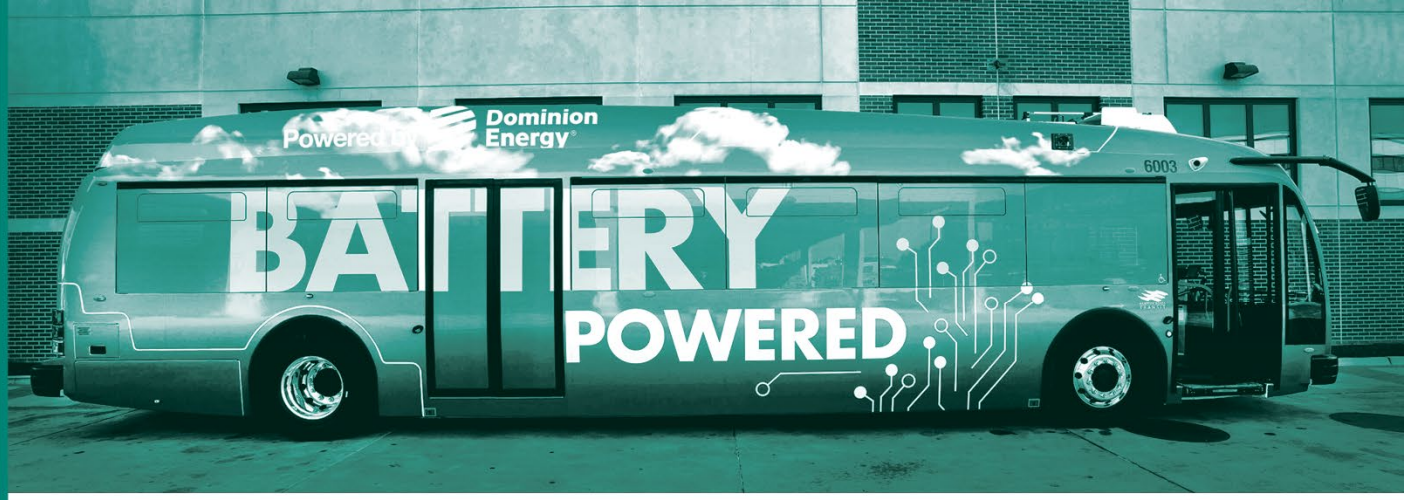

Modernizing Transit Fleets

Final Report

DRPT VIRGINIA DEPARTMENT OF RAIL AND PUBLIC TRANSPORTATION

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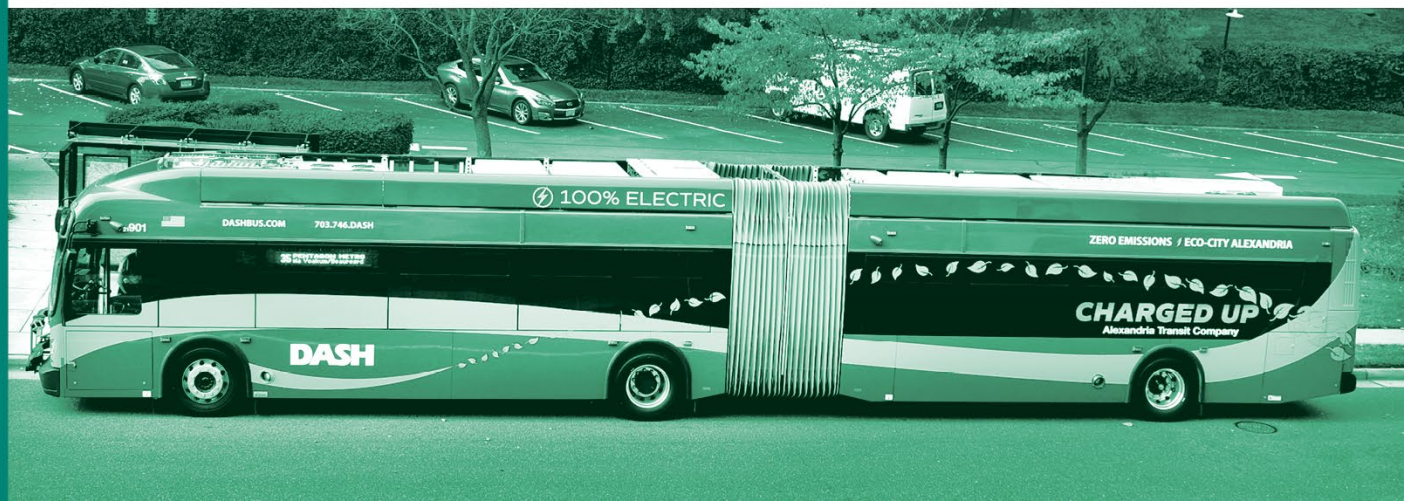

FINAL ✦ August 2024

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EXECUTIVE SUMMARY

The Modernizing Transit Fleets project aims to create a comprehensive resource guide and toolkit for Virginia's transit agencies that wish to transition their fleets to low- and zero-emission vehicles. It directly builds on, and is a direct result of, the analysis conducted through the House Joint Resolution 542 Transit Modernization Study, with a focus on gathering resources for rural and small-urban transit agencies to take advantage of technological advancements and federal funding opportunities. The Commonwealth of Virginia and the Department of Rail and Public Transportation (DRPT) recognize that providing guidance on low- and zero-emissions fleet transitions is a key component of modernizing travel in Virginia by keeping pace with emerging technology in the public transportation industry. The project team explored a variety of topics related to low- and zero-emissions bus deployment and engaged heavily with industry, utility, and agency stakeholders.

This final report represents a high-level summary of work conducted by the project team, to date, for the Modernizing Transit Fleets project. The primary focus of this document is to present the methods and approach that the project team used in each stage of the project. This report does not focus on the outcomes of the project, which are captured in technical memorandums and other project deliverables—most notably, the Guidebook. The following topics are included in this report:

- Industry Partner and Stakeholder Engagement
- Utility Provider Engagement and Planning
- Data Collection and Study Review
- Emissions Reduction Target Scenarios and Financial Analysis
- Workforce Development Opportunities Assessment
- Fleet Transition Plan Template
- DRPT Action Plan
- Guidebook
- Conclusion and Next Steps

I. INDUSTRY PARTNER AND STAKEHOLDER ENGAGEMENT

Approach

Industry partners and stakeholders played important roles in the development and refinement of the project resources as many will directly use or benefit from the resources developed through this project. The project team engaged with a range of partners and stakeholders, shown in **Figure 1**, throughout the project process. The engagement program included tailored engagement opportunities for specific audiences. For example, industry partners were best equipped to provide insight on topics relating to utility engagement and financial analysis. And agencies, the primary audience for the Guidebook, were best able to provide real-world challenges and refinements to make the resources more useful in agency processes. The following sub-sections summarize the engagement with these industry partners and stakeholders.

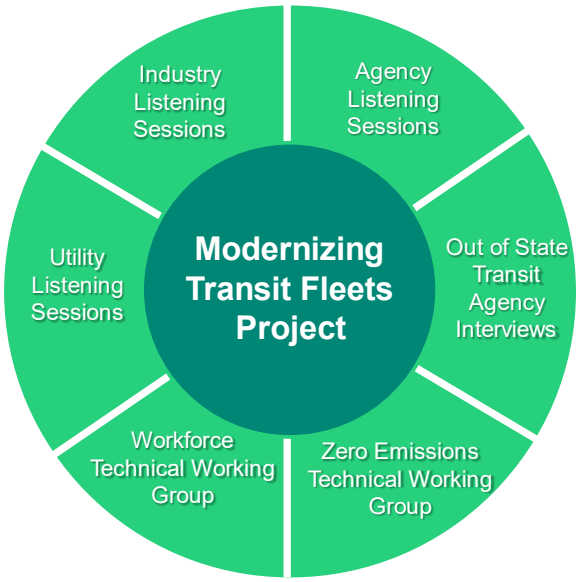


Figure 1: Modernizing Transit Fleets Stakeholder Groups

A summary of the stakeholder outreach activities discussed in this chapter of the Final Report are shown in **Figure 2**.

Figure 2: Stakeholder Engagement 'By-the-Numbers'

The project team also conducted interviews with utility providers and out-of-state agencies, discussed in the ***Utility Provider Engagement and Planning*** chapter and ***Data Collection and Study Review*** chapter, respectively. Summaries and takeaways from the Workforce Technical Working group are discussed in the ***Workforce Development Opportunities Assessment*** chapter.

Listening Sessions

The first phase of engagement focused on listening to and learning from ***agency representatives*** and ***industry partners***. Two virtual sessions were made available for each stakeholder group to allow for flexibility of scheduling for the invited attendees. Meeting dates and entities represented are detailed in **Table 1**.

Table 1: Entities Represented in the Listening Sessions

Agency Listening Sessions	Industry Listening Sessions
June 20, 2023 ***June 26, 2023***	***June 21, 2023*** ***June 27, 2023***
Attendees • Alexandria Transit Company (DASH) • Appalachian Agency for Senior Citizens (AASC) • Central Shenandoah Planning District Commission • Farmville Area Bus • Fredericksburg Regional Transit (FXBGO!) • Greater Lynchburg Transit Company (GLTC) • Mountain Lynx Transit • Mountain Empire Older Citizens, Inc. • Lake Country Area Agency on Aging (LCAAA) • OmniRide • Roanoke County • Valley Metro • Virginia Regional Transit • Williamsburg Area Transit Authority	***Attendees*** • Proterra • Sonny Merriman • ABB E-Mobility • Siemens

During the listening sessions, agency representatives expressed high-level questions on the following topics related to fleet transitions:

- Funding
- Resiliency
- Costs/Benefits or Risk Management
- Governing Board Directives
- Prioritization
- Hydrogen
- Studies
- Manufacturers
- Knowledge Gaps

During the industry partner listening sessions, attendees provided insight on how agencies can better plan for transitions. Partners advised agencies to understand the total energy grid capacity and strategic charging schedules, strategically plan vehicle procurement and preparation with utilization, and identify the responsibilities or the roles of involved parties. Stakeholders, both agencies and industry partners, noted that there is not a 'one-size-fits-all' approach to integrating new technologies.

Stakeholders also provided feedback on the project deliverables, including the Guidebook. Overall, stakeholders desired resources that included specifics on how to best coordinate with utilities, successful case studies, factors to consider, workforce development resources, and tools such as return-on-investment and route modeling.

Technical Working Groups

The project's technical working group was convened to solicit diverse perspectives, help to identify gaps and considerations, and review and provide feedback on technical memo content. The technical working group convened four times throughout the duration of the project. The schedule and purpose of the meetings are shown in **Figure 3**. **Over 22** entities were invited to the technical working group meetings.

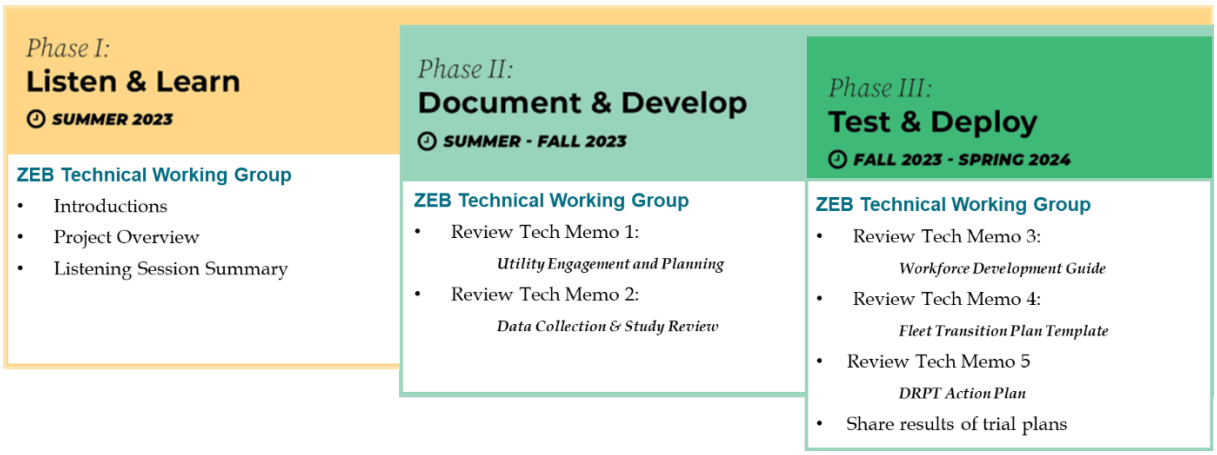


Figure 3: Technical Working Group Schedule and Purpose

The following subsections outline the details and key takeaways of each of the technical working group meetings. In addition to the project technical working meetings, the project also convened a workforce technical working group discussed in the ***Workforce Development Opportunities Assessment*** chapter.

Technical Working Group #1

The first technical working group meeting was hosted on September 12, 2023. **Sixteen** attendees representing **13** agencies participated in the meeting:

- Alexandria Transit Company (DASH)
- Blacksburg Transit
- Dominion Energy
- Eno Transportation Center
- Fairfax Connector
- Hampton Roads Transit
- Harrisonburg Department of Public Transportation
- Northern Virginia Transportation Commission (NVTC)
- Southern Environmental Law Center
- Virginia Department of Environmental Quality (VDEQ)
- Valley Metro
- Virginia Regional Transit
- Virginia Transportation Research Council

The meeting provided an overview of the project, technical memos, and the role of the technical working group. The presentation also included the findings of the project's agency and industry listening sessions. Members of the technical working group provided feedback on the challenges they currently experience and opportunities for the Guidebook. A brief summary is shown below:

- Desire for return-on-investment tools, case studies of successfully implemented systems, utility coordination for agencies, and EJ40 requirements.
- Challenges with timeline, contingency, scheduling/ordering, and integrating resilience planning.

