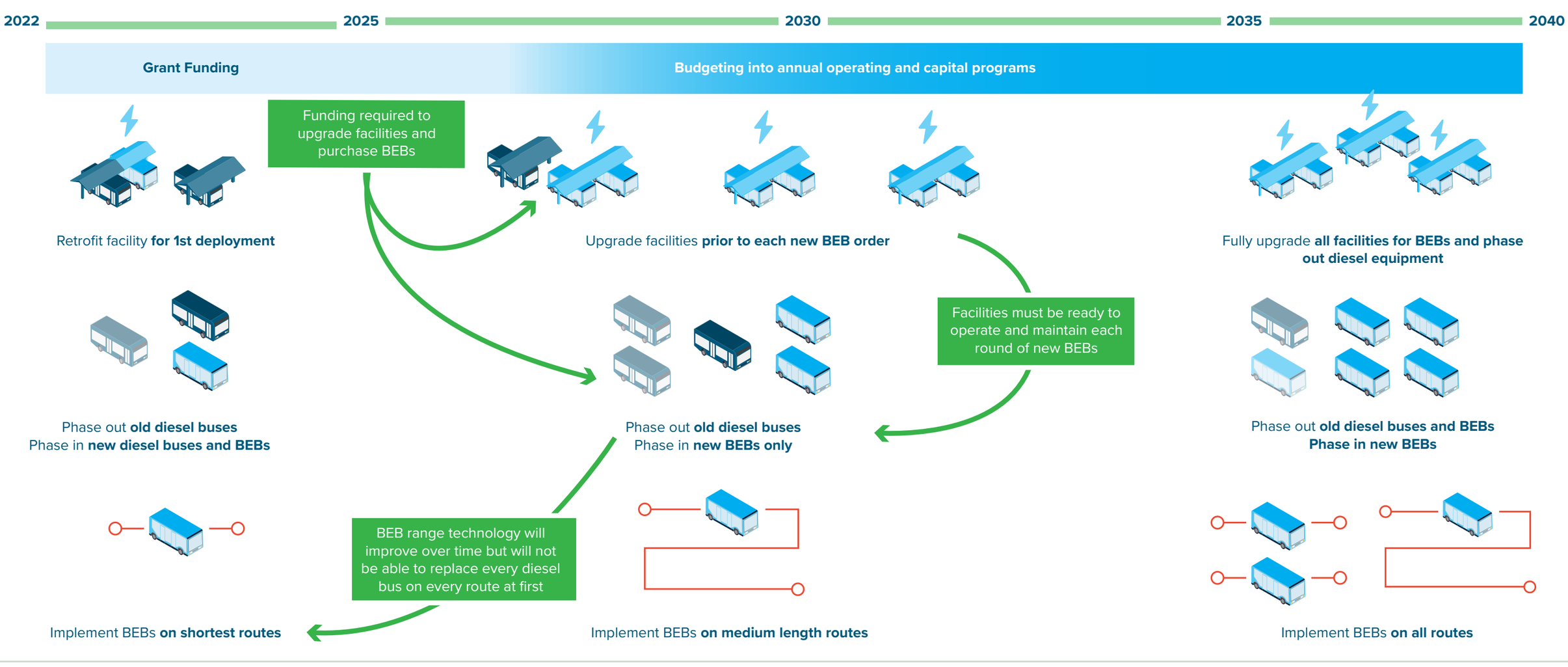
CONSIDER HIRING A CONSULTANT

Since many aspects of planning and implementing BEBs are different than traditional buses and may be new territory for staff, agencies may consider hiring a consultant to assist with any or all of the following:

- Financial planning and return on investment
- Operations planning
- Facilities planning and engineering
- Charging planning and engineering
- General planning services

Depending on each agency's internal capabilities, consultants may be helpful for anything from providing guidance for specific topics to planning, designing, and executing the entire BEB transition.

Example BEB Rollout Timeline *(will differ for each Agency)*



Source: Nelson\Nygaard

ESTABLISH BASELINE KNOWLEDGE OF BEB OPERATIONS

Agencies should establish baseline knowledge about BEB operations, including constraints associated with range and fueling, so BEBs can be integrated into existing operations as seamlessly as possible. BEB operations differ from operations of diesel, CNG, and hybrid buses beyond just fuel type. Key differences between diesel and electric buses are noted in the table below.

Transit agencies should consider the total cost of ownership for BEBs as they decide to pursue electrification. Costs beyond the initial purchases of vehicles and chargers may include higher electric bills (e.g., demand charges), maintenance and training needs, and other indirect costs, which may increase annual operating budgets.

There are a variety of resources and opportunities for transit agency staff to build capacity about BEB operations:

- **Consult published information**, such as this toolkit or those produced by TCRP and APTA.
- **Strengthen relationships with utility partners** to understand best practices for installing charging infrastructure, electricity rate structure, and potential impacts on electrical infrastructure (also see "Facilities and Utilities" section).
- **Consult with peer agencies**, including transit agencies in New York State.
- **Conduct site visits** with similarly sized transit agencies that have deployed BEBs.
- **Collect operational data from peer agencies** and evaluate experiences, including range limitations, fueling practices, and mechanical challenges (type of events, length of repair, staffing needs).
- **Attend industry conferences and webinars.**

ESTABLISH COMPREHENSIVE INVENTORY OF EXISTING BUS OPERATIONS AND FLEET

Transit agencies may establish an inventory of their existing bus operations and fleet, which may act as a baseline for comparing and contrasting more familiar diesel and CNG operations to new BEB operations. Data to collect on existing schedules and fleet includes:

- Daily miles driven
- Fuel consumption
- Vehicle type and age
- Cycle and layover time
- Street design and terrain (varied slopes, turns, and seasonal conditions)
- Maintenance needs

UNDERSTAND GARAGE CAPACITY NEEDS

Bus garages and facilities are one of the major areas affected by the BEB transition. Therefore, an understanding of garage capacity needs during this first stage can help navigate later roadblocks. This is especially important in the short-term transitional phases, as agencies have parallel fueling systems.

If depot charging is being used for the first deployment, additional space will be needed to install chargers, either on the ground or overhead, and to account for additional vehicles that may come from having BEBs for pilot and testing. Since agencies will have both BEB and diesel and/or CNG buses during the BEB transition period, extra space will be needed to house the fuel-specific equipment for all types of buses.

Diesel Bus vs. BEB Operations

	 Diesel Buses	 Battery Electric Buses
Operating Cost	**Dependent** on fuel prices	**Dependent** on electricity prices, including potentially high demand charges depending on charging strategy
Fueling	**Short amount of time** to fill up tank. **One fuel pump** can be used for many vehicles.	**Takes minutes to hours** to charge fully, depending if charged overnight in depot or fast charging to top off on route. **Individual charger or dispenser** is needed for each vehicle charging at the same time.
Yard Management	**Any bus can run any block**,* so operators can use any bus available for pull out	**Only certain buses can run certain blocks**, based on charge level and range
Space Requirements	**Indoor or outdoor** bus storage	**If charging in depot**, space is needed for chargers on floor or ceiling
Range Limitations	**Designed to easily operate** on any existing bus schedule blocks	**Battery constraints for longer blocks** (most currently available technology has range of 100-150 miles per charge), especially in extreme weather and terrain
Operator Training	**Driving habits of operator does not substantially change** vehicle range	**Driving habits of operator can significantly change** vehicle range
Maintenance	**More propulsion components** to maintain	**Fewer propulsion components** to maintain and less preventative maintenance needed, though batteries may need to be replaced

* A block is a unit used to schedule bus operators, usually consisting of several trips on one route that the operator continuously drives until their shift is over or they take a break.

GAIN A BASELINE UNDERSTANDING OF BEBS AND THEIR MANUFACTURERS

As agencies get started with planning for BEBs, they can work to understand how these vehicles and their manufacturers differ from conventional buses and what specifications may be needed for future RFPs. While some long-standing bus manufacturers (such as Gillig and New Flyer) are starting to manufacture BEBs, newer companies partly or entirely focused on BEBs (such as Proterra or BYD) lead the BEB space.

At a high level, the components of BEBs that differ from diesel or CNG buses include:

- **Battery Size** – impacts the amount of time and range a bus can operate between charges
- **Battery Type** – determines if buses can utilize fast charging or should be charged slowly overnight
- **Chargers** – can be procured with buses or separately
- **Charging System** – based on what type of charging connection the bus uses, such as plug in, pantograph, and inductive capabilities
- **Auxiliary Components** – such as heating and security systems, which can be electric or powered by auxiliary diesel units
- **Additional Services** – buses can be procured with additional services or software, such as maintenance

REVIEW EXISTING FLEET REPLACEMENT PROGRAM

Transit agencies maintain fleet replacement programs based on federal, state, and local regulations; BEBs are best planned in coordination with these programs factoring funding cycles and operational needs.

Broadly, different funding sources for buses have different caveats, such as:

- **FTA Funds** – buses can usually only be replaced once they reach the end of their useful life or beyond, typically 12-14 years, and spare ratio must be maintained
- **VW Funds** – zero emission buses must directly replace and put out of service a diesel bus
- **Local Funds** – usually the most flexible, can be used to buy new buses within or outside of typical vehicle replacement schedules

Since most funding for new buses will come from the federal level, it is important to review the existing fleet replacement program in order to be able to swap in BEB procurements. Given the 12+ year minimum lifecycle of buses and the state mandate to transition completely to zero emission buses by 2040 or earlier, each agency will have a point in time over the next several years when they should stop ordering any new diesel or CNG buses.

To meet the mandates, agencies may need to make critical decisions in the near-term to pursue additional funding, modify operations plans, and address space constraints. Additionally, transit agencies may speed up their vehicle replacement schedule, replacing diesel and CNG buses at the minimum useful life, rather than stretching out their lifespan to save costs.

EXPLORE CHARGING OPTIONS

BEBs can be charged in multiple ways and charging options should be matched with desired operating conditions. Things to consider while exploring charging options include:

- **On-route vs in-depot** – In-depot charging is generally simpler and cheaper to install but requires longer charge times, often overnight, while on-route charging helps with range limitations but requires acquiring land and setting aside time in schedules to charge
- **Type of charger** – plug-in charging requires a person to physically plug the charger into the bus, while pantograph and inductive requires maneuvering buses into the charging location
- **Charger manufacturer** – chargers can be ordered from BEB manufacturers for specific BEBs, or from third party manufacturers, which can often be used more universally

Transit agencies can eventually use a mix of charging options but may want to select one configuration for the first few deployments. Additionally, it is important to note that up front capital costs may be higher with the initial deployment because of the cost of vehicle charging stations, which may also require electric infrastructure upgrades and possibly other facility investments.