The feedback from the technical working group informed the development of the project tools and Guidebook.

Technical Working Group #2

The second technical working group meeting was hosted on October 24, 2023. **Nine** attendees representing **nine** agencies attended the meeting:

- Dominion Energy
- Fairfax Connector
- Hampton Roads Transit
- National Rural Transit Assistance Program (National RTAP)
- Northern Virginia Transportation Commission (NVTC)
- Rappahannock Electric
- Southern Environmental Law Center
- Virginia Transportation Research Council
- Virginia Regional Transit

The meeting provided an overview of the project, findings from the data collection and study review memo, funding opportunities, utility coordination, and a draft of the hydrogen checklist for agencies planning for fuel cell electric buses (FCEB). During the meeting, attendees participated in interactive real-time polling, responding to a number of prompts to help guide the discussion. Responses from agency representatives indicated that they plan to undertake a planning study and/or initial ZEB deployment before 2030 and desire fully zero-emissions fleet between 2040 and 2050. Responses revealed that 40 percent of utility representatives are currently working with transit agencies to prepare for fleet transitions. All attendees also provided insight on the organization of the Guidebook and discussed nuances of funding fleeting transitions. The feedback from the technical working group provided insights on the organization and content of the Guidebook.

Technical Working Group #3

The third technical working group meeting was hosted on February 13, 2024. **13** attendees' representing **13** agencies attended the meeting:

- Blacksburg Transit
- Eno Transportation Center
- Dominion Energy
- Fairfax Connector
- Harrisonburg Department of Public Transportation
- National Renewable Energy Laboratory (NREL)
- National Rural Transit Assistance Program (National RTAP)
- NiSource
- Northern Virginia Transportation Commission (NVTC)
- Rappahannock Electric
- Virginia Department of Environmental Quality (VDEQ)
- Virginia Transportation Research Council
- Virginia Regional Transit

In advance of the meeting, the project team shared the tools for attendees to trial. The meeting provided an overview of the project, the readiness checklist, fleet transition template, and financial and emission reduction tools. Attendees provided feedback on the usefulness or the checklists and tools. The feedback from the technical working group guided refinements to the checklists, tools, and the context provided in the Guidebook.

Technical Working Group #4

The fourth and final technical working group meeting was hosted on May 2, 2024. **11** attendees' representing **ten** agencies attended the meeting:

- Blacksburg Transit
- Alexandria Transit Company (DASH)
- Dominion Energy
- National Rural Transit Assistance Program (National RTAP)
- Southern Environmental Law Center
- The Climate Collaborative
- Virginia Department of Environmental Quality (VDEQ)
- Virginia Transportation Research Council
- Virginia Regional Transit

The meeting provided an overview of the project Guidebook including each of the sections and the types of resources provided. During the meeting, the project team shared the DRPT Action Plan and a preview of the sample actions included in the plan. The project team provided an update on the status of the ongoing trial of the Transition Plan Toolkit. Lastly, the project team provided an overview of technical memo #3, focused on workforce development, including the available information and resources. Attendees provided minimal feedback on the content.

Executive Level Briefing

DRPT staff and the project team hosted two executive leadership briefings for DRPT Executives. The first meeting was hosted on December 12, 2023, and the second meeting was hosted on July 25, 2024, with the project team attending in person at DRPT Headquarters in Richmond, Virginia. The project team provided a project overview, summary of stakeholder engagement, presentation of the readiness checklist and fleet transition template, and the financial analysis and emissions reduction tools.

II. UTILITY PROVIDER ENGAGEMENT AND PLANNING

Utilities play a key role in the transition to a low- or zero-emission fleet because no matter the vehicle technology or mix of technologies being implemented, the fuel source needs to be accounted for. Transit agencies should coordinate with utilities throughout the planning, design, construction, and implementation phases of the transition process to ensure a smooth fleet transition.

Utility Provider Engagement

The Modernizing Transit Fleets project team contacted 37 utility providers in Virginia with questions pertaining to establishing service for transit lots. Twenty of those utilities responded. Utility non-response was attributed to the medium of contact; using generic customer service numbers and contact forms yielded slow response, while direct email contact to engineers or other individuals at the utility saw higher response rates.

A common piece of information provided by electric utilities is that they cannot determine capacity availability without specific information on planned locations and load/demand. Until those two pieces of information are known, the utility cannot provide information with any degree of certainty. With natural gas utilities, this uncertainty extends to whether the location is close enough to a pipe that could supply a transit facility.

Information on lead times was provided by electric utilities. While the individual numbers differed, all utilities interviewed provided long lead time estimates for equipment. Utilities also noted wait times for right-of-way disputes could be lengthy. Estimated wait times for engineering and paperwork processing at a utility tended to be short, under a month. Generally, anything within the utilities' control can be done quickly, and anything outside of their control will take longer.

Any utility that was only a distributer but not a power generator noted that any large increase of demand on the grid may need to be confirmed with the energy provider. Municipality utilities that will need any grid extensions or have power added to the grid will need those plans reviewed and approved by the municipality.

Smaller grids all gave a similar response when asking about transit lots, indicating a need to talk to their City engineering department. Any power grid that did not have procedures for net metering in place indicated the same regarding adding power to the grid.

Transit agencies will want a point of contact within the engineering department of whichever utility they are dealing with. It will also be important to know any third-party decision makers such as townships or external power suppliers.

Electric and natural gas utilities within the Commonwealth range from large multi-state companies to local cooperatives. Each utility has a different structure and process for setting up accounts and new services. Generally, agencies should engage utilities as early as possible in the transition planning process.

Although larger utilities may have a defined process for accommodating large charging or refueling facilities, many smaller utilities interviewed did not have written guidance or procedures in place. Due to this lack of procedures transit agencies should expect a dialogue with their utility with both sides having key questions that may require additional research and back-and-forth conversation to answer. Most utility companies

interviewed allow an agent to apply for service and communicate on the transit company's behalf. This enables transit agencies to utilize outside experts to assist with these conversations.

Utility Cost Reduction Strategies

Bi-Directional Charging – Vehicle Grid Integration (VGI)

Traditional electrical vehicle (EV) charging transfers energy from the utility, first through a low voltage AC system, then through a charger, and to a vehicle's battery system. Bi-directional charging, also known as vehicle grid integration (VGI), allows for the energy stored in the vehicle's battery system to flow back through the charger into the AC system. This energy can be routed to several places:

- The facility's electrical system
- A stationary battery energy storage system (BESS)
- Another battery electric vehicle
- Appliances or loads
- Or the electrical grid

Reasons for incorporating VGI charging include:

- Reducing peak demand
- Generating additional revenue
- Better resiliency of the system

An EV can be described as a mobile battery energy storage system, or a battery on wheels. As such, it is a distributed energy resource that can return energy back into the grid. This can help create additional capacity for the grid during peak times of the day to avoid brownouts or require extra generation at the power plant. Typically, peak times for electric utilities are as follows:

- Residential: 6:00am - 10:00am, 5:00pm - 9:00pm
- Commercial: 10:00am - 5:00pm

In the middle of summer and winter, the peak demands are at their highest due to the increased use of air conditioning and heating, respectively. During peak times, the electrical grid can be strained and lead to brownouts. Utilities are adding sources of generation to lower dependence and emissions from typical coal-fired, hydroelectric, and/or nuclear generating plants. These additional sources may be solar, wind, or other alternative energies. Utilities are also increasing their usage of BESS to hold energy generated by alternative energy sources that do not need to be used immediately or energy that can be stored from the grid in off-peak hours. This stored energy can be utilized by utilities during peak hours to lessen the strain on the grid and reduce the amount of energy needing to be generated at the main plants.

VGI can turn battery electric vehicles into additional distributed energy resources. Distributed energy resources are small-scale energy sources that are geographically distinct from the main generating power plant, such as rooftop solar and batteries. When battery electric vehicles (BEVs) are used to put energy back into the grid, it is known as vehicle to grid (V2G). When V2G is utilized, it is for one of two purposes: to reduce peak demand on the local facility's electrical system or to generate revenue.

Transit agencies can utilize their fleets for V2G, but several factors need to be considered prior to implementation:

- **Dwell time of the battery electric buses.** First, each bus's time in the depot should be used to charge its battery to the charge level required for its routes the following day. If the bus is sitting at the depot for additional time beyond its charging, there may be an opportunity for V2G.
- **Schedule for the battery electric buses to dwell at the depot.** Since most bus depots will be subject to electric rate schedules that have on-peak and off-peak rates for energy use, it makes financial sense to optimize when buses are charged. Whenever possible, buses should be charged during off-peak hours so that the cost to charge is minimized. If buses dwell at a depot during on-peak and off-peak hours, and there is sufficient time to charge in the off-peak, V2G can be accomplished during the on-peak hours. The advantages to V2G during on-peak hours are reducing peak demand on the grid and revenue generation. When electricity is sold back to the utility during on-peak hours, the utility typically pays the higher peak rate. This is how part of the V2G business model works – buy low, sell high: charge vehicle battery at off-peak prices, sell back energy from the battery at on-peak prices.
- **Electric utility agreements need to be in place for VGI.** Transit agencies need to understand what the electric utilities will and will not allow for VGI charging and what is required for VGI charging. An interconnection application will be required. This application will let the utility know what amount of energy is being proposed to connect to their system and where it is located. The interconnect application process may take several months for the utility to review and approve.

Many transit agencies may find that their bus schedules will not allow for the additional depot dwell time to make V2G feasible. Time is the most limiting factor in the transit sphere. However, if time is available for buses to implement VGI charging, transit agencies should at least investigate the opportunity to see if it is right for them. The positive effects of VGI charging are:

- Reduced peak demand
- Revenue generation/reduced electrical bill
- Increased resiliency

Microgrids

VGI charging allows the battery of an EV to be an energy source, rather than just a load. And as an energy source, the vehicle's BESS can provide supplemental support to the facility's electrical system and grid as described previously. But when there also other sources of generation available, they can be interconnected to create a reliable system that sees the electrical system uptime maximized and the strain on the grid minimized.

The National Renewable Energy Laboratory (NREL) defines a microgrid as "a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid." The EV's BESS, solar panels, generators, utility connections, etc. are the load and resources. They are wired and networked together and programmed to operate efficiently with respect to the grid. When used in conjunction with the utility electric grid, the microgrid is operating in grid-connected mode.

Microgrids can also operate in island mode in which these distributed energy sources can operate the system when the grid is off-line. This typically happens during major storm events or extreme temperatures. The microgrid controller recognizes the utility is offline and the other energy resources become the main power source. Sources like solar panels and generators generate power that can be used immediately. Batteries can store the energy generated by these other sources (or the grid) when not immediately needed so that the energy can be utilized at a future time. Batteries can also help bridge short spans when there is a utility blip or peak shave to reduce strain on the utility grid.

Microgrids can help customers meet their carbon emission reduction goals. Customers usually do not have a say in how their power is generated, but utilizing microgrids allows for the customer to do so. Utilizing microgrids means incorporating renewable energy sources that are not fossil fuel based. Microgrids can also help reduce the amount of fossil fuels the main utility source generates, especially at peak hours. By offsetting fossil fuel generated power with green energy generated power, customers' power needs are met, and carbon emissions are reduced.

Many utilities will purchase excess generated power from their customers. This potential for revenue from the renewal energy sources of the microgrid can help lower the cost of the microgrid and give it a more reasonable return on investment. There can be significant costs for microgrids, especially if none of the distributed energy sources are already in place. According to a 2018 NREL study[1], microgrids can cost $2,000,000-$4,000,000 per megawatt. And based on transit type facilities and usage, the cost is likely to be in the upper half of that range.

For the purposes of battery electric buses and the transit agencies transition to their use, microgrids should only be employed: where the transit facility is mission critical; if the agency has a carbon emission reduction goal to meet; and/or where distributed energy sources are already existing. If the facility houses an emergency operation center, traffic operation center, etc., and downtime is unacceptable, there may be a case for a microgrid. The main reason microgrids are not a solution for every transit facility currently is the cost to deploy the microgrids.

If the agency already has distributed energy sources in place, is designing them into new facilities, or has grant money to fund these energy sources, the microgrid costs will be reduced and make for a more affordable solution. A functional microgrid can be as simple as a canopy/roof solar feeding into the facility's main switchboard and a generator being an emergency source on an automatic transfer switch. As the number and size of the distributed sources increases and the controlling mechanism increases in complexity, the cost of the microgrid will increase. Customers should consult with a professional engineer to determine if a microgrid is a viable solution for them, and if so, what size and complexity of microgrid.

Shared Fueling and Charging Infrastructure

Agencies should consider options for sharing charging and fueling infrastructure where possible to help reduce the capital costs of infrastructure. Though many transit agencies want to share infrastructure, a limited survey of industry partners representing both Battery Electric Bus (BEB) and Fuel Cell Electric Bus (FCEB) technologies revealed that there are very few examples of transit agencies successfully turning these desires into reality. Several hurdles to implementation were identified that agencies should consider if they want to pursue shared charging and fueling infrastructure.

[1] Giraldez, Julieta, Francisco Flores-Espino, Sara MacAlpine, and Peter Asmus. 2018. Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5D00-67821. https://www.nrel.gov/docs/fy19osti/67821.pdf.

BEB

- Often agencies do not overlap geographically, so there is limited potential to share on-route charging infrastructure. Northern Virginia is the primary exception, though the Northern Virginia Transportation Commission is addressing the potential for shared infrastructure through its ZEB strategic planning process.
- Depot charging requires several hours and scheduling needs preclude transit agencies from staggering their use of depot-based charging infrastructure.
- Sharing charging infrastructure with private businesses or the public would require physical separation of charging infrastructure at depot charging facilities. In Glasgow, First Bus has agreements with parcel delivery service (DPD) and the local police department to allow them to charge their vehicles in a fenced off part of the depot during the day.

FCEB

- Fuel cell electric vehicles are still a developing technology and there is a lack of standardization of fueling pressures. The best opportunities for FCEBs to share infrastructure are with other heavy vehicles such as tractor trailers and garbage trucks. Commercially available buses fuel at a pressure of 350 bar, but other heavy vehicles may fuel at either 350 or 700 bar.
- FCEB fueling infrastructure requires a relatively large footprint, similar to that of CNG. Agencies wanting to share fueling infrastructure would have to be proximal enough to fuel buses at another agency's facility without incurring a cost-prohibitive amount of deadhead mileage.
- Agencies may have differing comfort levels with grey, blue, and green hydrogen that could make joint fuel sourcing difficult.

If these obstacles can be addressed, the following existing technology may facilitate the sharing of infrastructure.

Discrete Radio Frequency Identification (RFID) tags can be assigned to individual vehicles across coordinating agencies/jurisdictions to allow charging or fueling infrastructure to track charging or refueling by agency. This may require some coordination of fleet management systems to ensure that vehicle RFID lists are automatically updated on a regular basis. Not only could transit agencies use this technology to share fueling infrastructure among themselves, but there are potentially opportunities for agencies with near major truck corridors to generate revenue by becoming a charging/fueling station for long-haul zero-emissions trucks.

Green hydrogen fuel can be produced from floating solar arrays. Opportunities may exist to coordinate with regional water reservoir managers to utilize floating solar arrays to reduce reservoir evaporation while producing green hydrogen that can be used by transit agencies.

Several cities share their charging stations with employees and/or the public, which can help generate operating revenue and leverage their infrastructure investments. This model could be used by agencies that operate smaller (<15 passengers) vehicles that utilize the same charging infrastructure as personal vehicles. Agencies can own the charging stations and contract technical support and maintenance with charging vendors. However, two other models, sharing ownership with the vendor, or full vendor ownership and operation, can provide flexibility, especially when sharing the fleet charging stations with private customers as shown in **Table 2**.

Table 2: Charging Infrastructure Operating Models

Model	100% Agency Owned and Operated	Shared with Vendor	100% Vendor Owned and Operated
Description	Agency purchases and installs the charging stations and keeps 100% of the charging and clean fuel credit revenue	Agency purchases equipment, vendor installs and operates stations; agency and vendor share ownership	Vendor purchases equipment and operates; agency or vendor pay for construction
Charger Maintenance	Via a maintenance contract; equipment provider provides driver support	Vendor provides technical support, maintenance, and operation	Vendor provides technical support, maintenance, and operation
Agency Staff Role	Potentially to issue work orders and financial reporting	Pay fees to vendor	Pay fees to vendor
Revenue Option 1	100% agency; agency sets price at charging station	Split: agency keeps station revenue; vendor keeps CFS credits	Split: agency and vendor each have a percentage of revenue
Revenue Option 2	N/A	Vendor pays agency a fee and retains all revenue	100% vendor

If an agency chooses shared or vendor-owned models, vendor contracts may require that the agency install only that vendor's charging stations during the term of the contract. If an agency chooses to own and operate the charging stations, each charging station vendor offers an optional maintenance contract that includes repairs from vandalism or accidents, and software/ hardware updates. Agency staff may expect to maintain wiring, breakers, panels, and meters.

Alternatively, rural transit providers, that typically operate smaller vehicles within larger service areas could make use of public charging infrastructure, rather than arranging for their own charging infrastructure on-site. Agencies and localities should be proactive in including transit providers in planning the deployment of new charging infrastructure for light-duty vehicles. Technology and charging-use agreements between agencies and vendors could allow charging priority for transit vehicles at these facilities to ensure service reliability.

Hydrogen Fueling

The project team researched hydrogen fuel production, availability, infrastructure requirements, and implementation strategies to develop a hydrogen fueling checklist for agencies interested in implementing hydrogen powered vehicles.

Green, Blue, or Grey Hydrogen

A common theme in reviewing hydrogen fueling technology, was the interest in the ultimate source of fuel used to generate the hydrogen. The hydrogen fuel industry uses different color names to describe how hydrogen fuel is produced. This naming convention helps hydrogen fuel consumers gauge the environmental friendliness differently produced fuel options. **Figure 4** describes each of the color naming conventions in detail. As the hydrogen industry evolves, the color naming conventions may change. Green, blue, and grey are the most discussed types of hydrogen for most agencies.

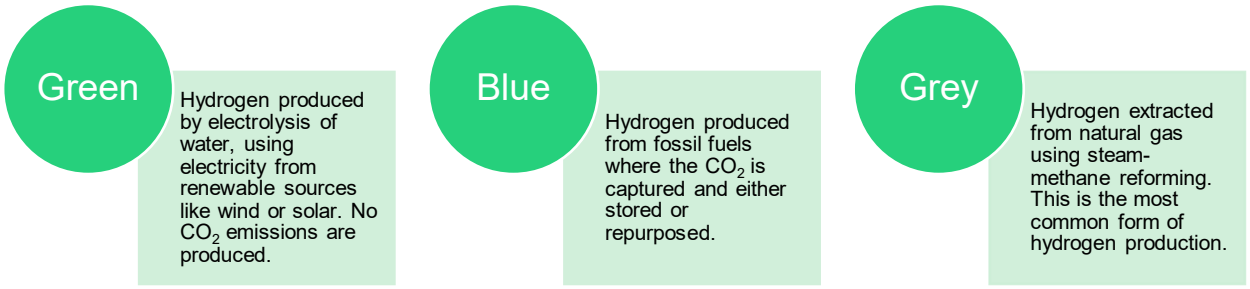


Figure 4: Hydrogen Naming Conventions

Fuel providers may not offer hydrogen produced using all three of these methods. As the hydrogen fuel market continues to mature, there will be more options available to agencies for sustainably produced hydrogen. Agencies may begin piloting FCEBs using more readily available grey hydrogen before transitioning to green as more renewable hydrogen production facilities come online. Periodic contact with fuel providers is recommended to stay updated on the availability of different types of hydrogen.

Vehicle Manufacturer and Model

A review of vehicles on or planned to be on the market revealed that different manufacturers of FCEBs provide different fuel tank capacities and may fuel at different pressures. These factors impact estimates of the amount of hydrogen fuel needed for operations and the specifications of the pressurization and fueling infrastructure.

On-site or Off-site Fuel Production/Fuel Delivery Method/Fuel Storage

Hydrogen can be produced at large, centrally located facilities, then transported to the point of end-use; small facilities near the end point of use; or produced on-site. An agency's preferred source of hydrogen fuel will be influenced by the amount of fuel needed and delivery distance. **Figure 5** below is a graphic that explains the preferred method of supplying fueling stations with hydrogen.

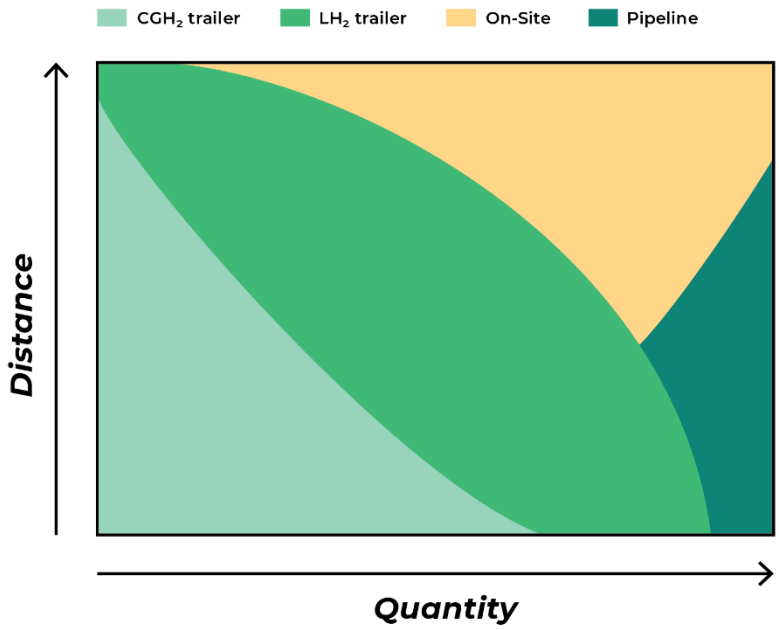


Figure 5: Preferred Method of Supplying Fueling Stations with Hydrogen

On-Site Production

A process called electrolysis can be used to produce hydrogen on-site. The hydrogen can be stored on-site until it is required for fueling. If the electricity used to power electrolysis is renewable, this method of hydrogen production will not produce any greenhouse gas emissions. This method can be a good option for properties that have limited options for fuel delivery and that plan to scale their use of FCEBs enough to recoup the investment in on-site production. Mass Transit District (MTD) in Urbana, IL has successfully implemented on-site electrolysis powered by an eight-acre solar array on a neighboring property.

Hydrogen can also be produced on-site using a Steam Methane Reformation (SMR) process that derives hydrogen from natural gas. This process will always generate emissions, though Renewable Natural Gas (RNG) offers an opportunity to limit these emissions.

Off-Site Production

For demonstration or low-volume projects, compressed gaseous hydrogen can be delivered in tube trailers. Trucks transport the tubes to the agency's facility from a centralized production location. This option reduces the need for capital intensive permanent infrastructure, but the gas comes in low volumes and requires frequent delivery. It also arrives to the facility at lower pressure than liquid hydrogen and will require additional compression at the fueling station on-site.

Agencies that anticipate scaling to large numbers of FCEBs and have limited space for on-site production would benefit from liquid hydrogen delivery and storage. Liquid hydrogen has a higher energy density than gaseous hydrogen and thus can be more cost-effective agencies needing to fuel larger numbers of vehicles. Equipment is required at the agency fueling facility to vaporize the liquid into a high-pressure product for FCEB fueling.

Table 3 below provides an overview of the factors agencies should consider when evaluating potential hydrogen supply sources.

Table 3: Hydrogen Supply Alternatives

Topic	Compressed Gaseous H_2	Liquid H_2	On-Site SMR	On-Site Electrolysis
Overall	Good for volumes <125kg/day	Excellent for large volumes	Good for large volumes	Can be good for large volumes
Distribution Costs	High; price drastically affected by location	Nominal; range flexibility	None	None
Price Volatility	Cost dependent on fuel prices but can be set with contract	Cost dependent on fuel prices but can be set with contract	Cost dependent on maintenance and CNG/RNG costs	Cost dependent on maintenance and electricity costs
Infrastructure Costs	Lower	Higher	Depends on production capacity	Depends on production capacity
Carbon Emission Reductions	Renewable hydrogen available at higher cost	Renewable hydrogen available at higher cost	RNG available at higher cost	Renewable energy is available at higher cost or renewable energy infrastructure can be installed on-site

III. DATA COLLECTION AND STUDY REVIEW

Early in the life of the Modernizing Transit Fleets project, the project team conducted data collection and a study review. This portion of the project intentionally completed near the inception of the project team's efforts, as its purpose was to lay a foundation on which to develop other project components. The data collection and study review was primarily research-based, though a series of interviews with peer state agencies were conducted as part of the study review. This portion of the project can be summarized with the following sections, all of which are detailed in the Task 4: Data Collection and Study Review technical memorandum:

- Project Background
- Goals & Policy Synthesis
- Best Practices & Resources

Project Background

The "Project Background" portion of the technical memorandum captures the history of the Modernizing Transit Fleets project. In detail, the project team described how the project builds on, and is a direct product of, the analysis conducted through the Virginia Transit Equity and Modernization Study. That study was realized in 2021, when the Virginia General Assembly passed House Joint Resolution 542, directing DRPT to conduct a needs assessment on transit equity and modernization in the Commonwealth. The study explored topics such as transit, accessibility, technology, electrification, safety, engagement, representation, and infrastructure. The Modernizing Transit Fleets project directly addresses six outcomes and recommendations of that study relating to low- and zero emissions buses, consisting of the following:

- Establish statewide goals for zero-emissions transit vehicles and a transition plan to convert agency fleets,
- Conduct recurring assessments of innovation in the zero-emissions transit vehicle industry,
- Develop implementation resources for agencies to assist with their fleet transition planning,
- Establish guidance for on negotiating technology contracts,
- Align MERIT (Making Efficient and Responsible Investments in Transit) program funding with zero-emissions goals,
- Expand opportunities for technology funding and implementation assistance.

Goals & Policy Synthesis

The "Goals & Policy Synthesis" portion of the technical memorandum summarizes research that the project team conducted on statewide priorities related fleet modernization and vehicle electrification, a timeline of milestones and targets related to low- and zero-emissions transit fleets in Virginia, and low- and zero-emissions transit opportunities for collaboration and coordination amongst agencies and with DRPT.