Photo from TCAT

BEGIN CONVERSATIONS WITH UTILITY PROVIDERS

Local electric utilities will be close partners for bus electrification efforts. Utilities can assist with fleet planning and site assessments, manage interconnection and capacity upgrades (known as "make-ready"), provide guidance on the most cost-effective rates for an agency's particular operations, and may potentially have funding available to help cover make-ready and/or charger costs. Utilities may also be able to assist with energy efficiency strategies to manage costs and energy consumptions. Steps include:

1. Determine the local electric utility that serves the transit agency. For agencies with large service areas, there may be more than one utility provider.
2. Schedule a meeting to discuss project goals and schedules and potential collaboration. Explore if there are opportunities to collaborate on shared goals, such as energy efficiency targets, shared need for infrastructure, and/or potential for on-site generation (solar).
3. Invite utility to visit transit agency bus depot and conduct an energy audit. Utility personnel can consider potential locations to install chargers, existing capacity of electrical infrastructure, and other opportunities to ease implementation of charging infrastructure.
4. Hold periodic meetings with the utility as BEB implementation plans take hold and make progress. At a minimum, collaboration is encouraged for:
   - Procurement of BEBs and charging infrastructure
   - Purchase of BEBs and expected delivery dates
   - Installation of charging infrastructure
   - Delivery of BEBs
   - 4-8 weeks after BEBs are deployed in operations

It is recommended to reach out to the utility as soon as possible while creating an electrification strategy (including near-term plans and long-term goals).

New York State Utility Providers and Contacts
(as of December 2021)

Utility	Contact Name and Title	Contact Email
Con Edison	Devi Mohan, E-Mobility & Demonstations	mohand@coned.com
National Grid	Ryan Wheeler, Fleet Electrification Product Owner	ryan.wheeler@nationalgrid.com
AvanGrid (New York State Electric & Gas Corporation and Rochester Gas & Electric)	Christina Ficicchia, Manager, Smart Grid Programs	christina.ficicchia@avangrid.com
Orange and Rockland	Brian Picariello, Electrification Section Manager	picariellob@oru.com
Central Hudson	T.J. Rizzo, Senior Program Manager – Electric Vehicle Portfolio	trizzo@cenhud.com

UNDERSTAND EXISTING GRID CAPACITY AT SITE(S)

Transit agencies should work with their utility to determine the existing grid capacity at their site(s). This information will inform electrification plans as it will help agencies understand how many vehicles (and chargers) can be powered by the site's existing electrical distribution infrastructure and when additional vehicles will require more investments to accommodate increased use. Infrastructure upgrades can be costly and may require long lead times (sometimes over a year), so identifying needs early in the process will help agencies strategize, budget, and manage electrification plans into short-, medium-, and long-term phases.

The major New York utilities, including Central Hudson, Con Edison, National Grid, NYSEG, RG&E, and Orange and Rockland, offer a Fleet Assessment Service that includes site feasibility and rate analysis to aid fleet owners in identifying cost- and time-saving synergies associated with electrifying fleets. This assessment is designed to be a collaborative, iterative process between the utility and the fleet operator; iterations can take months, so agencies are encouraged to reach out to their local utility early in their electrification planning process.

Transit agencies are encouraged to complete the Fleet Assessment Service Application (linked below under "Stage One Resources") and email it to their utility using the address listed on the website (also linked below). Transit agencies with operations and/or depots in multiple utility jurisdictions must fill out a separate application for each jurisdiction and send to the appropriate parties.

A representative from the utility, either the contact listed on the prior page or their colleague, will respond to each request within 10 business days with information about the electricity available at the transit agency's depot and will work with the agency on:

- **Site Feasibility Analysis** – determine power demand, distribution impacts, and potential cost-saving synergies of electrification plans
- **Rate Analysis** – understand the electricity costs required to electrify the fleet, potential managed charging solutions, and rate options available to reduce energy bills and avoid demand charges to the extent possible.

In addition to the assessment services outlined above, some utilities may offer funding for make-ready infrastructure and/or charging equipment.

Once transit agencies have a sense of what is feasible in the near-term (either with existing infrastructure or minimal upgrades), staff can determine the size and scope of the initial BEB deployment.

STAGE ONE RESOURCES

TCRP Research Report 219 – Guidebook for Deploying Zero-Emission Transit Buses, 2021
http://www.trb.org/Publications/Blurbs/180811.aspx

TCRP Synthesis 130 – Battery Electric Buses—State of the Practice, 2018
http://www.trb.org/Publications/Blurbs/177400.aspx

USAID-NREL Partnership – Electrifying Transit: A Guidebook for Implementing Battery Electric Buses, 2021
https://www.nrel.gov/docs/fy21osti/76932.pdf

Joint Utilities of New York – EV Make-Ready Fleet Assessment Services Website
https://jointutilitiesofny.org/ev/make-ready/fleet-assessment

...and **Application**
https://jointutilitiesofny.org/sites/default/files/Joint%20Utilities%20Fleet%20Assessment%20Application_Fillable.pdf

US Department of Energy Alternative Fuels Data Center Federal and State Laws and Incentives
https://afdc.energy.gov/laws

The State of Sustainable Fleets, 2021
https://www.stateofsustainablefleets.com/

NY Case Study:

Central District Transportation Authority (CDTA)

OVERVIEW

The Capital District Transportation Authority (CDTA) is the transit agency for Albany, Schenectady, Saratoga, and Rensselaer Counties. CDTA's service area spans 207 square miles and within the service area, provides transit for a population of 511,949. CDTA's fleet consists of 255 buses, not including commuter buses which are not directly operated by CDTA. In January 2020, CDTA deployed four New Flyer Xcelsior CHARGE 40-foot buses, which was the first BEB deployment for the agency. CDTA has three bus divisions, and the BEBs are charged at the Watervliet Ave garage in Albany.

FUNDING

CDTA's total BEB deployment cost thus far is $4.9 million, including $900,000 per bus, $121,000 per charger, and $805,000 for maintenance training and tools.

Funding for these components and equipment came from federal, state, and local sources:

- $900,000 from FTA's Low and No Emissions Vehicles Grant Program
- $250,000 from the New York State Legislature
- $1.1 million from the Volkswagen Settlement
- $2.6 million from CDTA's vehicle replacement reserve

PLANNING AND OPERATIONS

In September 2018, CDTA began pursuing plans to test plug-in electric buses with an initial focus on plug-in hybrid buses, funded by the Low-No grant and VW settlement funds. CDTA also began an informal information sharing agreement with Quebec to build electric bus best practices. In December 2018, the Executive Board voted to purchase four all-electric buses and four high-capacity chargers. In January 2020, the BEBs were deployed through a pilot that was expected to run six months. With the success of the pilot program, four additional BEBs were included to expand the pilot in the five-year capital budget in April 2021. CDTA continues to collect performance data through this extend pilot.

Under the pilot program, buses are rotated throughout the service area to ensure that they can operate in all types of conditions. CDTA provides maintenance and training for the vehicles through their own budget.

UTILITIES AND FACILITIES

CDTA sources its energy from National Grid. CDTA has partnered with National Grid and Sage Engineering to design appropriate upgrades of the electrical capacity at CDTA headquarters. National Grid also installed a new transformer to double the electrical capacity of the garage, which can currently support up to 12 charging ports. CDTA plans to charge two buses at a time overnight to reduce the demand on the power grid. The buses can take an 85% charge in about four or five hours. CDTA currently owns four Siemens direct current depot chargers at the 110 Watervliet Avenue facility. High efficiency LED lighting was installed in each of the charging stations to enhance safety measures.

CDTA is currently undergoing several studies to determine its capacity for upgrading existing facilities for electrification. CDTA is working with National Grid to upgrade the current infrastructure at 110 Watervliet Avenue in Albany to help with reaching capacity for its current chargers as well as be prepared for future electrification, with a goal of 25% fleet electrification in Albany. CDTA is also currently working on a plan to replace its current facility on Maxon Road. The new facility will be designed for 100% electrification and is expected to be operational in 2025-2028.

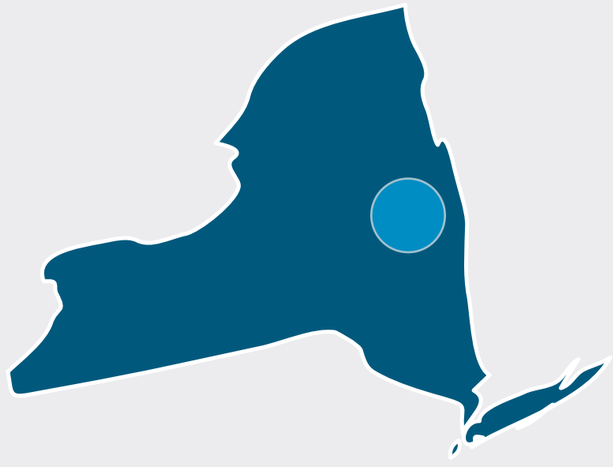
TOOLS AND DATA

Despite CDTA's BEB program only being in the pilot phase, it does have some evaluation data of the first year of service with the vehicles. CDTA uses the following tools specific to its bus electrification efforts:

- Viriciti for real time monitoring and reporting on range and efficiency
- New Flyer Connect for range and efficiency by vehicle system
- Siemens for charging data
- National Grid Energy Profiler Online for utilities data
- SATEC metering for charging data and charging cost reports

FUTURE PLANS AND CLIMATE GOALS

CDTA is part of the Governor's call to electrify the five largest upstate and suburban transit authorities, with 25 percent by 2025 and 100 percent by 2035. CDTA will be able to procure additional BEBs within the next few years with the help of funding partners, but full electrification is constrained by charging and facility infrastructure. The agency is currently working to develop an electric fleet transition plan.



NY Case Study:

Rochester-Genesee Regional Transportation Authority (RTS)

OVERVIEW

The Rochester-Genesee Regional Transportation Authority (RTS) serves the eight-county area in and around Rochester, NY. RTS's service area consists of 293 square miles and supports the mobility of a population of 694,394. There are 214 vehicles in the fleet, and 10 are New Flyer BEBs that are currently in service. RTS has 10 in-depot chargers, and the current BEB procurement contract allows up to 30 buses.

FUNDING

RTS's total project cost for electrification so far is $12.4 million. Included in this project cost is the following:

- 10 BEBs at a cost of $8.75 million
- 10 in-depot chargers at $640,000
- $2.2 million electrical infrastructure upgrades

These investments have a projected estimated savings of $187,000 over the life of a bus compared to the non-electric buses in the fleet.

RTS's funding for its electrification is pooled from several sources. RTS received $7 million from the NYS Department of Transportation, $2.3 million from the NYS Department of Environmental Conservation, $1.7 million of self-provided funding, $1 million from the Federal Transit Administration, and settlement money awarded from the Volkswagen multi-state lawsuit. The VW settlement funds will be utilized for the purchase of the next 10 BEBs plus an additional seven later in the future. Additional funds were acquired through a grant from the Unified Planning Work Program to be used for on route charging analysis.