Documents reviewed by the project team to determine statewide priorities included documentation of DRPT grant programs and guidelines, as well as statewide plans to gauge the extent to which consistent policies and priorities related to fleet modernization and vehicle electrification were established and incorporated into various transportation planning processes. The following documents were reviewed as part of this process:

- DRPT Grant Program Policies and Guidelines
- DRPT Multimodal System Design Guidelines
- VDOT Resilience Plan

- Virginia Coordinated Human Services Mobility Plan
- Virginia Electric Vehicle Infrastructure Deployment Plan
- Virginia Electric Vehicle Readiness Study
- Virginia Statewide Integrated Mobility Initiative
- Virginia Transportation Plan (VTrans)
- Commonwealth of Virginia Clean Energy Policy
- 2022 Virginia Energy Plan

The project team found many and varied efforts throughout Virginia toward sustainability in the forms of vehicle electrification, carbon reduction, etc., but they are not guided by established guidelines, policies, or priorities at the statewide level. Currently, there are no officially adopted statewide targets, actions, or deadlines for vehicle electrification, carbon reduction, or overall resiliency. Therefore, DRPT allows agencies the autonomy to make their own choices regarding the adoption of low- or zero-emissions transit vehicles.

Various document types were consulted to construct a comprehensive timeline of milestones and targets related to low- and zero-emissions transit fleets in Virginia. Documents reviewed included all available Zero-Emission Vehicle Transition Plans, Transit Strategic Plans, and Transit Development Plans for transit agencies operating in Virginia. Each document associated with Virginia transit agencies was examined to identify key milestones or decision points related to each agency's fleet transition. In addition, federal documentation was reviewed to determine any federal goals, targets, or milestones associated with low- and zero-emissions transit, emissions reduction, transit electrification, and decarbonization. The following documents were reviewed:

- U.S. National Blueprint for Transportation Decarbonization
- USDOT Climate Action Plan
- Global Drive to Zero (Webpage)

The intent of the timeline of milestones and targets that was developed is to show the trend of planned fleet electrification efforts across Virginia, and how those align with federal and global efforts. The timeline was not comprehensive of significant milestones across the United States but served to provide a high-level snapshot of the currently planned fleet transition milestones that have been established across Virginia's transit agencies (as explicitly reflected in zero-emissions bus plans), across the backdrop of any notable goals and milestones across the country and globe. The timeline was a snapshot in time and will change as more agencies begin planning and establishing explicit goals/milestones for low- or zero-emissions fleet transitions.

The project team then used the compiled timeline to identify various opportunities for collaboration and coordination amongst agencies and with DRPT, which should be evaluated on an ongoing basis, as more Virginia transit agencies develop goals for fleet electrification and implementation timelines.

Best Practices & Resources

The "Goals & Policy Synthesis" Best Practices & Resources portion of the technical memorandum included an overview of peer guides, a summary of funding sources relevant to transitioning to low- and zero-emissions fleets, and a brief overview of the current market and associated drivers.

Some statewide agencies across the United States have recognized the opportunity to guide and equip transit agencies in their state with the roadmap, tools, and resources to pursue planning and implementation of low- or zero-emissions fleets. California, Oregon, Colorado, and New York are among those who have

published such guides. The project team reviewed the four aforementioned guides and invited the associated statewide agencies to participate in interviews to capture lessons learned from the guide development process and use. An agency representative from Minnesota was also interviewed. Minnesota does not currently have a statewide guide for transit agencies on preparing for and/or deploying low- or zero-emissions buses. However, MnDOT and the state are known for their commitment to aggressive greenhouse gas emissions reduction goals. In addition, Metro Transit (Minneapolis/St. Paul) shares a commitment to greenhouse gas emissions reduction of which one strategy is bus fleet electrification. The following individuals shown in **Table 4** were interviewed for a total of 4 peer interviews in which the project team gathered information about the motivation, development, and relative success and/or usage of the guides since publishing:

Table 4. Peer Agency Interviewees

State	Agency	Interviewee Name	Interviewee Role
Colorado	Colorado Department of Transportation (CDOT)	Michael King	Assistant Director of Electrification & Energy
New York	NYSERDA; NYPA	Richard Mai; Anna Shulman	Clean Transportation Senior Project Manager; e-Mobility Program Coordinator
Oregon	Oregon Department of Transportation (ODOT)	Ryan Phillips	Public Transportation Climate Specialist
Minnesota	Minnesota Department of Transportation (MnDOT)	Mark Nelson	Interim Director for Office of Transit and Active Transportation

Since funding is a key foundation upon which the ability for transit agencies to transition fleets rests, and agencies must depend more heavily on external funding mechanisms to support fleet transitions, the project team compiled an overview of federal, state, and regional funding opportunities available to transit agencies in the Commonwealth of Virginia. The project team also developed a cross-tabulation of all the funding sources and their respective applicability to various aspects of low- and zero-emissions fleet transitions.

The project team also compiled a summary of the various low- and zero-emissions bus propulsion technologies available on the market today, as well as resources to find more detailed and up-to-date information on the state of the market. The project team also summarized the available low- or zero-emissions buses (ranging from 29’ to 60’ buses) that are included on the Commonwealth of Virginia’s state procurement contract.

IV. EMISSIONS REDUCTION TARGET SCENARIOS AND FINANCIAL ANALYSIS

The Tool was developed to aid agencies in the creation of their specific transition plans that fulfill the requirements for the FTA's Low-No Vehicle Program with a minimum amount of pre-existing knowledge. The Tool's key outputs are the fleet procurement schedule, fleet composition over time, total cost of ownership, and emissions reductions associated with the transition to low- or zero-emissions technologies.

The Tool allows the agency to define their own transition timeline and technology split for a given year. When using the Tool, agencies can adjust the timing of their transition based on their available budget, route feasibility, infrastructure, personnel, or any other constraints that is relevant to the plan. The tool also allows the agency to select the technology that best suits their needs at any given time, which could include a split between battery electric and fuel cell purchases, or a slow phasing-in of a new technology to gain familiarity over time.

The tool includes its own instructions to guide agencies through how to update it for its individual ZEB Fleet Transition plan. The tool is broken into the following tabs:

- Fleet Input: This tab allows agencies to enter fleet composition information, fleet purchase costs, and ZEB purchase percentages. This tab, like the other input tabs, includes default values but also allows an agency to overwrite this with updated information.
- Infrastructure Input: This tab allows the user to customize a variety of assumptions related to infrastructure including the charger to dispenser ratio and the inflation rate which will impact the final outputs.
- Fleet Composition Output: This tab calculates and provides output tables and graphs summarizing vehicle purchases and fleet composition.
- MOVES Output: This tab uses exports from the EPA's Motor Vehicle Emissions Simulator (MOVES) tool to estimate vehicle emissions. An agency may leave the default statewide values or use the MOVES tool to generate more local values and add it to this tab.
- Emissions Output: This tab calculates and provides output tables and graphs summarizing emissions for a variety of emissions including CO_2, NO_x, $PM_{2.5}$, PM_{10}, and SO_2.
- Total Cost of Ownership Output: This tab calculates and provides output tables and graphs summarizing for both capital and operating costs.

Infrastructure Inputs	
General	
Inflation Rate	3%
Existing Conditions	
Number of CNG Maintenance Bays	3
Number of Non-CNG Maintenance Bays	3
Existing Electrical Power (kW)	2000 kW
Fuel Cell Electric Bus Infrastructure Assumptions	
Delivery Type	Hydrogen Not Used
Battery Electric Bus Infrastructure Assumptions	
On-Route Chargers	0
Dispensers per Charger	2
Buses per Charger	2
Cutaway Charger Power	20 kW
Bus Charger Power	120 kW
Costs	
Bus Charger Cost	$75,000
Bus Charger Installation Cost	$5,000
Cutaway Charger Cost	$8,000
Cutaway Charger Installation Cost	$2,000
Dispenser Cost	$2,500
Dispenser Installation Cost	$1,000
Planning Project Cost	$75,000

Figure 6. Example of Infrastructure Inputs

V. WORKFORCE DEVELOPMENT OPPORTUNITIES ASSESSMENT

Adopting low and zero-emission vehicles will require agencies to upskill their workforces to meet the evolving requirements of new equipment, technology, and processes. This memo investigates the workforce-related elements of the transition to low and zero-emission vehicles identifies the skills that operators and mechanics will need, how agencies can provide training, and how agencies should structure their transitions to low and zero-emission buses considering their workforce needs.

Adopting a new vehicle technology requires considerable investment and planning. The transition to low and zero-emission vehicles by transit agencies across Virginia and the country is being spurred by record levels of federal support. In addition to federal finance supporting the purchase of new transit vehicles, fueling infrastructure, and workforce development; federal agencies and partner organizations are developing guidance and providing support to agencies to tackle the considerable technical and managerial challenges associated with new vehicle technology.

Despite this support, many agencies do not have sufficient guidance on how they can ensure their workforces have the requisite skills and certifications to operate, maintain, and plan service for vehicles powered by batteries, natural gas, and hydrogen fuel cells. The challenge of adopting low and zero-

emission vehicles is exacerbated by the pre-existing transit workforce shortage.[2] Agencies across the country of all sizes report a years-long difficulty recruiting and retaining transit operators and mechanics. These challenges are likely to grow as agencies seek to attract and retain workers with new and in-demand skills. As a result, agencies will need to plan to ensure their workforces can support the deployment of low and zero-emission fleets.

We developed a chapter of the Zero-Emission Transition Guidebook to help agencies navigate the workforce dimension of their transition to low and zero-emission vehicles. First, it provides context related to federal and state policy, as well as the market for transit workers. Second, it provides guidance for designing a program to train new and existing workers, including considerations for vehicle type and agency size and capability. Lastly, it outlines ways that DRPT, the Virginia Community College System, and other state agencies can support the expansion and enhancement of the state's transit training ecosystem through interagency coordination. A step-by-step agency toolkit for addressing low and zero-emission vehicle workforce issues supplements this memo in the appendix.

In addition, we developed three resources for DRPT and Virginia transit agencies to assist them with structuring successful apprenticeship programs for frontline operations and maintenance roles.

Economic, Regulatory, and Technical Contextualization

The project team conducted extensive research into the baseline economic, regulatory, and technical issues facing transit agencies and their workers as they transition to low- and zero-emission vehicles. The coming transition from conventional fossil-fueled vehicles to electric buses will test the public transportation industry in ways that will certainly seem new. This portion of the guidebook chapter discusses these at length, including how the technical skills required of operators and mechanics will change, how operations and planning roles will interact in new ways, and how relationships between agencies and labor will need to adapt to conditions that they have never encountered before.

The guidebook included a summary of policy, administrative, and funding context research, including both federal and Virginia-specific information affecting the decisions of transit agencies and their workers. The guidebook also examined the economic circumstances of different transit roles, including original research comparing the wage and employment competition in Virginia to the rest of the United States, as well as competition for the same roles in different sectors of the economy. This information will help transit agencies understand the policy rationales for transitioning their fleets and workers, where they may seek financial assistance to support their workforces through this transition, and the context in which existing and potential workers are making employment decisions. This information also helped prepare the project team for recruiting, convening, and involving the Transit Workforce Technical Working Group in the guidebook's recommendations, as discussed in the next section.

Transit Workforce Technical Working Group Involvement

This section summarizes outreach conducted with stakeholder groups to learn about workforce challenges related to the adoption of battery-electric bus (BEB) and other low-emission technologies, as well as opportunities for increasing the state's capacity for training, hiring, and retaining workers in this key industry.

[2] American Public Transportation Association. "Transit Workforce Shortage." Washington DC, March 2023. https://www.apta.com/wp-content/uploads/APTA-Workforce-Shortage-Synthesis-Report-03.2023.pdf.

Overview of Outreach Process

The project team identified four groups affected by the changing workforce needs of adopting low-and zero-emission vehicles:

- Organized labor
- State transportation and energy agencies
- Transit agency planning staff
- Representatives from educational institutions involved in the training of transit workers

The project team worked with DRPT to identify appropriate representatives from each group and invited them to participate in a three-part series of workshops held over Microsoft Teams:

1. An introductory session with all participants
2. Meetings with each individual group of stakeholders
3. A final wrap-up session to present and discuss findings from each individual group.

The project team ultimately held eight discussions in total, including follow-up meetings with labor representatives and the Virginia Community College System. Approximately forty people participated. Insights from each stakeholder meeting were incorporated into the final guidebook. The working group attended a subsequent presentation where DRPT presented the final report and toolkit.

Primary Takeaways

The focus groups revealed broad support for the transition to low-and zero-emission vehicles, and stakeholders expressed optimism that new technologies, such as BEBs, offer benefits to workers and communities. Participants noted that low-and zero-emission fleets emit less air pollution and are cleaner for the mechanics who work on them. In addition, the new technologies have the potential to attract a younger generation of workers to the profession.

At the same time, stakeholders were clear-eyed about the workforce-related challenges of fleet transitions. The three primary takeaways from the engagement effort are:

1. **Low-and zero-emission vehicles are different.** Electric vehicles require substantial changes to the work of most agency staff. Hands-on experience is key for operators and mechanics. Others, like planners and dispatchers, will also need time and training to adapt their routines to new conditions, such as monitoring individual vehicles' battery state of charge cooperatively with other workers they may not have historically interacted with day to day.
2. **Fleet transitions are best approached as iterative processes.** Given the complexity and expense related to low and zero-emission buses, stakeholders suggested that agencies adopt a gradual transition process that allows agencies to learn from experience. Agencies reported that it has been helpful to start with a small number of vehicles so they can try them out on a small number of routes, observe how they impact operations, and adapt their work processes incrementally. More generally, agencies will need resources to monitor the fleet transition process and implement changes as needed.
3. **Community colleges are underused resources in transit training.** The Virginia Community College System (VCCS) has an established process for working with local employers to develop training programs. This decentralized process focuses on relationships between individual community colleges and their region's employers to develop courses that are relevant to each region's economy. Virginia's transit agencies and other stakeholders should work with their local

community college to expand the system's capacity for training transit workers, in particular bus mechanics. For example:

a. Transit agencies should send representatives to participate on curriculum advisory committees to advocate for and design courses that affect transit workers, including vehicle maintenance. Labor organizations may also wish to participate directly or cooperatively with their transit agency.
b. Where training is included as an element of vehicle purchase agreements, agencies could direct original equipment manufacturers (OEMs) to train instructors at local community colleges as a "train the trainer" program.
c. Virginia state agencies such as the Department of Workforce Development and Advancement, the Department of Labor, and the Virginia Economic Development Partnership can support the expansion of community college transit training programs through funding and other administrative and coordination support.

Subgroup Summary: Organized Labor

Table 5. Organized Labor Subgroup Participants

Participants	
Greg Akerman	Northern Virginia Director, Baltimore-D.C. Building Trades
Virginia Diamond	President, Northern Virginia Labor Federation
Karen Camplin	Environmental and Climate Justice Chair, Virginia NAACP
Raymond Jackson	President, American Transit Union Local 638
Matthew Girardi	Political Affairs and Communications, American Transit Union Local 638
Damian Cannon	Asst. Business Manager (Maintenance), American Transit Union Local 638
Dee Baker	Member, American Transit Union Local 638 (WMATA)
Glenn Miller	Member, American Transit Union Local 638 (WMATA)

The representatives from transit unions and other labor organizations emphasized the need for a clear and formalized system of training and certification so that workers can take advantage of the new opportunities afforded by the transition to low and no emission vehicles. They indicated that sudden changes of uncertain origin would alienate workers and make it difficult for their representatives to arrange for a smoother transition.

Labor representatives requested that training and certification expectations for every role should be clearly identified from a single source, and that the delegation of the authority to make this decision should be clear and dependable. For example, if the state is going to set requirements and multiple departments are going to publish the requirements (e.g., the Department of Labor and DRPT), then the publications should be joint to eliminate confusion. In addition, participants said that a centralized body should make training resources available, or at least identify these resources, so that these are accessible to workers. They indicated that a balkanized system where different organizations develop their own resources ad hoc would be to everyone's disadvantage.

In addition, participants suggested that agencies should incorporate a phase-in period into their transitions plans and a timeline for announcing new trainings and certification requirements. This would allow relevant organizations to assemble necessary training resources, give workers time to upskill, and help agencies identify if they need to hire additional staff. Agencies should supplement outside instruction at community colleges or elsewhere with in-house hands-on training, such as an apprenticeship or mentorship programs, participants said.

Participants emphasized the importance of helping current employees upskill, especially in maintenance roles. They indicated that several agencies have implemented upskilling assessment programs: current workers who may not show aptitude or interest in high-voltage systems could remain employed and work on more familiar systems like brakes and suspensions.

The specific context of each agency will impact needs related to training. For example, although smaller agencies may have fewer training needs because they have fewer staff and perhaps a narrower range of modes and technologies, those agencies may have less technical expertise in-house and therefore have greater needs at the outset of the transition. By contrast, staff at agencies that already operate high-voltage systems, including diesel-hybrid buses or agencies already operating electrified rail modes, will be familiar with high-voltage electricity safety protocols, and require less additional training to deploy BEBs.

Subgroup Summary: Transit Agency Management

Table 6. Transit Agency Management Subgroup Participants

Participants	
Erik Olsen	Senior Transportation Planner, Blacksburg Transit
Tim Witten	ITS Manager, Blacksburg Transit
Ben Simms	COO, Hampton Roads Transit
John Nason	Director of Bus Maintenance, Hampton Roads Transit

Transit agency representatives who participated in the focus group emphasized that fleet transitions are complex undertakings that induce changes across many agency functions. Three themes of concerns emerged from our conversation, some of which do not have clear solutions yet.

First, agencies face difficulty in adopting standardized workforce requirements related to BEBs because the vehicles produced by different manufacturers have themselves not been standardized. Agency staff emphasized that this situation requires ad hoc responses that look chaotic or unsupportive to operators and mechanics and leaves a feeling of uncertainty.

Second, the range limitations of BEBs have implications many transit agency roles, not just operations and maintenance. For example:

- Operators, dispatchers, and planners will need to coordinate monitoring vehicle range and state of charge information and share that information across departments. This information sharing will need to happen in real time to ensure service continuity day to day, as well as in the long-term to ensure that the fleet and charging infrastructure is meeting the needs of the service.
- Planning staff will need to incorporate range considerations into service planning and schedule blocking. This may come to include monitoring individual operators' management of battery state of charge on a given route over time, a tricky subject not yet explored.
- All staff whose work involves vehicle range will need training. However, it may not be clear what training each role needs until new processes and procedures for monitoring range have been established, which in turn may not be apparent until after implementation.

The above three examples support the earlier assertion by the labor representatives that zero-emission bus transitions would benefit from a phase-in period with milestones for evaluating the workforce implications across agency work functions.

Agency staff also reported that workers have varying levels of interest in becoming proficient in new vehicle systems. Several experienced participants reflected on a previous automotive technological revolution – when engines shifted from carburetors to fuel injection – and noted that many mechanics at that time simply

did not want to learn the new systems. Some of today's mechanics who have experience working on internal combustion engines may not be interested in learning to work on electric vehicles, but their skills remain relevant, and they still have much to contribute to ensuring vehicle state of good repair. Likewise, low-and zero-emission vehicles are cleaner to work on and involve electronics, aspects that may help attract younger workers to a transit industry still struggling with an overall worker shortage. Agencies must find a way to utilize the skills and interests of all workers, including those who are not yet employees, during the fleet transition process.

Subgroup Summary: State Transportation, Energy, and Environmental Agencies

Table 7. State Transportation, Energy, and Environmental Agencies Subgroup Participants

Participants	
Mitch Huber	Statewide Transit Planner, DRPT
Paige Lazar	Statewide Transit Planner, DRPT
Thomas Ballou	Air Data Analysis Manager, DRPT
Karitsa Holdzkom	Senior Policy Analyst, Transit Workforce Center
Vince Maiden	Associate Director, Energy Efficiency and Financing, DOE
Danny Plauger	Executive Director, VA Transit Association
Erin Belt	Decarbonization Lead, VDOT

State agency participants identified opportunities for their organizations to cooperate in the transition to low- and zero-emission vehicles, including transit, noting that such efforts will require leadership and considerable coordination.

Participants noted an opportunity for mission integration that make even better use of state and federal funding. On the one hand, the Department of Transportation (VDOT), Department of Energy (DOE), and the Department of Environmental Quality (DEQ) each have policy goals and funding related to clean transportation, including zero-emission vehicles and electrical grid improvements. However, these and other agencies are unsure how to direct their funds to worthy projects, especially since workforce development is not a traditional part of those agencies' portfolios. On the other hand, VCCS and the state Department of Labor do have workforce development capabilities and networks, but typically react to the needs of local employers rather than make statewide "leading" investments.

The group recognized that a centralizing coordination body could help direct available funding from transportation, energy, and environmental agencies towards labor and workforce programs more effectively than a decentralized system. The state's new Department of Workforce Development and Advancement (DWDA), which was inaugurated in July 2023, is likely to play an important role in ensuring adequate resources for training and licensing.

In addition to establishing a framework for centralization and coordination, focus group participants identified several other roles for state agencies to play. One refers to the National Electric Vehicle Infrastructure Program (NEVI). Enacted as part of the Bipartisan Infrastructure Law in 2021, the program makes about $1 billion dollars each year ($16 million dollars apportioned to Virginia annually) available to build a national network of light-duty electric vehicle chargers. The program makes associated workforce development programs eligible, and the Federal Highway Administration has deferred approval of such workforce development programs to states.

This critical policy component means that Virginia state agencies have the authority to determine not just the ability to fund workforce development for light-duty chargers specifically, but also whether a NEVI-

funded program that cooperates with other state programs, such as those that would also train heavy-duty electric vehicle charging infrastructure installation alongside, also qualifies. Likewise, the Virginia DOE has funding for grid electrification that could include workforce development programs, which in turn could leverage NEVI funding.

State agencies can also play a role in supporting development and expansion of community college programs and certifications. Many community college transit training programs are constrained by number of instructors and the amount of physical training resources available, which limits the amount of hands-on training that can be provided. As noted by other participants in other focus groups, this is a significant barrier: less hands-on time in the classroom punts this experience gap to employers, and too few instructors or materials are bottlenecks for the new worker pipeline. The transit agency focus group nonetheless lauded community college training programs: state agency investment in these existing programs, as well as jumpstarting internship and mentorship programs, can relieve strain and grow the pool of available workers. Participants indicated this would have the largest positive effect on smaller and rural transit agencies.

Subgroup Summary: Education Representatives

Table 8. Education Representatives Subgroup Participants

Participants	
Bobby Rowe Sr.	Faculty, Manufacturing & Transportation Pathway Tidewater Community College
Laura Garcia-Morena	Automotive Technology Instructor, Northern Virginia Community College Alexandria
Peter Agbakpe	Pathway Dean, Tidewater Community College
Yolanda Crewe	Director of Operations, Career Education and Workforce Programs, VCCS
Tonia Haney	Automotive Technology Instructor/Program Head Reynolds Community College

Participants in the education subgroup included representatives from the Virginia Community College System (VCCS), a statewide agency, and a collection of individual community colleges from around the state. Participants described the role that community colleges currently play in vocational education in Virginia, with a particular focus on automotive training. Current automotive training programs at community colleges fall into two major categories: general mechanic training and manufacturer-based training. General training courses cover principles of automotive maintenance common across vehicles, while manufacturer-based programs focus on specific vehicle makes and models (e.g., a specific Cummins heavy-duty diesel engine class) and are offered in response to the needs of local employers.

Community colleges determine what types of programs and courses to offer in conjunction with their local regional employers to ensure relevance and practicality to students. To facilitate this, individual colleges use program advisory committees to develop their offerings. These committees are comprised of local employers and likely instructors, which together help shape what types of workforce training programs the college provides as well as the specific topics to be taught. Participants indicated that transit agencies rarely participate in these advisory committees, but that it would be an entirely appropriate avenue for transit agencies to develop training programs for mechanics and other agency work functions.

Critically, participants indicated that the community colleges operate in a decentralized way. While VCCS provides support and acts as a repository for courses and curricula developed at community colleges in Virginia, individual colleges have their own advisory committees and adapt their curricula to the needs of their regional employers. This underscores the importance of transit agency involvement in curriculum and advisory committees at their local community colleges.

Focus group participants also recommended transit agencies also collaborate with VCCS or some other state labor entity, including DWDA, and low- and zero-emission transit vehicle OEMs to create statewide general training programs supporting medium- and heavy-duty low-and zero-emission vehicles and manufacturer programs supporting the fleets at individual transit agencies. Manufacturer-specific training may become relevant once low- and zero-emission transit vehicle technologies change less rapidly.

Echoing the discussion in other discussion groups, participants in the educational representative discussion noted that existing transit training programs are at capacity and suggested that DRPT and state agencies could provide financial support to procure materials, provide training space, and train trainers.

Recommendations from the Working Group Involvement Process

This section presents a synthesis of the findings from the focus groups and recommendations for three groups whose work touches the workforce component of the transition to low-and zero-emission vehicles: transit agencies themselves, DRPT, and other related state agencies.

Recommendations for Transit Agencies and their Workers Training

Workers who operate and service new vehicle systems will require additional training and certification. Agencies and their workers, whether unionized or not, should work shoulder to shoulder to ensure workers have the skills they need. Recommended actions include:

- Engaging with community colleges' existing system to convey training needs and requirements.
- Supporting apprenticeships for growing and retaining workforce.
- Clarifying training requirements, including notifying employees of training opportunities and the requirements of various roles.
- Working together to ensure smooth labor agreement revisions.

Operational Planning

Deploying low- and zero-emission buses will involve substantial operational and planning changes. Agencies should explore how deploying low- and zero-emission buses will affect the roles and responsibilities of staff, including operators, mechanics, dispatchers, supervisors, and planners. Agencies should create a plan for how to use new information (especially related to vehicle range) to improve operations.

Ensuring Adequate Staffing

The zero-emission transition will involve upskilling and increased competence in the workforce. At the same time, transit agencies continue to face a worker shortage, a situation only made more competitive by an increased demand for high-voltage skills. Agencies should plan for higher wages and retention bonuses, which will be necessary to attract and/or keep higher-skilled workers (either new recruits or upskilled existing workers).

In addition, agencies should have a plan for utilizing workers with different interests and skills. This includes providing pathways for existing workers who do not show immediate aptitude or interest in working on high voltage systems to continue to work productively on other vehicle systems (e.g., brakes and suspension), as well as ways for these workers to transition into other roles such as supervisory positions.

Recommendations for DRPT

DRPT should direct some of its funding to low- and zero-emission vehicle implementation, reserving some specifically for workforce development. Such assistance could come in the form of both technical assistance and demonstration projects, as well as helping to coordinate the actions of agencies across the state government.