PLANNING AND OPERATIONS

RTS's first 10 BEBs were deployed in September 2020. Currently the agency is installing infrastructure to support the next 10 BEBs it plans to purchase. Phasing of vehicles has been based on facility capacity. Each facility upgrade is considered the beginning of a new phase.

UTILITIES AND FACILITIES

RTS has conducted a series of facilities upgrades in parallel with their BEB deployments, including upgrading a transformer. RTS has partnered with NYPA since the early planning stages of RTS's BEB program, prior to the purchase of any BEBs. Going forward, NYPA will continue to be involved in facility design meetings for the next 11 to 20 chargers. RTS, NYPA, and the provider will continue to work to build the infrastructure that can confidently service the planned BEB deployment expansions.

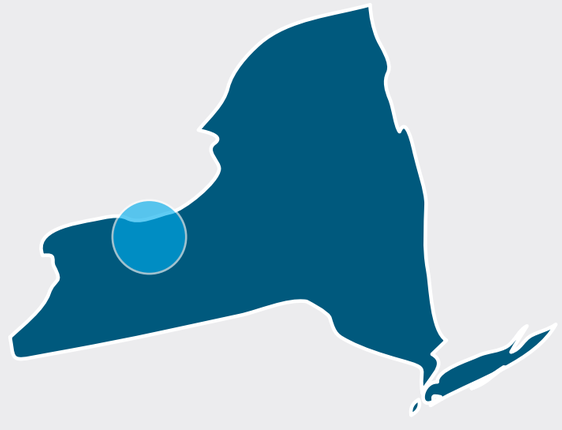
TOOLS AND DATA

RTS utilizes spreadsheets, New Flyer Connect, and EV Connect to plan and manage bus deployments. They are currently in the process of procuring software and services for charge management. Vericity and Electrify are two companies in talks with the transit agency.

In terms of performance tracking, RTS is hoping to track range and reliability, maintenance and fuel savings, and any peak charging issues. In Rochester's cold climate, current data is showing that the buses are using more power for heating than actual running of routes, during colder winter days.. The data on maintenance costs and efficiency and financial savings on fuel is inconclusive at the moment.

FUTURE PLANS AND CLIMATE GOALS

RTS plans to reach full deployment by 2035 per Governor Cuomo's mandate, with 25 percent electrification by 2025. Despite the tight timetable, RTS is on track to reach 36% deployment by 2025, putting it ahead of schedule. RTS' short-term plans include building a charging depot, to accommodate charging up to 60 additional buses. RTS is also looking into other alternative fuel sources outside of battery electrification. The transit agency has been researching hydrogen fuel cells to combat issues with cold weather, charging and fueling time, and range deficiencies as well as creating redundancies in case of emergencies.



Innovative Deployments Outside of New York (Part 1)

Environmental Justice in King County, WA

Agency: King County Metro

King County Metro launched its BEB service and related infrastructure in South King County, home to historically underserved communities, and prioritized deployment of new zero-emissions buses on service operating in those neighborhoods. This strategy focuses local air and noise pollution reductions in low-income and minority communities most vulnerable to the public health impacts of transportation pollution. Many projects out of the South King County BEB operations base are subject to local "priority hire" requirements, recruiting from within the community.

Performance Indicators in Stark County, OH

Agency: SARTA

With the support of the Low or No Emission Grant Program, SARTA and CALSTART conducted a performance analysis in 2020 of their hydrogen buses with both quantitative and qualitative components. Quantitative indicators included fuel usage and emissions reductions, time usage analysis, vehicle efficiency, and cost per mile. Emissions reduction measurements included the impacts from all stages of use, including the production, processing, and delivery of fuel, not just tailpipe emissions. This "well to wheels" framework allowed SARTA to highlight the importance of reducing the emissions of their fuel inputs and identifying potential future investments in renewable hydrogen sources. Interviews with a SARTA maintenance manager and bus operator were also conducted to understand point-of-use performance of the buses and hydrogen fuel cell program.

Long-Distance Routes in Wenatchee, WA

Agency: Link Transit

In 2021, ten 35-foot BYD K9S battery-electric buses have been placed into service on Link Transit's system, serving a mainly rural region of Wenatchee, Washington. Service is supported by four 300kW Momentum Dynamics inductive charging stations. With periodic charging at these stations at the end of routes, the range increases from 200 miles on a single battery charge to more than 350 miles, especially important in extreme weather when battery life shortens. A previous generation of BEBs purchased by Link Transit faced reliability and performance problems during daily operations, but they have seen these issues worked out in the new purchases.

Renewable Energy in Indianapolis, IN

Agency: IndyGo

In 2016, IndyGo in Indianapolis, Indiana, began use of its 1-Megawatt solar array on the roof of the agency's operations and administrative facility. The PV installation aims to produce enough energy to offset the charging of 13 electric buses. The array costs a total of $2.2 million, with approximately 80% of funding coming from a federal capital grant. IndyGo plans on expanding the solar capabilities using a Low or No Emissions Grant.

Forward-Thinking Facilities Planning in Boston, MA

Agency: MBTA

Massachusetts Bay Transportation Authority is converting its bus fleet to zero-emissions vehicles over the next several decades and is updating and modernizing bus facilities to prepare for the transition. The MBTA will replace or upgrade all nine bus maintenance facilities, one every two to three years, to accommodate the necessary charging and electrical infrastructure. As part of the renovations, the MBTA will also expand the facilities to allow for more 60-foot buses as well as additional bus service in the future. The oldest facility in the system is the first to be updated, followed by a facility that serves neighborhoods with high proportions of transit-critical riders. Public engagement and design review is being conducted for each project.

Battery Leasing in Park City, UT

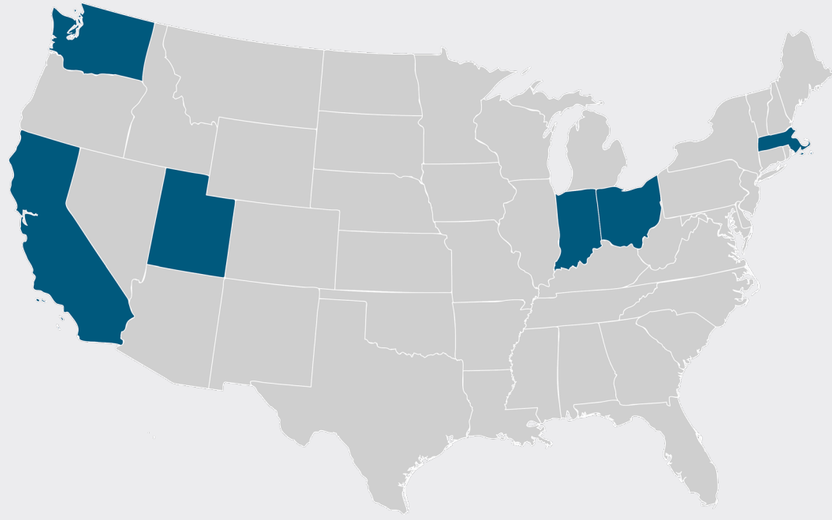
Agency: Park City Transit

Park City Transit in Park City, Utah was the first agency to participate in Proterra's battery leasing program. In 2017, Park City deployed six Proterra BEBs, purchased at the same upfront cost as a traditional diesel bus, leasing the batteries separately. Park City will pay a fee to Proterra's credit facility each month to lease the batteries, rather than the battery cost being included in the upfront BEB purchase. Proterra owns and services the batteries, with a performance warranty for the 12-year life cycle of the bus. At the end of the lease, Proterra plans to put the batteries to a secondary use, such as stationary grid storage.

Training in Oakland, CA

Agency: Alameda-Contra Costa Transit District (AC Transit)

To support the introduction of BEBs into its fleet, AC Transit provides operational training for bus operators, mechanics, and other support and supervisory staff in coordination with equipment manufacturers. The trainings come in several stages and different levels of complexity, most of which are led by the equipment manufacturers at first, with "train the trainers" sessions to allow for future trainings to be in-house. The first step is basic familiarization and safety, which is similar to the trainings that occur any time there is a new vehicle type, whether or not it is a zero-emissions bus. These sessions are required for all mechanics, service employees, supervisory staff, and trainers. Further advanced training is provided as necessary to the relevant employees, mostly mechanics, with advanced mechanics courses ranging from 30 to 40 hours each, in addition to an optional 5-week technical training program for mechanics and synchronous learning opportunities.



Stage 2: Initial Deployment

The pace of an initial deployment is often driven by available funding—both for the higher cost of battery electric buses, as well as funds needed to upgrade facilities and install bus chargers in maintenance facilities or other locations if utilizing on-route charging. Funding cycles may vary and will require planning and finance staff to take advantage of multiple opportunities. Staff will also need to coordinate to ensure grant program requirements can be met.

Photo from NYCT

Funding is an important consideration, but not the only one.

Additional factors include the battery range required for existing bus routes, space to adequately charge and deploy BEBs, and the utility provider's ability to provide the necessary electricity or capacity upgrades if needed.

Initial deployments should consider all factors: funding, operational needs, facility requirements, and utility capacity. The constraints for each will inform the scale, and timeline of the deployment.

This stage guides transit agencies through how to factor different needs to determine the design of an initial program, ways to engage and prepare staff for new vehicle technology, and how to monitor deployments to inform future expansion of BEBs.

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Action Steps for Stage Two

- **Determine the scale of initial deployment** (i.e. number of BEBs), based on factors such as funding availability and garage capacity
- **Identify expected BEB deployments**; will buses be used on routes that accommodate BEB operations or will BEBs be deployed generally in system operations? This decision informs charging infrastructure equipment and could influence vehicle procurement decisions
- **Secure funding for procurement of buses and infrastructure** and align the timing of investments, including coordination with utility provider
- **Set metrics to measure initial deployment** and determine how to collect data
- **Procure initial BEBs and chargers**
- **Upgrade electrical infrastructure** as needed and ensure utility provider is also making any required investments
- **Train operators to drive BEBs** and maintenance staff to service BEBs (will likely be coordinated with vehicle manufacturers)
- **Develop deployment plan**, including charging schedule given utility tariff structure and update yard management plan
- **Deploy BEBs on select routes**
- **Collect data** on BEB performance and charging rates
- **Report out findings** and collaborate with New York peer agencies and partners

SECURE FUNDING FOR INITIAL DEPLOYMENT

To secure funding for the initial deployment, agencies should apply for any and all grant funding opportunities they are eligible for. Funding will most likely inform the size of initial BEB procurements and deployment, with careful consideration of service, facility, and utility constraints. The previous section outlines both federal and state discretionary programs. New opportunities are also emerging, particularly in the context of pandemic recovery, economic stimulus, and tackling the climate crisis. Agencies should keep track of information through federal and state legislative e-alerts or stay in touch with local federal delegation staff, who often can both anticipate federal opportunities and offer letters of support for competitive grant applications.