Recommended technical assistance activities include:

- Working with smaller agencies and community colleges to develop internship programs.
- Developing templates for apprenticeship programs and provide "tailoring support" as agencies adapt programs to their own contexts.
- Facilitating coordination between agencies that might rely on the same community college.
- Providing funding to support agency strategic planning efforts that address the need to readjust staffing levels and responsibilities, as well as training and certification of workers.
- Developing a joint equipment procurement program. In addition to cost savings, community colleges could offer training courses more frequently if a group of agencies purchased the same types of vehicles.

Recommendations for demonstration activities include:

- Acquiring tester buses that agencies could borrow to get hands-on experience to inform their fleet transitions. These buses could migrate from agency to agency for defined periods.
- Finance pilot programs to develop statewide standardization. For example, purchasing, deploying, and evaluating different BEB charging equipment configurations to both inform future joint procurement specifications and give piloting agencies the opportunity to learn on new equipment.

Recommendations for Other State Agencies

Other state agencies, including VDOT, DOE, DEQ, DOL, and DWDA, can support the workforce component of the transition to low-and zero-emission vehicles through coordinated support to training programs. Coordinating the activities of many disparate state agencies will require considerable effort, including relationship-building and perhaps executive or legislative action. Actions state agencies can take now include:

- Developing a coordinated interagency apparatus for gathering workforce needs, identifying worthy projects/programs, communicating with stakeholders, and allocating funding. Such an effort could be led by the new DWDA and supported by identifying a “workforce czar” at each agency.
- Providing financial support to community colleges for the acquisition of necessary physical and human resources related to transit training. State agencies may need to identify new or unused mechanisms for delivering funding to training programs.
- Developing unified statewide guidance connecting transit agencies to training resources.

Idealized Potential Structure for Statewide Coordination

Based on the conversations with the various focus groups, the project team developed a conceptual diagram of how different organizations and funding mechanisms could interact synergistically to enact the recommendations made above (**Figure 7**). The diagram in part merely describes relationships that already exist. However, while it is in no way an official articulation of policy or guidance, it also proposes a set of relationships that could improve coordination across multiple scales of government and between otherwise disconnected parts of the ecosystem that ultimately provides public transportation in Virginia.

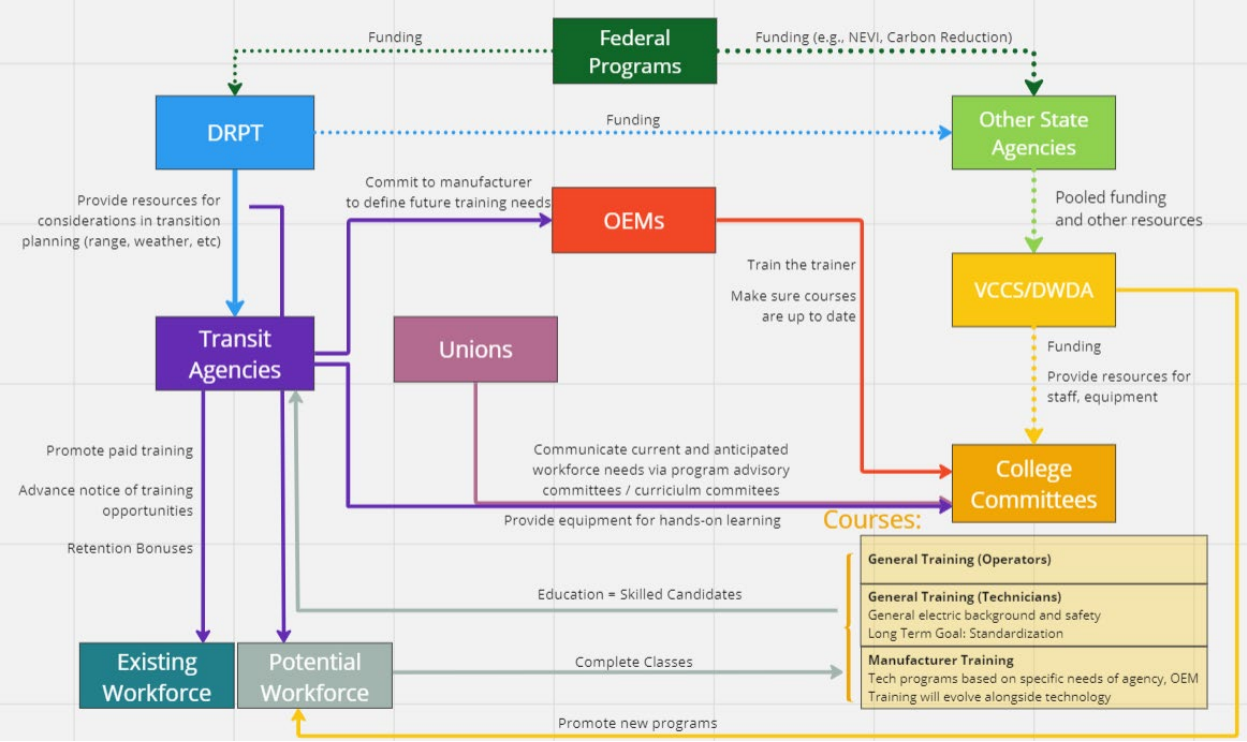


Figure 7: Proposal for Structure of Statewide Coordination on Transit Training

Guidance for Transit Workforce Apprenticeship Programs

After discussion with DRPT, the project team pursued an expanded scope to develop materials that would assist Virginia transit agencies with establishing apprenticeship programs for frontline operations and maintenance roles. This expanded scope stems from information identified through developing the guidebook chapter. These additional materials do not appear in the guidebook but will be available as standalone guidance to DRPT staff and transit agencies as they pursue avenues to upskill their workers in the coming years, regardless of fuel type.

The three guidance documents include:

An **Apprenticeship Program Resource Guide** for transit agencies. Apprenticeship programs provide an opportunity to develop a dedicated workforce customized to an agency's specific needs. However, apprenticeship programs can involve many different types of costs, including curriculum development, compensation for trainers, and tuition at community colleges, which are not eligible expenses under DRPT's grant program. This guide provides a summary of state and federal funding opportunities for apprenticeship programs, the types of expenses they can support, and the types of apprenticeship programs that are eligible.

Grant Application Guidance to assist transit agencies in developing and implementing a successful apprenticeship program that meets the requirements for transit apprenticeship program funding from the DRPT. This document supplements the grant description and application instructions provided in the DRPT Blue Book. By following this guide, transit agencies will be able to create a structured program that addresses key components necessary for a successful grant application.

A **tailoring support memorandum** for DRPT staff to use as they assist Virginia transit agencies. In 2024, DPRT expanded the scope of the Public Transportation Workforce Development grant program so the state's transit agencies could use the funding to support apprenticeship programs in operations positions. In addition to the Transit and Commuter Assistance Grant Application Manual and other guidance documents provided by DRPT, agencies may seek additional assistance from DRPT staff when designing their apprenticeship programs and preparing their applications. This memorandum contains guidance for DRPT staff in responding to such inquiries and addresses likely topics of interest to transit agencies.

VI. FLEET TRANSITION PLAN TEMPLATE AND ZEB TRIALS

Fleet Transition Plan Template Creation

The Fleet Transition Plan template includes tools that aid agencies with pre-planning, data analysis, and transition plan report writing. It is important for the agencies to follow the process as pictured in **Figure 8**.

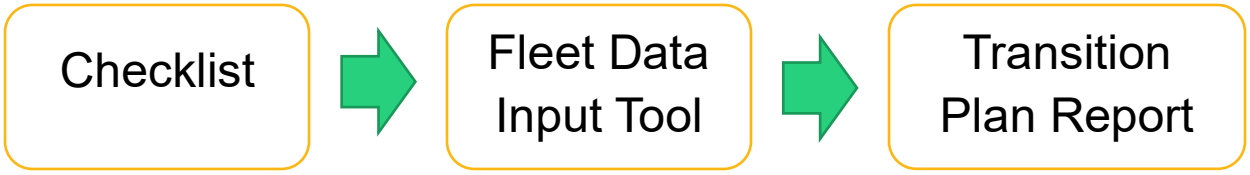


Figure 8. Fleet Transition Plan Template Process

The project team's initial step was to provide guidance for early engagement and pre-planning to ensure agencies were prepared to utilize the Fleet Lifecycle Evaluation and Electrification Tool (FLEET). This guidance and early planning were provided in the form of the Low or Zero Emission Transition Planning Checklist (Checklist). The Checklist provides a series of questions that prompts the agency on suggested activity that should be completed or discussed prior to starting the work to complete the FLEET. The Checklist was developed based on previous reports created during the DRPT Equity and Modernization Study, consultant industry knowledge, and feedback from Modernizing Transit Fleet project partners. The Checklist serves as a guide for the agency planning process, which includes understanding the transit agency's service parameters, accessing, and understanding fleet data, and exploring the steps needed to address future needs and priorities.

Once agencies complete the steps and questions in the Checklist, and have a good understanding of their service requirements, they are ready to complete the FLEET, which is the second step in this process. The FLEET was developed to aid agencies in the creation of their own transition plans that fulfill the requirements for The Federal Transit Administration (FTA) Low or No Emission (Low-No) Grant Program with a minimum amount of preexisting knowledge. The FLEET was designed to simplify the analysis process for agency staff. The project team worked together to ensure the FLEET consists of the correct fields for inputs and outputs that would provide information to aid in completing agencies' Fleet Transition Plan reports. Outputs are captured in the form of tables and graphs. These outputs provide information for the fleet, fuel, emission, and facility assessments. Costs pulled from these assessments will aid in providing the total cost of ownership over the transition period.

After the completion of the Checklist and the FLEET, agencies should have the necessary outputs and information to start working on the Fleet Transition Plan report. The Fleet Transition Plan report consists of the six elements required for the Low-No program and the Grants for Buses and Bus Facility Competitive Program. These six elements are:

1. **Fleet Assessment:** Demonstrate a long-term fleet management plan with a strategy for how the agency intends to use the current request for resources and future acquisitions.
2. **Funding Needs Assessment:** Address the availability of current and future resources to meet costs for the transition and implementation.

3. **Policy Assessment:** Consider policy and legislation impacting relevant technologies.
4. **Facilities Assessment:** Include an evaluation of existing and future facilities and their relationship to the technology transition.
5. **Partnership Assessment:** Describe the partnership of the agency with the utility or alternative fuel provider.
6. **Workforce Analysis:** Examine the impact of the transition on the agency's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the agency to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.

The Fleet Transition Plan report was created as a fill in the blank template accompanied with instructions for each section. The report includes standard language for each section, suggested language to aid agencies, and prompts for agencies to provide specific language associated with their operations. The objective of providing the report template was to simplify the process and help agencies visualize and understand the content of the final transition plan report.

Zero Emission Bus (ZEB) Trials

The project team's focus was centered around support for a small urban transit agency and a rural transit agency. The two agencies chosen for the ZEB Trials were Bristol Transit and Bay Transit. Prior to the ZEB Trials starting, Bristol Transit removed themselves and opted not to participate in the project. The project team decided to move forward with Bay Transit only.

Bay Transit leadership was provided an overview of the Modernizing Transit Fleet (MTF) project. Additionally, the project team provided Bay Transit separate overviews of the Checklist and FLEET. Bay Transit was given time to digest the Checklist and FLEET before introducing the Fleet Transition Plan report template. The project team followed-up with Bay Transit periodically to answer questions and provide support. As a result of this follow-up, the project team was informed by Bay Transit that the template and transition plan report were somewhat confusing and complicated. The project team met with Bay Transit to clarify questions for the FLEET and created an updated version of the transition plan report that simplified the language and placed instructions into a separate document for a cleaner read. Consequently, Bay Transit gained a better understanding of how to complete the FLEET and transition plan report. However, Bay Transit had competing priorities and limited staff to complete the MTF tasks within the scheduled timeline. Completion of the FLEET and the transition plan report were pending at the time this report was written.

VII. MTF ACTION PLAN

The MTF Action Plan is intended to provide insight and guidance for potential future areas of study, project options, and agency support. Expected outcomes of this project are outlined below.

1. An evaluation of readiness for both the electric grid and other alternative fuel distribution systems within and nearby the Commonwealth
2. An evaluation of the financial hurdles and opportunities of low- and zero-emissions bus transitions
3. An understanding of needs and opportunities to support workforce development
4. A comprehensive toolkit that aids agencies in stakeholder engagement, understanding the process and technical requirements for low- and zero-emissions transition, and conducting their own FTA-compliant low- and zero-emissions transition plan

Action Plan Summary

The project team focused on the five primary tasks of the MTF project to identify takeaways and provide recommendations for next steps. Those primary tasks are Industry Partner and Stakeholder Engagement, Utility Partner Engagement and Planning, Data Collection and Study Review, Workforce Development, and the Fleet Transition Plan Template. Recommendations for these task areas are focused on training, education and outreach, collaboration and coordination activities, data integrity improvements, better access to resources, and improved communication. The following summarizes key takeaways of each task.

Industry Partner and Stakeholder Engagement

There are three primary takeaways from the industry partners and stakeholders. First, discussion and interviews highlighted the concerns with the reliability of zero emission vehicles, emergency response (emphasis on safety), resistance from the public and political opposition, and the overall cost of low or zero emission transition. Second, this working group expressed a need for additional tools to assist agencies with zero emission transition planning. Agencies need support with understanding range, route feasibility, and how to manage mixed fleet operations. The third takeaway is helping agencies work towards and ecosystem approach to planning. Transit agencies and other stakeholders want to understand what the synergies are with zero emission infrastructure as they pertain to opportunities to collaborate and share costs, such as procurement build components of utility agreements, charging infrastructure, bus build, and A&E design work.