SET KEY METRICS FOR SUCCESS BASED ON STAKEHOLDER INPUT

While public mandates and environmental goals may prompt a transit agency to begin a BEB program, measuring success must incorporate internal and external goals. Further, data collected from an initial BEB deployment can help a transit agency prepare for full scale transition. Setting key metrics at the outset also ensures objective and transparent decision making. Metrics should be compared to the baseline current (diesel or CNG) fleet and operations, established in Stage 1. Example metrics include:

- Fuel costs per mile
- Kilowatt hour per mile
- Maintenance cost
- Emissions reduction
- Vehicle availability
- Customer satisfaction

Key performance indicators from operational effectiveness, maintenance effort, and financial costs can be measured along with emissions reductions and customer and community satisfaction. Communicating these measures, and the extent to which a BEB program is achieving them, will help Board members and other stakeholders recognize the value to the transit agency, which may help make the case for additional resources, from funding to workforce development.

Finally, transit agencies must also consider how their BEB deployment impacts disadvantaged communities. The Climate Leadership and Community Protection Act (CLCPA) requires transit agencies and other state agencies to use funding so that disadvantaged communities receive forty percent of the overall benefits. In addition, the $16 Million New York Truck Voucher Incentive Program (NYTVIP) will fund agencies for 100% of the incremental vehicle cost if the buses are housed at depots or operated on routes that are located within a half-mile of a disadvantaged community.

DEDICATE STAFF TIME TO ELECTRIFICATION EFFORTS

Transitioning to BEBs will have significant impacts on agency staff and systems. While impacts may accrue to individual departments differently, they will span the full suite of transit staff (administration/finance, operations, maintenance, and planning). Understanding the impacts of new fueling systems by department will help determine where resources are needed.

Multiple departments will be involved in bringing a new vehicle technology into deployment; this includes planning, operations, maintenance, finance, procurement, and information services department. Tasks may include researching and developing fleet specifications, grant writing, facility planning and construction, and coordination of training for operators and mechanics. Assignment of BEBs may require adjustments to schedules and dwell times (if charging on route), modifications to yard management, and adjustments to job descriptions for utility workers.

Transit agencies may want to consider assigning a point person within the agency, or hire a new position, to manage upfront project coordination, work with the utility provider, and manage ongoing data collection and documentation. An identified staff person will ensure safety protocols are followed and can support a range of tasks including looking for funding opportunities, communicating to stakeholders, and measuring success. Communication, both internally and externally, will be critical to ensuring alignment of effort and managing expectations of project delivery.

DETERMINE THE SCALE OF INITIAL DEPLOYMENT

As mentioned, funding will most likely inform the pace and scale of BEB deployments, while service characteristics, including facility and staff capabilities will inform the level of risk. Many agencies prefer to begin a program with a small-enough fleet to ensure peak service requirements can be met without BEBs.

The decision about how to integrate BEBs into service operations is also tied to decisions about charging infrastructure. Dependent on the size of the route blocks, there may be flexibility to assign vehicles to multiple routes, or BEBs may be restricted to a handful of shorter assignments.

Charging infrastructure, such as on-route chargers, also influence operations. Depot charging is less capital intensive as it does not require land acquisition and requires minimal adjustment to schedules. On-route charging commits BEBs to a specific route or geographic area. It also may result in higher electricity costs during peak demand.

Ideally, initial deployments are flexible to collect data on a range of operating conditions—from urban, low speed, stop and go service in high ridership areas to more arterials, highways, and faster speed areas. In addition, varied slopes, turns, seasonal conditions, and other street conditions will test the range capacity of the battery. Multiple assignments expose more operators to the new technology, so agencies can separate driver behavior from vehicle performance. In short, transit agencies should minimize risk but also generate enough information to determine next steps in the BEB investment. Environmental benefits of BEBs can also be distributed throughout the service areas, including underserved environmental justice communities.

From the facilities perspective, most agencies prefer to conduct their initial deployment within existing space constraints and without major retrofits or utility investment. The configuration of chargers may be less of an issue with a small number of buses, but at scale, space and electrical requirements could be significant. Considering space and utility investment alongside consideration for future expansion may save time and money later.

DETERMINE WHICH BLOCKS TO DEPLOY BEBS

Depending on the size of the system, and the length of routes and blocks, agencies can assign buses using a simple spreadsheet to compare block lengths to range ability. Schedulers can take a conservative approach, knowing performance will almost always fall short of manufacturer specifications. Another way to determine where to assign buses is to conduct a route simulation and collect data in real world conditions. Bus manufacturers are often willing to help collect the data or deploy a test bus to demonstrate range capability. New York agencies can also benefit from peer systems currently deploying BEBs and use their real-world data as well.

Understanding bus performance in the transit agency's service area, including the range of route conditions, weather, and technical specifications for the fleet, will ensure the appropriate vehicle type and also inform larger scale deployment needs. Initial deployment may begin on the shortest routes, but it will be important to test out different terrains and routes, urban versus highway conditions, and other factors in order to understand future fleet needs.

Ideally, an initial deployment can meet the performance requirements of a portion of routes, with enough flexibility to test different service areas and conditions. In addition, agencies may desire or be required to assign initial BEBs in environmental justice areas with poor air quality.

UPDATE YARD MANAGEMENT PLAN

Transit agencies may need to make changes to the management of their bus yards and transit facilities to accommodate BEBs. Many transit systems are already at capacity for parking buses and will need to find additional space to park vehicles and/or locate chargers. While some agencies assign fleet to specific routes, such as branded services, diesel fleet in general is more interchangeable. BEBs add another factor in how buses are assigned. In addition, charging requirements may also impact overnight maintenance and cleaning schedules.

Agencies should review pull-out and pull-in needs and include the input of utility workers, foremen, and supervisors. Considerations include which transit employees will be assigned to charge the bus, determining how much additional time is needed to move vehicles to assigned locations in the yard, and ensuring buses are assigned and lined up as needed for pull-out. Because BEB technology may only be able to serve some of an agency's routes/blocks, it is critical to assign the right driver to the right vehicle.

Example of Block Planning Spreadsheet

Vehicle Block				Time (minutes)			Distance (miles)			Battery	
Route	Trip_ID	Block ID	# of Trips	Revenue Time	Operational Time	Detour Buffer Time	Revenue Miles	Operational Miles	Detour Buffer Miles	Operational Daily kWH Needed	Battery (kWH) Needed
Route 1	1	R1_1	12	1,080	1,140	16	144.8	165.1	2.4	509	708
Route 1	2	R1_2	12	1,063	1,123	16	144.8	165.1	2.4	507	704
Route 1	3	R1_3	12	1,046	1,106	16	144.8	165.1	2.4	504	700
Route 1	4	R1_4	12	1,029	1,089	16	144.8	165.1	2.4	502	697
Route 2	1	R2_1	14	1,080	1,140	19	112.1	130.6	2.8	442	614
Route 2	2	R2_2	14	1,065	1,125	19	112.1	130.6	2.8	440	611
Route 2	3	R2_3	14	1,050	1,110	19	112.1	130.6	2.8	437	607

Source: Nelson\Nygaard

PROCURE INITIAL BEBS AND CHARGERS

New York State has an FTA-compliant bus procurement contract that includes BEBs. Using the state contract could save time and may be particularly helpful if transit agency staff are less familiar with BEBs or associated infrastructure. Procurement of buses and chargers can be combined or done independently. Choosing to procure separately may provide more flexibility for future purchases if future buses are from different manufacturers.

Additional considerations include slow versus fast charge, in-depot versus on-route charging, and charge type (plug-in, overhead conductive, or inductive). New York agencies may also need to consider auxiliary diesel heaters in colder months.

Many agencies prefer depot charging for the ability to overnight charge and keep utility costs down; however, range limitations may also necessitate on-route charging, or it may also be desired if planning to deploy BEBs on a specialty route, such as a downtown circulator or bus rapid transit line.

TRAIN OPERATORS AND MAINTENANCE STAFF

Most agencies should be familiar with training operators and mechanics when new buses arrive. BEBs operate very similarly to diesel buses but also have new components that will be unfamiliar to drivers and mechanics. Transit agencies will need to provide safety training for operators, supervisors, mechanics, and other facilities staff. Depending on the deployment plan, initial training may be limited to operators who are assigned to the BEB blocks; however, that can be challenging depending on how an agency assigns work. Finding the time to train all operators can also be challenging, but conversely, transit agencies risk not being able to deploy a BEB if there are not enough trained drivers.

In addition, transit agencies will need to coordinate with first responders and develop local protocols to respond to potential hazards unique to BEBs. The RFP for bus procurement should include training; ideally scheduled shortly after delivery so it does not delay revenue service deployment. Some agencies may consider a “train the trainer” approach, where supervisors, training personnel, and foremen receive more detailed training so they can provide training directly to employees in the future.

Because driving habits can impact battery performance, agencies may find it useful to use collect data by operator. Driver acceleration and breaking could impact performance and inform additional training to preserve battery life. Monitoring vehicle performance by driver may inform future training to utilize techniques that use less energy.

Also, because BEBs generate less noise than a traditional bus, transit agencies who have deployed BEBs have identified pedestrian safety concerns. Training should prepare operators for this, including turning the vehicle off when parked.

COLLECT PERFORMANCE DATA

Data collection is an important component of the initial deployment, providing insight into how buses are performing and how they can best be utilized. Data on vehicle performance serves two purposes:

1. Findings can inform future BEB operations, including an understanding of costs and benefits.
2. Daily monitoring ensures any issues can be addressed with minimal disruption to operations. BEBs, like any new technology, has a learning curve; information will help staff adjust, adapt, and improve overall performance. New York state requires performance monitoring as part of their grant requirements, so it will be important to align metrics with those requirements as well.

Agencies will want to collect data across a range of topics and issue areas, as well as performance across different conditions including:

- Weather
- Different route lengths
- Topography and road conditions
- On board equipment such as A/C and heating
- Bus stop spacing
- Urban vs rural routes
- Passenger loads
- Driver behavior

In addition to tracking performance across different conditions, agencies should also track costs associated with charging, operations, and maintenance.

COLLECT CHARGING DATA

Perhaps the biggest concern transit agencies face is the difference between real world battery range and the manufacturer predicted range. Agencies should monitor energy consumption by vehicle (and by driver) to better understand vehicle performance relative to the operating conditions. In addition to adapting to new vehicle technology and making adjustments in the short term, battery performance will also inform maintenance needs, future vehicle specifications, training, and charging strategy.

Bus manufacturers offer their own tools, including hardware on the buses, as well as software to monitor activity. This is proprietary, and vendors may limit agencies to customized reports and retain some control over data transmission. Some transit agencies prefer to procure separate charge management software that not only provides guidance on optimized charging, but also may provide data that is more easily accessed on a daily basis through a more nuanced reporting tool.


Photo from NYCT

MAKE INITIAL ELECTRICAL UPGRADES

Once transit agencies have spoken with their utility and have a sense of existing electrical grid capacity at their site, staff can determine what sorts of electrical upgrades will be required to support the initial BEB deployment.

Three factors influence electricity costs: overall consumption (how much), speed of charging (how fast), and timing (when). For a pilot of just a few BEBs using depot chargers and charging overnight, electrical upgrades will likely be relatively minimal. Deployments of more buses and/or operational schedules that require buses to quickly charge—either at the depot or on route—may require significant upgrades to the site(s).

Charging equipment should be installed before BEBs arrive onsite. Working with the utility is critical to prepare for the size of the first deployment, energy capacity needs, and timing. Ideally, projecting the long-term objectives of the BEB program will allow the utility to consider ways to future proof any initial investments. Installation could take six months from the point that transit agencies let the utility know what need, longer if they go through demand and cost modeling. However, the first deployment should be relatively simple with one charger per bus.

As the transit agency works directly with the utility to understand what upgrades, if any, are required, they may also explore any incentives the utility may have available to help offset the infrastructure costs associated with preparing a site for BEB charger installation. Be mindful of construction and interconnection timelines and try to align them as closely as possible to BEB delivery schedules.

OPTIMIZE CHARGING SCHEDULE GIVEN UTILITY TARIFF STRUCTURE

Once transit agencies finalize plans for the initial deployment—including number of BEBs, number and power levels of chargers, general charging schedule, and other factors—they should work with the utilities to update the rate analysis received in Stage 1. This will help ensure that transit agencies are utilizing the best rate option available to reduce their energy bills.

Whichever tariff structure selected, agencies should be particularly mindful of time-of-use (TOU) rates, where the per kilowatt price of electricity varies throughout the day, and demand charges, where additional fees are incurred on electric bills based on the maximum electricity use at any one time over the course of the billing cycle. These sorts of charges can dramatically increase electric bills if not managed appropriately.

Some fleets—especially those with small initial deployments—may be able to manage their charging schedules manually, by simply not plugging in during peak electricity demand hours and/or ensuring not all BEBs are charging at the same time. However, agencies may want to consider investing in a charge management system (CMS), which is software that can be integrated with charging hardware to help manage these costs and optimize charging schedules automatically. A list of companies offering CMS can be found in Appendix A.

STAGE TWO RESOURCES

TCRP Research Report 219 – Guidebook for Deploying Zero-Emission Transit Buses, 2021
http://www.trb.org/Publications/Blurbs/180811.aspx

TCRP Synthesis 130 – Battery Electric Buses—State of the Practice, 2018
http://www.trb.org/Publications/Blurbs/177400.aspx

USAID-NREL Partnership – Electrifying Transit: A Guidebook for Implementing Battery Electric Buses, 2021
https://www.nrel.gov/docs/fy21osti/76932.pdf

Altoona Bus Research and Testing Center – Bus Testing Reports
https://www.altoonabustest.psu.edu/bus-list.aspx

California Air Resources Board – Innovative Clean Transit Roll Out Plans https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit/ict-rollout-plans

BEB Manufacturers Websites, such as:
Proterra https://www.proterra.com/applications/public-transit/
New Flyer https://www.newflyer.com/buses/
BYD https://en.byd.com/bus/
Gillig https://www.gillig.com/battery-electric

Atlas Public Policy Fleet Procurement Analysis Tool https://atlaspolicy.com/rand/fleet-procurement-analysis-tool/

Federal Funding Opportunities
https://www.grants.gov/

New York State DOT Funding Opportunities
https://www.dot.ny.gov/funding

Search Foundation Opportunities
https://candid.org/

Information on available federal, state and private grants
https://www.assembly.state.ny.us/gan/

NY Case Study:

Metropolitan Transit Authority (MTA)

OVERVIEW

The Metropolitan Transportation Authority (MTA) serves one of the most densely populated regions in the world. With a service area of 321 square miles around New York City, MTA serves over eight million people with a fleet size of 5,800 vehicles, 75 of which are BEBs (in addition to 10 pilot BEB leases that ended in 2021). Sixty of these buses are 40-foot New Flyer BEBs which were ordered in November 2021 and are expected to enter service starting in late 2022. The MTA uses a combination of depot overhead chargers (150-300 kW) and on-route overhead chargers.

FUNDING

In November 2021, MTA spent $64 million on the 60 40-foot New Flyer BEBs. In conjunction with this capital spending, MTA entered into a $39 million agreement with the New York Power Authority (NYPA) to install overhead chargers at four of the charging depots. In the 2020-2024 Capital Plan, MTA is planning to spend $1.1 billion on buses and depot upgrades. MTA's funding sources are a combination of federal, state, and local funding. Projected funding was expected from congestion pricing, but it is currently unclear when and if the policy will be implemented.

PLANNING AND OPERATIONS

In its 2018 Bus Plan, MTA made a commitment to electric buses moving forward, starting with 10 pilot buses (five New Flyers and five Proterra). These vehicles were purchased using 3-year leases with a mix of on street charging and depot charging that informed the RFP for the next purchase of standard BEBs. MTA purchased an additional 15 electric articulated buses, 16 in-depot chargers, and one mobile charging unit from New Flyer in January 2019. MTA followed up this purchase in June of 2021 with 60 standard BEBs from New Flyer.

In terms of deployment, MTA piloted the articulated BEBs on the longest service route to test the range and durability of the batteries. Other buses were first deployed on shorter routes that are relatively easier to operate. Additionally, MTA partnered with New Flyer for training and maintenance. New Flyer agreed to provide maintenance for the buses and training for the NYC Transit crews to eventually take over the operations and maintenance.

UTILITIES AND FACILITIES

MTA's utility provider is Con Edison. Through a partnership with NYPA, the MTA is installing BEB chargers for the upcoming deployment of 60 buses. In addition, Con Edison is partnering with the agency to install a new power supply at one location. MTA has entered into an off-hours rebate program with Con Edison in exchange for charging overnight in off-peak usage hours. As part of the BEB investments, funding for upgrades to current facilities is a part of MTA's Capital Plan. However, MTA faces several challenges in making upgrades to facilities. MTA's depots have major space constraints, with 200-300 buses per garage and constrained ceiling heights. There are also space constraints for all of the boxes for charging infrastructure, both in depots and on route.

TOOLS AND DATA

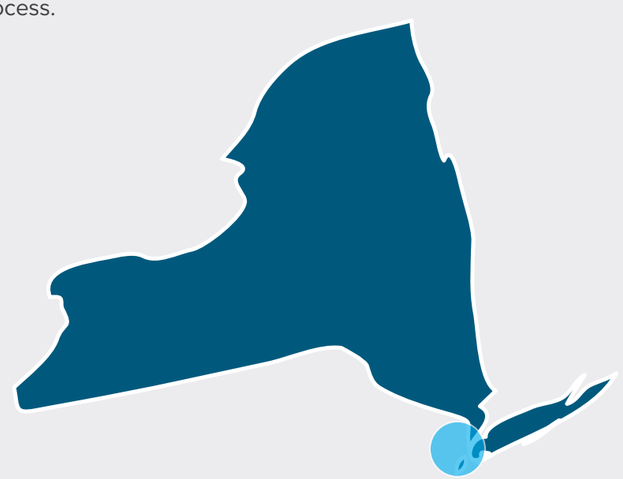
Currently, MTA mostly uses spreadsheets in-house to plan and manage BEB deployments. MTA uses HASTUS for service planning for non-electric buses but has not yet tried to use its BEB module. As MTA scales up its BEB deployment, the agency will likely have to move beyond spreadsheets for planning and integrate new software.

MTA currently collects data on charging times and the range of service the BEBs provide during these early stages. So far, charges last three to four hours, which means that BEBs can operate on two-thirds of MTA routes.

FUTURE PLANS AND CLIMATE GOALS

MTA has set a target of a fully zero emissions fleet by 2040. In the 2020-2024 Capital Program, New York City Transit (NYCT) and the MTA Bus Company, combined, plan to purchase 400 new standard electric buses at a cost of $753.1 million, 100 articulated electric buses at $206.1 million, and depot modification for BEBs at up to eight locations at a cost of $120 million.

Additionally, MTA's Sustainability Department is working to put solar panels on MTA facilities, which will provide energy back to the grid. There is interest in the possibility of directing this energy into batteries or chargers. For the MTA, reducing local air pollution is an important goal for electrification alongside broader climate change and environmental justice considerations. The MTA is prioritizing low-income and minority communities for zero-emission bus deployments as part of their location selection process.



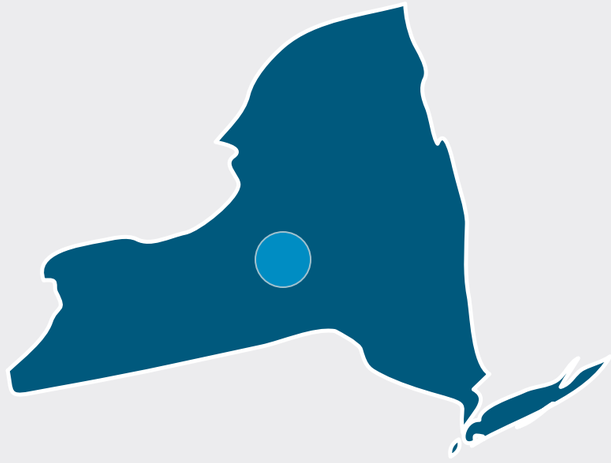
NY Case Study:

Tompkins Consolidated Area Transit (TCAT)

OVERVIEW

TCAT is the public transportation provider for the City of Ithaca and Tompkins County, with a service area of 25 square miles and a population of 103,617 people. The agency has 55 buses in its fleet. TCAT has deployed seven BEBs, all 40-foot ZX5+ Proterra buses, and has upgraded its facilities to put in place 12 125kW in-depot chargers.

Image from Trevor Jenson



FUNDING

TCAT's deployment so far has costed approximately $1 million per bus, $60,000 per charger, and $1 million for the infrastructure to support the chargers. The agency received an FTA Low-No grant for three BEBs, plus additional funding from the VW settlement, Cornell University, and city and county sources. TCAT's partnership with Cornell also includes advertisement on campus.

PLANNING AND OPERATIONS

TCAT began planning for electrification in 2017 with the Low-No program award from the FTA in 2018. Conversations with its utility provider, NSEG, began in 2018. In 2019, additional funds were identified with the availability of VW settlement funds. In March 2021, the first order of seven buses arrived; these BEBs were deployed into service in April 2021.

The agency is using this first set of BEBs to see how well they can be operated on TCAT's routes and to gauge the driver experience. The buses have been deployed on a variety of geographies and routes. TCAT's buses currently use diesel heaters, due to the difficult nature of operating fully-battery powered buses in Tompkin County's cold and hilly terrain. TCAT estimates that 70% of its routes can be served by BEBs with diesel heaters.