Utility Partner Engagement and Planning

Utility partner engagement is key for a successful transition to zero emission vehicles. The key takeaway from the project team's engagement with utility partners centers around awareness, preparation, and coordination. Early awareness is an integral part of the zero-emission transition planning for utility providers. Concerns center around overall timeline coordination, logistics for shared infrastructure opportunities, charging optimization, and cost implications as they pertain to electric vehicle rates.

Data Collection and Study Review

Takeaways for the Data Collection and Study Review task are focused on low and zero emission guidelines, policies, priorities, and funding gaps. The project team found that efforts in the Commonwealth to address sustainability in the areas of vehicle electrification and carbon reduction are not guided by statewide targets, actions, or timelines. Additionally, the project team found that the fewest opportunities for funding for

activities related to zero emissions are in the areas of workforce development, feasibility studies, and zero emission implementation plans.

Workforce Development

The focus groups and stakeholders that were engaged for the Workforce Development task had a positive outlook for low and zero emission transition. The project team noted their enthusiasm for the benefits that workers and communities across the Commonwealth may receive. These benefits are improved air quality, cleaner working conditions for maintenance technicians, and an increased appeal to a younger generation of workers. Takeaways for the Workforce Development task include understanding training needs and adapting to the new technology by the workforce, undergoing a phased approach to low and zero emission fleet transition in an effort to learn and implement processes that will help agencies become more successful over time, and Commonwealth agencies and stakeholders are encouraged to collaborate with local community colleges to expand the system's capacity for training transit workers and bus mechanics. The project team noted that transit agencies and labor organizations should participate in curriculum advisory committees with the community colleges, partner with original equipment manufacturers (OEM) to develop "train the trainer" programs.

Fleet Lifecycle Evaluation and Electrification Tool (FLEET)

As mentioned in the ZEB Trials section of this report, Bay Transit had not completed the template at the time of this report. However, feedback from the technical working group suggests the Tool contains the necessary data points to aid in the completion of analyses and ultimately the fleet transition plan report. The most important takeaway as it pertains to utilizing the Tool creation is to continue to educate agencies on the specifics of the planning process, inputs, and outputs (specifically small and rural transit agencies). As agencies become more educated with aspects of the new technologies, the Tool will become easier to use and comprehend.

Recommendations

The project team prepared recommendations for each of the task areas discussed in the MTF Action Plan. These recommendations also include associated benefits and guidance such as implementation effort, timeline, and agency or other organization support. Recommendations are intended to be the basis for next steps with transitioning transit fleets to low or no emission across the Commonwealth. The recommendations are capture in the MTF Action Plan Matrix shown in **Appendix A**.

VIII. "MODERNIZING TRANSIT FLEETS: A GUIDE TO LOW- AND ZERO-EMISSIONS TRANSIT BUSES"

Modernizing Transit Fleets: A Guidebook to Low- and Zero-Emissions Transit Buses ("Guidebook") was developed as the primary product of the Modernizing Transit Fleets project, compiled because of and in combination with all the aforementioned work by the project team. Its purpose is to equip interested Virginia transit agencies with resources to assist with transitioning their fleets to low- and zero-emissions vehicles. The Guidebook provides high-level technical guidance to make the pursuit of modernizing transit fleets—by means of cleaner propulsion technologies—easier to achieve. While there are no clear directives from the Commonwealth that require agencies to transition their fleets by a specified date or achieve a certain emissions reduction goal, the purpose of the Guidebook is to assist agencies in being poised to act strategically, swiftly, and in advance of any state requirements. The Guidebook cover is shown in **Figure 9**.

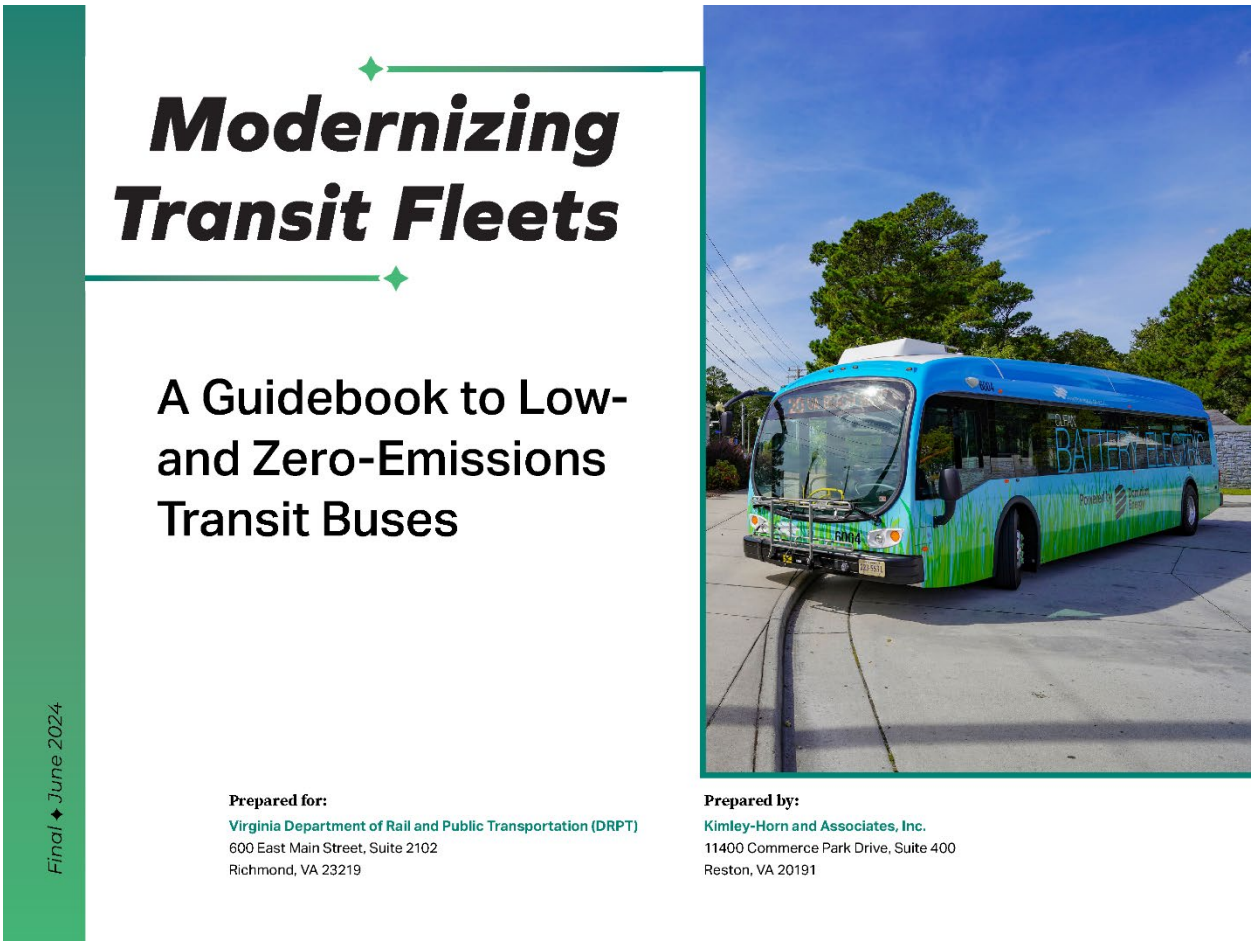


Figure 9. Guidebook Cover

This technical guidance contained in the Guidebook is organized by the following key topics and should not be interpreted as a step-by step guide, nor should it be interpreted as preferring or specifying which propulsion technology/technologies should be selected by agencies.

- **Funding and Procurement Guidance**: Identifying Funding Sources; Preparing a Grant Application; Regional, State, and Federal Funding Sources; Fleet Transition Template and Tool; Financial Analysis and Emissions Reduction Tools
- **Utility Coordination**: Overview of Low- and Zero-Emissions Propulsion Technologies: Battery Electric Buses (BEBs), Fuel Cell Electric Buses (FCEBs), Natural Gases (CNG, RNG, LNG)
- **Infrastructure Considerations**: BEB, FCEB, Natural Gas (CNG, LNG, RNG), and Propane Infrastructure; Making the Choice
- **Workforce Development Guidance**: Guiding Principles for Workforce Development; Designing Training Processes and Programs
- **Vehicle Deployment Guidance**: Goal Setting for Fleet Deployment; Pilot Programs; Decision Making and Flexibility; Monitoring and Reporting

Although there is an implicit and necessary chronology of various steps involved in fleet transitions, agencies across the Commonwealth are currently in varying stages of pursuit of transitioning to low- or zero-emissions fleets. In addition, fleet propulsion technologies should not be viewed as one-size-fits-all and should be evaluated and selected according to each agency's unique service and needs. The Guidebook can be used in the order of topics presented, or in the order deemed most relevant to an agency's needs or transition progress. If the agency is unsure of where to start, the project team recommends referencing the chart below, in **Figure 10**, which outlines the sections of the Guidebook addressing various key questions an agency may be asking at various stages in the transition process.

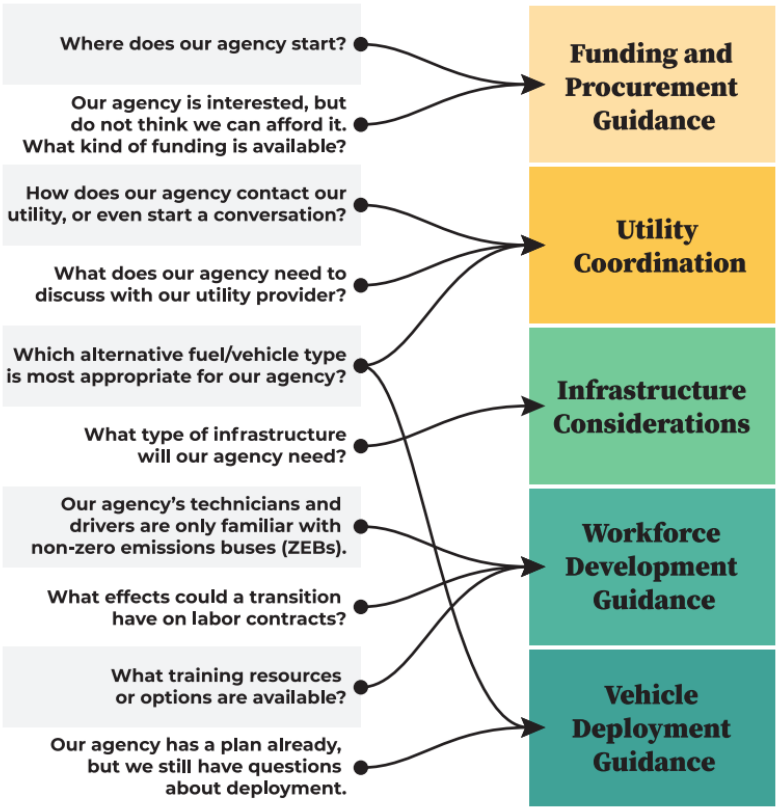


Figure 10. Support for Guidebook Navigation

The Guidebook available through DRPT's website and is considered to be a live document, as DRPT intends to update the Guidebook as is necessary.

IX. CONCLUSION AND NEXT STEPS

Low and zero-emission transit service is quickly becoming the future for transit agencies throughout the United States. A low and zero-emissions future was affirmed by transit agencies and local stakeholders throughout Virginia during the "Virginia Transit Equity and Modernization Study," but the adolescence and technical complexity of low and zero-emission technologies creates roadblocks for interested agencies in pursuing a transition to alternative fuel service. The Modernizing Transit Fleets was created to provide Virginia transit agencies, planning organizations, and relevant stakeholders with the necessary information so that transit agencies can make informed decisions when transitioning to zero-emission service. Through this effort, the Modernizing Transit Fleets project produced five technical memorandums, a guidebook, and multiple planning tools to assist transit agencies through the financial and environmental impacts of a transition. The developed resources cover several considerations a transit agency should acknowledge when proceeding with zero-emission transition including peer agency interviews, utilities coordination, data collection, emissions reduction, workforce management, etc., which should provide the platform for transit agencies to forecast their needs in completing a zero-emission transition both in the short and long-term.

Transit agencies can utilize the information contained throughout the guidebook or the technical memos throughout any part of their transition to low or zero-emission service. However, it is recommended that transit agencies begin consulting the materials during their pre-planning/initiation process. As part of the planning/initiation process, transit agencies will go through a fleet transition readiness checklist which will help transit agencies gauge the scope and scale of work needed to complete a low or zero emission transition based on each agency's needs and priorities. During this time, DRPT will also be assisting Virginia transit agencies, especially small and rural agencies, through the early phases of planning and analysis to ensure transit agencies understand and know how to use the FLEET tool, and transit agencies are obtaining the necessary information to coordinate and partner with utility partners and ultimately complete their transitions.

Low and zero-emission transit service is still in its adolescence, especially in Virginia, so technological capabilities, legal requirements, and methods of best practices are malleable and subject to change. DRPT will serve as the lead agency in guiding the transition efforts to ensure the transit agencies have access to the most up-to-date information, meeting the requirements to obtain federal and state funding, and leveraging shared resources and information to solve statewide challenges and achieve efficiencies. Additionally, DRPT will continue to evaluate the deliverables of the Modernizing Transit Fleets project to ensure their continued accuracy and applicability within the continually changing informational and technological landscape. The guidebook and related materials are considered living documents, so DRPT will take the necessary steps in updating and/or rehauling the tools and informational guides if their materials are no longer accurate or relevant.