For the first twelve months of deployment, there is Proterra staff onsite to do maintenance and train TCAT staff. Classroom training consists of four hours for bus operators and 48 hours for mechanics.

UTILITIES AND FACILITIES

TCAT has been working closely with NYSEG for facility and electric upgrades, with discussions in the works since 2018. Due to the shift away from manufacturing industries in the region over the last few decades, Tompkins County has unused grid capacity in 2020. NYPA's eMobility team helped TCAT design and install chargers and electrical capacity infrastructure.

TCAT's facilities have been upgraded to have the capacity for 12 125kW chargers currently. The agency is exploring installing multi-dispensers from Proterra, which would allow them to charge up to 48 buses at the current facility with 12 chargers.

TOOLS AND DATA

TCAT uses Maximo for preventative maintenance management. For BEB data, Proterra provides some crucial data points, but TCAT is working to integrate tools for BEBs and existing planning in-house. TCAT hopes to collect miles-per-gallon equivalent data from its initial deployment and to understand if maintenance and fuel savings are as modeled. TCAT is also tracking range and reliability.

FUTURE PLANS AND CLIMATE GOALS

TCAT plans to be 100% electric by 2035, according to NY State's goals. However, purchasing timelines will be dependent on other agencies, since TCAT's bus orders per cycle will be small, and they plan to join with other offers from other agencies. TCAT is planning to build a new facility in the next 10 to 15 years, and they are also researching electric microtransit vehicles.

The first round of BEBs was launched on Earth Day to highlight its climate and sustainability impacts. The agency also hopes that nicer buses may entice people back on board transit, with GPS tracking, Wi-Fi, and USB charging ports.

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Innovative Deployments Outside of New York (Part 2)

Full Fleet Transition in Antelope Valley, CA

Agency: Antelope Valley Transportation Authority (AVTA)

AVTA was the first transit agency in the US to convert its entire local fleet to electric buses. In 2016, AVTA awarded a contract to BYD to provide up to 85 BEBs in five years, manufactured at a local Southern California facility. As of May 2021, all 65 vehicles in the local fixed route fleet are BEBs, with all-electric commuter buses currently being phased in, with expected completion by the end of 2021. The fleet includes 45-foot commuter coaches and 60-foot articulated buses. To support the all-electric fleet, AVTA utilizes on-route wireless induction charging as well as overnight hard-wire charging in a depot. With the wireless charging stations, the BEBs can remain in revenue service for as long of a distance as their diesel counterparts. The depot has 87 charging stations, with a 1.5-megawatt backup generator that can power all the charging infrastructure in an emergency.

Charging-as-a-Service in Anaheim, CA

Agency: Anaheim Transportation Network

The Anaheim Transportation Network in Southern California has a Power Purchase Agreement and Charge Management Service contract with AMPLY Power to manage all aspects of charging for their electric buses. The 20-year contract, begun in 2020, covers system design, charging infrastructure installation, equipment purchase, operations, and maintenance for a fixed price per KWh consumed by the agency. Management and operations services include charge automation software to flatten peak electrical demands in order to reduce the need for utility service upgrade requirements and minimize electrical grid impacts. Infrastructure support includes the installation of charging stations and subcontracting for the installation of solar panels, as well as the construction of future infrastructure as the electric fleet expands.

Gross Cost Contracting in Pune, India

Agency: PMPML (Pune Mahanagar Parivahan Mahamandal Limited)

For e-bus adoption in Pune, India, PMPML decided to procure, operate, and maintain e-buses on a gross cost contract (GCC) basis (also known as a wet lease). The GCC model is a contract structure for public transport services in which a transit authority pays a bus operator on a per-kilometer basis for a city bus service with specific route concessions. In this case, PMPML pays a per-kilometer fee and handles service standards, scheduling, route planning, and fare collection. The operator procures the buses and infrastructure and handles operations and maintenance, including the provision of a driver and crew. The GCC model reduces capital and technology risk for the agency because there is no outright purchase and thus no upfront cost barrier. However, the agency must monitor key performance indicators (KPIs) carefully to ensure that the operator is meeting its requirements.

Renewable Energy and Energy Storage in Martha's Vineyard, MA

Agency: Martha's Vineyard Transit Authority (VTA)

As part of the agency's transition to an all-electric fleet, VTA launched a single-user renewable energy microgrid to power the growing fleet. The microgrid uses on-site solar power and battery energy storage, and is an energy distribution, storage, and generation network that can be disconnected from the main power grid in the case of power outages. The fleet is powered largely through the 700 kW DC solar PV array at the existing VTA depot, which is owned and operated by VTA and Enel X in a public-private partnership. The energy storage systems, one 100-kW system and two 280-kW systems, capture and store solar energy to allow for charging outside of sunlight hours.

Renewable Energy and Energy Storage in Anaheim, CA

Agency: Anaheim Transportation Network

Included in Anaheim Transportation Network's contract with AMPLY is the construction of a 545kW solar canopy that provides 25% of the total expected energy consumption of the fleet. The complete solar charging infrastructure includes TESLA MegaPack battery energy storage systems, microgrid controller units, and heavy-duty charging stations.

Public Private Partnership in Santiago, Chile

Agency: Red Metropolitana de Movilidad

RED, the public transportation agency for the Santiago Metropolitan Region, entered into a public private partnership with energy technology company, Enel X, as well as Metbus and BYD, to create an innovative model for financing and deploying electric buses and their associated infrastructure. The business model consists of a single service provided by Enel X, including the electric buses, charging stations, and electricity. With 500 buses, 11 depots, and 245 charging stations already on the ground in Chile, Enel X is contracted to eventually manage and operate more than 1,400 electric buses, making Santiago Chile the second largest operator of electric buses in the world—behind Shenzhen, Cina.

Stage 3: Commitment to Full Scale

Many agencies share the concern about BEBs' ability to meet the ranges required for their existing services, particularly those in rural areas with long routes. Range anxiety also stems from the knowledge that cold weather, topography, and on board equipment can greatly impact what is promised by the bus manufacturer. Initial deployments should generate useful data to build confidence on BEBs' ability to meet operational needs and it may inform the location and approach to vehicle charging.

Photo from NYCT

Beyond vehicle range requirements, facilities may need to be upgraded or expanded to accommodate charging infrastructure and vehicle staging to ensure assigned deployment.

Physical space is also related to the power supply, which involves coordination with utility providers. Anticipating facility and utility investments is critical to ensuring funding is available to meet these requirements, in addition to the additional cost of BEBs.

This stage assumes successful initial deployments will provide direction on future fleet and facility needs and guides transit agencies towards fully incorporating BEBs into their fleet as part of ongoing operations. This includes assuming the higher cost of BEBs in fleet replacement programs; addressing remaining facility investments to ensure the necessary charging infrastructure, including power requirements; and aligning available vehicle technology with operational needs, specifically range requirements that do not require increases in fleet or operational costs.

Action Steps for Stage Three

- **Procure BEBs** through ongoing transit revenue streams in line with vehicle replacement schedules
- **Make a plan for upgrading all facilities** (or construct new facilities) to charge fully electric fleet
- **Determine how to deploy BEBs** on existing schedules based on vehicle range, or update schedules to work for BEBs
- **Ensure resiliency** of the system

WORK TOWARDS FULL SCALE BEBS MOSTLY THROUGH ONGOING TRANSIT REVENUE STREAMS

New York State has set a goal to transition all state vehicles to zero emission by 2040. Given the 12-year useful life of a transit bus, New York transit agencies will need to be ready to purchase only zero emission vehicles starting in 2028. Grant programs at the federal and state level have been able to provide funding for the incremental cost of vehicles for initial pilots or deployments, along with some one-time capital costs for facility upgrades. However, long-term planning will require an agency to budget for BEBs and associated infrastructure as part of their ongoing annual operating budget and capital program.

Transit agencies may consider developing a long-term BEB transition plan, including an ongoing review of costs and benefits and total cost of ownership. This will help to anticipate the higher cost of BEBs, but also might identify some savings related to preventative maintenance and diesel fuel. In addition, continued advocacy for greater transit funding at the local, state, and federal level will ensure the cost to transition to BEB fleet will not come at the expense of quality service.

Agencies may also consider alternative funding models such as:

- **Bus and Battery Leasing:** Leasing buses and batteries reduces the need for an initial capital outlay and lowers the transit agency's risk in this new technology. However, leasing draws from the agency's operational budget and, while overcoming the up-front capital requirement, costs more in the long run. The terms of financing will dictate the accounting categorization of the asset, whether it is a capital expense or an operational expense, which may complicate the use of this financing option.
- **Power Purchase Agreement (PPA):** In a PPA arrangement, the financier provides the capital needed and the service required for the asset in return for guaranteed use of the asset, which includes a fixed price for units delivered. This scheme fits well for third-party funding and operations of electric bus charging infrastructure in which the use of the asset can be calculated with accuracy, and capital requirements are defined by engineering designs. An additional benefit to a transit agency is handing off the risks of owning and operating charging infrastructure to a third party that is motivated to optimize the infrastructure and cost of energy delivered.
- **Charging-as-a-Service (CaaS) Models:** Charging infrastructure for BEBs can require a large upfront cost for transit agencies, as well as the technical knowledge needed to understand charging equipment needs, utility rates, and energy infrastructure. Transit agencies may not have this funding and technical capacity in house. An opportunity to simplify this process and spread costs out over the longer term is to enter into a public-private partnership or charging-as-a-service (CaaS) project.

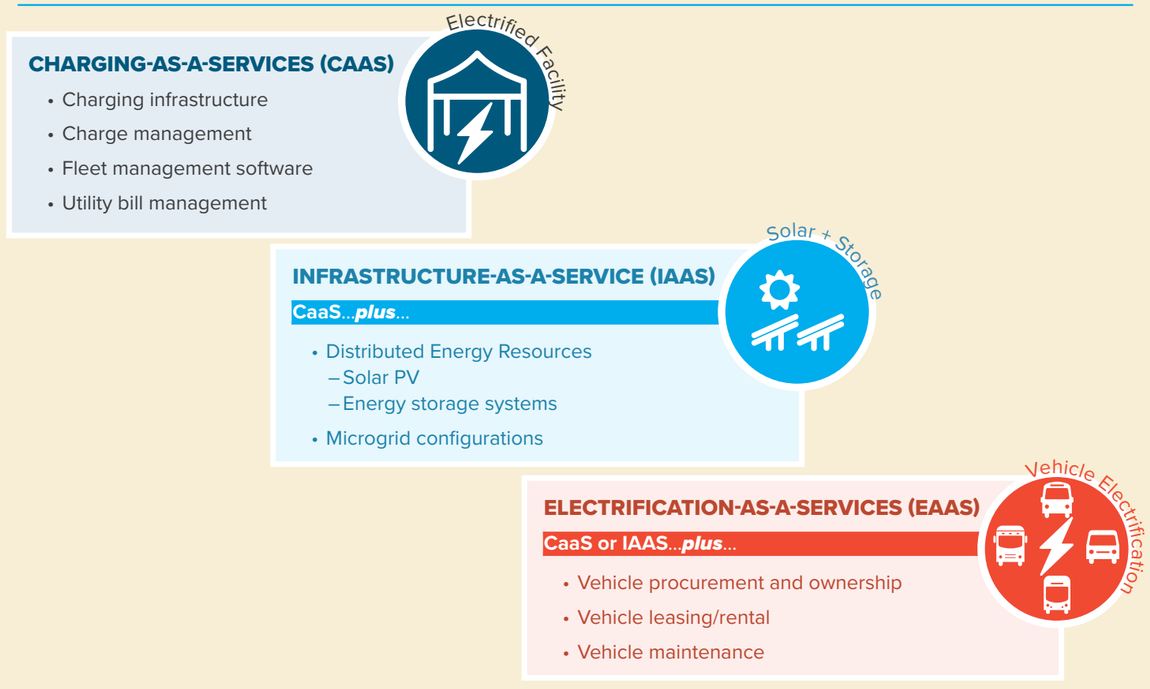
A CaaS partnership is where a third-party company (outside of the transit agency and utility company) designs, builds, finances, operates, and maintains charging infrastructure for a transit agency, and the transit agency pays a fee on a recurring basis. CaaS models may take different forms and some may also include distributed energy resources and/or vehicle procurement and maintenance (see illustration at right).

While lifetime costs may be higher, upfront costs are significantly less for transit agencies, and the third-party takes on most of the financial risk. Less project management and technical expertise is needed on the transit agency staff side as well. For agencies that contract services, there are opportunities to explore CaaS and similar models through incorporating them into the RFP process, where existing and future contracted operators can either also service charging infrastructure or partner with different contractors who do this work.

THINK ABOUT TOTAL COST OF OWNERSHIP

In order to achieve the environmental and community benefits of BEBs, transit agencies will also need to make the business case to board members and other stakeholders to ensure that the transit agency can continue to meet its mission to provide high quality public transit service. This will require active participation in the management of utility costs to optimize charging practices, adjustments to training to ensure vehicles are operated and maintained to maximize performance, and careful consideration of deployment plans and facility investments to minimize operating and capital costs. Several New York agencies are well on their way to calibrating their early deployments to minimize costs and optimize performance—shared experience amongst providers will provide best practices for New York transit agencies.

Charging-as-a-Service



DETERMINE THE RATE AT WHICH TO SCALE UP BEBs

Only a handful of agencies have achieved 100% transition to zero emission vehicles. Today's BEB technology does not meet the range required across all routes and services. In addition, many agencies in New York provide service that cannot be served with existing BEB technology—such as demand response service with smaller vehicles to longer commuter services on coach buses.

Agencies may be able to implement an initial deployment, but full transitions will require either an adjustment to operating practices/service design or an increase in fleet, both of which will increase operational costs. Other options include consideration of other alternative fuels such as fuel cell or hydrogen buses. While additional vehicle technologies will allow for faster transition, it also introduces a more complex fleet makeup and additional facility and infrastructure needs. Some agencies may choose to wait until BEB technology matures to the point where range is not an issue and more BEB vehicle types are available.

Beyond external factors, the speed at which agencies can transition will relate to the timing to procure according to their fleet replacement plans, capital funding to retrofit and expand their facilities, utility readiness to increase electric supply, and the capacity of agency staff to both manage new investment and successfully incorporate BEBs into daily operations.

DEPLOY BEBs ON MORE BLOCKS

BEBs are most easily deployed on routes where their mileage is well within the expected range and service schedules allow for long periods of time for depot charging. In addition, transit facilities that have ample space for parking and charging will find it less challenging to accommodate chargers and separate BEBs for easy vehicle assignments during pull out.

Transit agencies that operate on flat roads and in moderate climates will face fewer challenges than places with more hilly terrain, steep grades, and varied temperatures ranging from extreme cold to very hot and humid. Most New York agencies will face constraints due to multiple factors and may need to conduct more real-world testing and incremental deployment strategies. Transit agencies may need to consider solutions such as auxiliary heating systems, to preserve battery life.

The gap between available electrical power and grid capacity will also inform the rate at which BEBs can be deployed. If additional investments are required by the utility provider, the timing of utility upgrades, new power lines, and potentially new substation investments may be more of a factor than internal limitations due to block or route lengths.

Photo by RTS

PROCURE BEBS IN LINE WITH VEHICLE REPLACEMENT SCHEDULES

FTA requires that transit agencies maintain a fleet replacement schedule which ensures fleet are properly maintained and replaced in accordance with their useful life. Agencies must also follow requirements around spare ratios to ensure fleet are being properly utilized for revenue service. If the higher cost of a BEB delays procurement of new fleet, it could result in higher maintenance costs for older diesel vehicles. In addition, one-time grants may spur a large vehicle purchase, which will impact replacement costs in outer years.

Timing purchasing decisions that incrementally replace fleet, targeting older fleet with higher maintenance costs, road calls, and poor emissions quality will ensure BEBs have a positive impact on the overall fleet replacement program. Mandates may influence a faster replacement rate, but federal requirements must be followed to ensure vehicles meet their useful life. In addition, new vehicles may require investment in workforce development to ensure mechanics are familiar with new electrical systems. Other factors include developing an inventory for spare parts, purchasing tools, and modifying preventative maintenance programs, as well as factoring the costs of battery replacement at some point during the vehicle life.

EXPLORE MORE EFFICIENT CHARGING OPTIONS

Beyond higher vehicle costs and infrastructure improvements, another challenge involves assessing and planning for the cost of electricity. Diesel and CNG fuel costs are a volatile commodity, and price fluctuations are managed with futures contracts and volume procurements. This approach is possible given the historical record of fuel prices. Electricity costs are a new element for transit agencies and although price is stable, it remains somewhat unfamiliar. As a result, agencies are often surprised by demand charges, which are incurred at defined thresholds. This is an easily managed problem with smart charging, and utility representatives have become more proactive in their guidance for fleet customers.

These variables make it difficult to accurately budget, as well as impact how initial decisions around depot and on-route charging and facility investments are made. Additional stressors on the grid, such as increased demand and weather events, make long-term planning more difficult. Because of all of these factors, a combination of on-route and depot charging may balance charging needs across a service area. Charging schedules may need to be adjusted several times to optimize costs.

Agencies can also explore generating and/or storing energy on site, which may reduce electricity costs, help create more resilient systems, and be more environmentally sustainable long term. For example, installing solar panels can feed electricity into directly charging buses. When buses do not need to be charged, electricity generated from solar can be directed into the grid or stored on-site through battery storage, which can be utilized during other high demand times without enough sunlight, saving on demand charges. Lastly, transit agencies may also want to consider more diversity in their fleet at scale, with hydrogen as another way to achieve a zero-emission fleet.

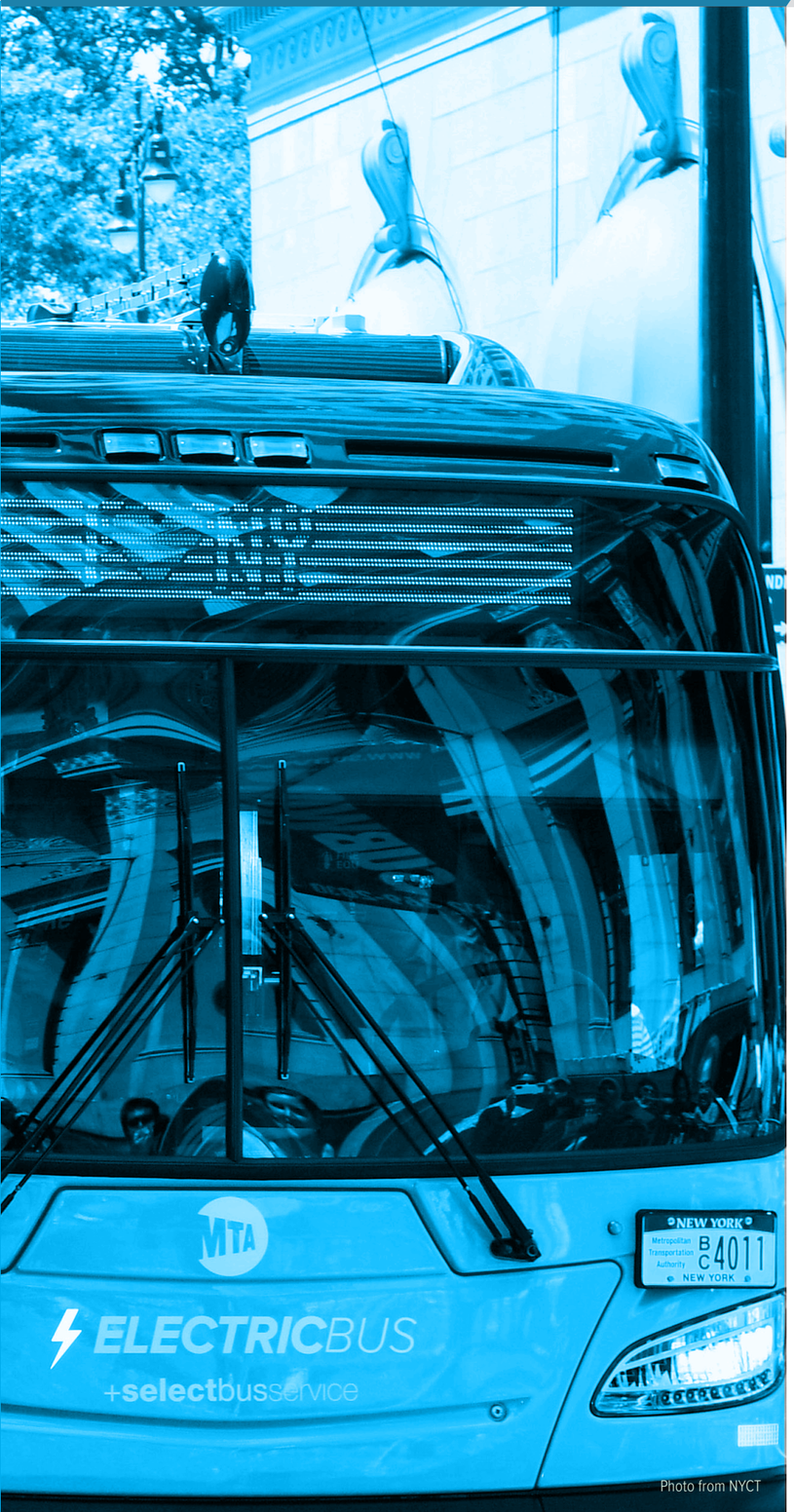


Photo from NYCT

EXPANDING GARAGE CAPACITY FOR BEBS

As transit agencies move from initial pilot deployments to full-scale electrification, they will most certainly need to upgrade their facilities, both space- and electricity-wise, to allow for successful yard management and charging of BEBs. Depending on existing facility space and infrastructure, this may involve expanding existing facilities or perhaps securing new facilities. Staff should utilize data and best practices gleaned from initial deployment(s) to inform the plan to manage buses and charging as agencies expand their BEB deployments.

These expansions and upgrades should be aligned with the fleet's vehicle replacement phasing. Factors to consider while aligning vehicle replacement and facility expansion include:

- Lead time for BEB orders: 1-2 years
- Lead time for space upgrades in facility: variable, based on how much new construction is needed
- Lead time for electrical upgrades in facility: highly variable, requires conversations with utility providers
- Vehicle replacement cycles: each bus order, conventional or BEB, will be in service for 12 years or longer, so each time a bus is due to be replaced reflects a major decision point for the agency

Facility upgrades should be timed so that there is enough capacity to operate and maintain new BEBs prior to the arrival of each new procurement. Depending on the needs of specific agencies, it may be beneficial to build out facilities all at once to fit multiple rounds of procurements, as opposed to making incremental changes.

Eventually, agencies will be able to phase out diesel equipment, which may open up additional space and present cost-saving opportunities by eliminating redundant systems. New safety procedures related to a high-voltage work environment will also need to be implemented.

UPGRADE ALL FACILITIES TO CHARGE FULLY ELECTRIC FLEET

As additional BEBs are added to the fleet, agencies should continue to work with utilities to ensure that the electric infrastructure is prepared to charge these vehicles and to ensure that they are managing charging appropriately to minimize electricity costs. Collaborating with energy efficiency organizations can also help agencies take advantage of make-ready incentives and/or increase efficiency in other parts of agency operations.

Transit agencies may also want to consider investing in on-site electricity generation (e.g., solar panels) and/or battery storage to mitigate electricity costs, especially if operational plans require charging during "peak" periods of grid demand. Additionally, investing in resiliency opportunities, such as microgrid development, can help ensure agencies are able to operate even during emergencies when the grid may be down.

To help minimize capital expenditures and the strain on limited internal planning resources, transit agencies may wish to take advantage of charging-as-a-service or infrastructure-as-a-service models, such as those described in Stage 2.

STAGE THREE RESOURCES

Zero Emission Bus Resource Alliance (ZEBRA)
http://zebragrp.org/

APTA
https://www.apta.com/research-technical-resources/zero-emission-bus/

New York Public Transit Association (NYTPA)
nytransit.org

The International Association for Public Transport (UITP)
http://www.uitp.org

Center for Transportation and the Environment (CTE)
https://cte.tv

CALSTART - Taking Commercial Fleet Electrification to Scale: Financing Barriers and Solutions, 2021
https://globaldrivetozero.org/site/wp-content/uploads/2021/03/Taking-Commercial-Fleet-Electrification-to-Scale-White-Paper.pdf

Tool Provider Appendix

[Listed alphabetically]

Tool Provider	Tool Type(s)*	Description
Advanced Clean Tech (ACT) News	Buyers' Guide Funding Programs Database	ACT News provides information on the latest trends driving the future of commercial transportation, including over-the-road fleets, aviation, maritime, rail, and seaports. Coverage includes emerging topics such as connected technologies, efficiency strategies, autonomous, digitization, electrification, and alternative fuels. The ACT Buyers' Guide is a directory of organizations that bring to market the advanced vehicles, fuels and technologies driving the future of sustainable fleet transportation. Download product brochures and technology guides, view informational videos, and contact company representatives to set up a meeting. ACT News also offers a database of federal, state, and local funding programs that are currently available to assist fleet operators in the deployment of clean vehicles and equipment, and new infrastructure developments.
AMPLY Power	Charge management software (CMS) Charging-as-a-Service (CaaS)	AMPLY Power is a comprehensive electric vehicle charging and energy management provider for fleets operating trucks, buses, vans, and light-duty vehicles. Their OMEGA™ Charge Management System optimizes charging for lowest-cost energy while offering improved resilience and reliability, all in a user-friendly dashboard. AMPLY also offers a charging-as-a-Service (CaaS) model, assuming responsibility for all charging aspects of an EV fleet—from EVSE procurement and installation to operations and maintenance.
CALSTART	Vehicle model catalogue Infrastructure Planning Guide Consulting services	CALSTART is a national nonprofit focused on accelerating clean transportation. Their Zero-Emission Technology Inventory (ZETI) tool is an interactive online resource that provides fleets with information about worldwide commercially available offerings of zero-emission medium- and heavy-duty vehicles (MHDVs). Fleets can search by vehicle type (e.g., transit bus), region (e.g., U.S. & Canada), and manufacturer. They also offer a simple Infrastructure Planning Tool for transit fleets to help guide successful electric bus charging.
Center for Transportation and the Environment (CTE)	Consulting services	CTE is a member-supported nonprofit organization that develops, promotes, and implements advanced transportation technologies, vehicles, and fuels that reduce environmental pollution and fossil fuel dependency. CTE offers Fleet Transition Planning services that consider energy requirements, fleet procurement timelines, fueling and infrastructure needs, total cost of ownership projections and operating, and maintenance costs.
Canadian Urban Transit Research & Innovation Consortium (CUTRIC)	Consulting services	CUTRIC is a non-profit organization that spearheads, designs, and launches technology and commercialization projects that advance next-generation zero-carbon mobility and transportation solutions across Canada. It also develops low-cost simulation tools that help transit agencies across Canada and the United States predict how their electric buses, hydrogen fuel cell buses and autonomous smart vehicles (for first kilometre/last kilometre solutions) will operate in real-time on roads and in service. CUTRIC's RoutΣ.i™ 2.0 modeling tools helps transit agencies reach their decarbonization and electrification goals scientifically and neutrally and include duty cycle analyses, charging analyses, GHG emission reduction analyses, electricity cost assessments, and suitability analyses.
eIQ Mobility	Fleet Electrification Modeling Charging Facility Modeling Charging Infrastructure	eIQ offers a range of fleet electrification solutions, from EV feasibility assessments, and energy and cost modeling, to EV charging infrastructure. Their EValuate tool provides data-driven fleet electrification insights that include recommendations about EVs and chargers, as well as detailed information about costs, savings, greenhouse gas emissions, and incentives. Their REVeal ™ tool provides energy load and cost modeling for EV charging facilities. They also offer EV Charging Infrastructure design, financing and management through their parent company, NextEra Energy.
Electriphi	Charge management software (CMS) Electrification Planning Deployment Services Charging-as-a-Service (CaaS)	Electriphi's Charge Management software helps fleets save on energy costs and track key operational metrics. They offer software-as-a-service. They also offer an online Total Cost of Ownership Calculator, a free Fleet Electrification Planning Tool, and all-inclusive deployment services, including design, OEM selection, project financing (including charging-as-a-services or fleet-as-a-service options), and integrations between chargers, vehicles, telematics and enterprise systems.
Greenlots	Charge management software (CMS) Turnkey EV Charging Solutions Charging-as-a-Service (CaaS) Energy Management	Greenlots helps fleet owners and operators realize the total cost of ownership savings from transitioning to electric vehicles while providing reliable and accessible EV charging solutions. Their SKY™ EV Charging Network Software enables customers to efficiently deploy and manage their own network of smart EV charging stations at scale. Their Turnkey Approach to EV Charging includes site evaluation, hardware procurement, engineering and construction services, installation and commissioning, managed charging software, and operations and maintenance. Greenlots also offers Charging-as-a-Service, a subscription-based EV charging package that provides turnkey EV charging solutions with minimal upfront purchasing costs. Their energy management solutions help customers minimize electrical bills and reduce the need for costly infrastructure upgrades by managing the charging load at each site. Energy management solutions include peak load management, distributed energy resources (DERs) integration, and/or demand response. Greenlots can also help fleets identify and leverage existing state and federal incentives that will help you reduce the project's capital expenses.

*Type(s) include main products and/or services offered by tool provider. Offerings may change or expand.

Note: This list is not intended to be comprehensive. Rather, it includes the main providers that the project team spoke with for this project. New tool providers are entering the market quickly, and fleets should conduct their own research before selecting tool providers.

Tool Provider	Tool Type(s)*	Description
Innovations In Transportation (INIT)	Electrification Planning Charge management software (CMS)	INIT offers a range of electromobility solutions for transit fleets. Their planning system, eMOBILE-PLAN provides users with simulations to determine exactly which e-buses are right for their transit system. It also identifies the best charging strategy. Of particular interest to transit fleets, the tool can also identify specific parameters such as varying outside temperatures or route topology and provide efficient optimization algorithms so blocks are created that are both economical and robust. Their MOBILEcharge charge management tool ensures uptime and cost-effective charging of buses and also integrates with their depot management system, MOBILEDMS.
Microgrid Labs (MGL)	Electrification Planning / Optimization of EV Battery, Charging and Energy infrastructure DER and Microgrid Modeling, Simulation and Optimization Consulting Services	MGL is a consulting and software company specializing in commercial fleet electrification and microgrids. Their services range from initial assessment, feasibility studies, modeling, simulation and optimization to support during implementation and operations phase. Their modeling and optimization software, EVOPT models the driving /charging process, quantifies electrical demand and derives the right balance of vehicle battery, charging infrastructure, and operational needs. Their modeling and optimization software, DEROPT optimizes distributed energy resources (DERs) and microgrids.
Sawatch Labs	EV Suitability Assessment EV Infrastructure Planning EV Management	Sawatch Labs utilizes fleets' operational data to provide them with actionable recommendations to optimize operations. Their EV Analytics software, ezEV provides fleet EV suitability assessments while their infrastructure planning software, ezIO can predict daily charging locations and demand curves. And their ionEV software allows fleets to manage EVs by tracking savings and emissions reductions, comparing to a business-as-usual baseline, and tracking charging by location and type.
The Mobility House	Charge management software (CMS) Consulting services	The Mobility House is a technology company working to help create a zero-emission energy and mobility future. Their technology platform, ChargePilot enables reliable and efficient charging of electric vehicle fleets and vehicle grid integration using intelligent charging and energy solutions. They also offer consulting services such as fleet and charging analyses and distributed energy resources (DER) evaluation.
ViriCiti	EV Telematics Charger Monitoring Charge management software (CMS) Depot Management	ViriCiti is a technology company dedicated to accelerating the transition to zero-emission transport. Their public transport telematics tool allows fleets to manage all vehicle and charging station types in one portal, cut costs through driving style analysis and smart charging. They also offer charger monitoring, smart charging, and Depot View, a real-time overview of the EVs and chargers in your depot. In partnership with BAE Systems, their EV Mode system allows fleet operators with BAE Systems Series-ER (Electric Range) electric hybrid systems on transit buses to switch hybrid buses to all-electric mode automatically in predefined geofenced areas.

*Type(s) include main products and/or services offered by tool provider. Offerings may change or expand.

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