APPENDIX A – MTF ACTION PLAN

ID Number	Task	Recommendation	Benefits	Desired Outcome Category	Implementation Effort	Timeline Short-term (<2 years) Medium-term (2-5 years) Long-term (>5 years)	Potential Lead Agency	Potential Partner/Supporting Agency and Organizations
IPS.1	Industry Partner Stakeholder	Develop and maintain a database of primary utility company points-of-contact (POC) for electrification across the Commonwealth of Virginia	Single POC • Assist agencies with streamlining • Aid in fostering relationships with utility companies in planning and implementation of electrification.	Evaluation of Readiness (Electric Grid/Alternative Fuel Distribution)	Low	Short Term - set up Long Term Management	DRPT	NAN/A
IPS.2	Industry Partner Stakeholder	Create a peer-to-peer network of transit agencies across the state seeking to transition their fleets	Establishing Peer Network • Would allow for cross-agency relationships • Information exchange regarding the pursuit of fleet transitions	Comprehensive Toolkit for Low or Zero Emission Transition	High	Short Term	DRPT	N/A
IPS.3	Industry Partner Stakeholder	Advocate for federal funding (i.e., RTAP or other) to support ZEBRA memberships for VA transit agencies	VA Transit Agencies (pursuing fleet transitions) • Benefit from the information exchange, training programs, shared research • Access to ZEBRA member benefits	Evaluation of Financial Hurdles to Low or Zero Emission Transition	Medium	Medium Term	DRPT	FTA, VDOT, DEQ, Va DO Energy
IPS.4	Industry Partner Stakeholder	Hold an "Electrification 101" seminar at a determined frequency (~1-2x/year) to orient transit agencies to ZEB language and the state of the market	Education and Outreach • Introduce agencies to common terms and basic principles • Provide state of the market information related to electrification • Grow the knowledge base for zero emission technology and associated processes for operation • Increase familiarization and comfort level with zero emission technology	Comprehensive Toolkit for Low or Zero Emission Transition	Medium	Short Term - set up Long Term Management	DRPT	Expert Resource Transit Agency
UPE.1	Utility Provider Engagement	Develop one pager on transit agency electrification and the transit project development process to share with utilities	Education and Outreach • Provide visibility into agency needs for planning assistance for electrification project. • Aid in initiating conversations utilities' efforts to accommodate fleet electrification.	Evaluation of Readiness (Electric Grid/Alternative Fuel Distribution)	Low	Short Term	DRPT	Utility Companies (with service areas in VA)
UPE.2	Utility Provider Engagement	Coordinate with utilities to ensure they are ready to accommodate utility agreements that need to be in place to accommodate vehicle grid integration	Coordination • VGI will allow agencies to utilize vehicle to grid (V2G) charging • May aid in reducing operating costs	Evaluation of Readiness (Electric Grid/Alternative Fuel Distribution)	Medium	Short Term	DRPT	Utility Companies (with service areas in VA)
DCSR.1	Data Collection	Maintain an up-to-date timeline of explicit goals and milestones associated with fleet transitions for VA transit agencies	Planning • Aid DRPT in identifying opportunities to support agencies or foster collaboration and partnership across agencies (where timelines allow)	Comprehensive Toolkit for Low or Zero Emission Transition	Medium	Short Term - set up Long Term Management	DRPT	N/A

ID Number	Task	Recommendation	Benefits	Desired Outcome Category	Implementation Effort	Timeline Short-term (<2 years) Medium-term (2-5 years) Long-term (>5 years)	Potential Lead Agency	Potential Partner/Supporting Agency and Organizations
			• Allow DRPT to identify opportunities to support agencies by coordinating bulk orders of low- and zero-emissions buses (where procurement timelines for multiple agencies allow) • May alleviate the fleet transition burden on smaller and rural agencies					
DCSR.2	Data Collection	Establish a regular touchpoint with VA transit agencies, so DRPT can inform agencies of the state of the alternative fuels market and allow agencies to exchange status updates on fleet electrification or emissions reduction efforts	Education and Outreach • Would allow for cross-agency relationships • Information exchange regarding the pursuit of fleet transitions • Introduce agencies to common terms and basic principles • Provide state of the market information related to electrification (Similar to items 2 and 4)	Comprehensive Toolkit for Low or Zero Emission Transition	High	Short Term - set up Long Term Management	DRPT	N/A
DCSR.3	Data Collection	Coordinate with VA transit agencies by region on utilities coordination and the potential for shared fueling/charging solutions	Coordination • Increased collaboration between small and rural transit agencies in the same or nearby areas • Help to alleviate the burden of fleet transitions on the agencies	Evaluation of Readiness (Electric Grid/Alternative Fuel Distribution)	Medium	Short Term	VA Transit Agencies	DRPT (potential to support/foster collaboration)
DCSR.4	Data Collection	Maintain an audit history of the data submitted by VA agencies (create a VA Data Repository).	Planning • May improve data integrity and provide insight into changes that occur pertaining to agency submissions.	Comprehensive Toolkit for Low or Zero Emission Transition	Low	Short Term - set up Long Term Management	DRPT	N/A
DCSR.5	Data Collection	Provide guidance to VA agencies to incorporate outputs from the Low and Zero Emission Transition Plan Tool (if prepared) into their Transit Asset Management Plan. Initially, guidance should be updated and communicated	Planning • May drive improvements with data collection and foster a more thorough plan for agencies that plan or have deployed low and zero emissions vehicles. • May provide increased visibility to the MTF Low or Zero Emission Transition Planning Tool	Comprehensive Toolkit for Low or Zero Emission Transition	High	Short Term	DRPT	NA
DCSR.6	Data Collection	Make edits to the TSP and Grant Application Manual that incorporates activities and outcomes of the MTF Low or Zero Emission Transition Planning Tools **(refer to TSP and grant application recommendations in Data Collection and Study Review Section)**		Evaluation of Financial Hurdles to Low or Zero Emission Transition	High	Short Term	DRPT	NA
WD.1	Workforce Development	Centralize transit workforce development information clearinghouse and develop unified statewide guidance for using transit workforce training resources there	Education and Outreach • Will satisfy labor and agency concerns about policy whiplash and timelines for implementation	Understand the Needs and Opportunities for Workforce Development	Low	Short Term - set up Long Term Management	DRPT	VDOT, DEQ, DO Energy, DOL, DWDA, etc.
WD.2	Workforce Development	Identify training and certification expectations for transit roles, if appropriate, along with timelines for		Understand the Needs and	Medium	Short Term	DRPT	VDOT, DEQ, DO Energy, DOL, DWDA, etc.

ID Number	Task	Recommendation	Benefits	Desired Outcome Category	Implementation Effort	Timeline Short-term (<2 years) Medium-term (2-5 years) Long-term (>5 years)	Potential Lead Agency	Potential Partner/Supporting Agency and Organizations
		enforcing those expectations. Provide guidance on ways to meet them.		Opportunities for Workforce Development				
WD.3	Workforce Development	Identify ways that transit agencies and/or DRPT can supplement outside instruction with in-house hands-on training with ZE equipment	Training • Improve CC training capacity and outcome quality	Understand the Needs and Opportunities for Workforce Development	Medium	Short Term	DRPT	VDOT, DEQ, DO Energy, DOL, DWDA, etc.
WD.4	Workforce Development	Support transit agencies to establish and operate internship and mentorship programs for operations and maintenance roles	Training • Improves transit agency training capacity, retention rates, and recruitment capacity	Understand the Needs and Opportunities for Workforce Development	Low	Medium Term	DRPT	VDOT, DEQ, DO Energy, DOL, DWDA, etc.
WD.5	Workforce Development	Identify ways to support community colleges and other technical education for transit operations and maintenance roles.	Training • Improve training capacity and pipeline durability for tomorrow's challenges	Understand the Needs and Opportunities for Workforce Development	Low	Medium Term	DRPT	VDOT, DEQ, DO Energy, DOL, DWDA, etc.
WD.6	Workforce Development	Develop and expand joint procurement programs that allow both transit agencies and their technical education partners to purchase similar equipment	Coordination • Improve cost outcomes for agencies and taxpayers • Streamline training outcomes statewide	Understand the Needs and Opportunities for Workforce Development	Medium	Medium Term	DRPT	VDOT, DEQ, DO Energy, DOL, DWDA, etc.
WD.7	Workforce Development	Develop a coordinated interagency apparatus for gathering workforce needs, identifying worthy programs, communicating with stakeholders, and allocating funding	Coordination • Improve effectiveness for a range of electrification and workforce development programs across the state government	Understand the Needs and Opportunities for Workforce Development	High	Short Term - set up Long Term Management	Unknown	VDOT, DEQ, DO Energy, DOL, DWDA, etc.
FTPT.1	Fleet Transition Plan Template	Continue support with Commonwealth agencies to further analyze operation. Feasibility study will provide important information needed for utility support/partnership to insure infrastructure planning starts early.	Planning • Gives a higher fidelity look at fleet and operations • Provides a better understanding of routes that may not be feasible.	Comprehensive Toolkit for Low or Zero Emission Transition	Medium	Short Term	Transit Agency	Expert Resource/DRPT
FTPT.2	Fleet Transition Plan Template	Conduct and annual review to ensure current FTA requirements are reflected in the current version of the transition plan template.	Education and Outreach • Ensure accurate information • Aid in transit agencies being able to plan more appropriately	Evaluation of Financial Hurdles to Low or Zero Emission Transition	Medium	Short Term - set up Long Term Management	DRPT	Expert Resource
FTPT.3	Fleet Transition Plan Template	Develop tool to aid Commonwealth transit agencies with analyses that cover redundancy, resilience, and emergency response.	Planning • Provides additional information that addresses preplanning for emergency situations and aids in mitigating service interruption.	Comprehensive Toolkit for Low or Zero Emission Transition	Medium	Short Term	Transit Agency/Expert resource	DRPT

ID Number	Task	Recommendation	Benefits	Desired Outcome Category	Implementation Effort	Timeline Short-term (<2 years) Medium-term (2-5 years) Long-term (>5 years)	Potential Lead Agency	Potential Partner/Supporting Agency and Organizations
FTPT.4	Fleet Transition Plan Template	Create an automated Transition Planning template that can be accessed and completed electronically.	Planning • Will aid in further streamlining low and zero emission transition planning process	Comprehensive Toolkit for Low or Zero Emission Transition	High	Short Term	DRPT	Expert Resource

APPENDIX B – TECHNICAL MEMORANDUMS

MEMORANDUM

To: Daniel Wagner
Tiffany Dubinsky
Virginia Department of Rail and Public Transportation

From: Jeffrey Sallee
Sam Sink
John Jackson
Kimley-Horn and Associates, Inc.

Date: November 6, 2023

Subject: UTILITY COORDINATION TECHNICAL MEMO #1

This memo is intended to convey information on the electrical, natural gas, and hydrogen suppliers in the Commonwealth of Virginia. These suppliers, also called utilities, are responsible for owning, distributing, and establishing services to end customers for electric, natural gas, or hydrogen. A listing of the suppliers will be provided as an attachment to this memo. A sample of the utility one-page informational sheets is also provided at the end of this memo. For the Modernizing Transit Fleets (MTF) guide, each utility will be represented with an informational sheet. Each sheet will convey the utility name, address, point of contact, contact information, procedures for initiating work requests with the utility, rate schedules, and load letters.

At the time, this document is being prepared, information regarding electric utilities is still being finalized. Therefore, some information may not be present at this time.

This memo will also cover topics that may allow transit agencies to reduce costs associated with infrastructure and electricity/fuel.

Lastly, this memo will cover hydrogen fueling options and provide a checklist of how to procure hydrogen fueling services.

UTILITIES

Electric and natural gas utilities within the Commonwealth range from large multi-state companies to local cooperatives. Each utility has a different structure and process for setting up accounts and new services. This memo and the ultimate MTF Guide deliverable outline the strategy for incorporating the various utility processes into step-by-step, digestible instructions for transit agencies to follow when transitioning their bus fleets to compressed natural gas (CNG), battery electric, or hydrogen fuel-cell. The key to coordination with these utilities is early communication. Bring the utility into the transition process as early as possible to give the utility ample time to:

- perform their own assessments and designs;
- order equipment that has long lead times;

- get the project on their construction schedule;
- and get cost to transit agency (if any).

The local utility is the transit agency's partner from the planning stage, through design and construction, and through operation. The utility will be with the transit agency for the life of the project, so it is important to have a good working relationship with them. Attached to this memo is a list of the utility providers in Virginia that will be the transit agencies partners in establishing services for their low or no emissions fleet. This list will help the transit agencies identify the utility in their territory.

There are also opportunities to reduce costs for new fleet operations and maintenance facilities that the utility can either directly or indirectly support for the transit agency. Some of those strategies are discussed in the following sections.

COST REDUCING STRATEGIES

Bi-Directional Charging – Vehicle Grid Integration (VGI)

Traditional electrical vehicle (EV) charging transfers energy from the utility, first through a low voltage AC system, then through a charger, and to a vehicle's battery system. Bi-directional charging, also known as vehicle grid integration (VGI), allows for the energy stored in the vehicle's battery system to flow back through the charger into the AC system. This energy can be routed to several places:

- the facility's electrical system,
- a stationary battery energy storage system (BESS),
- another battery electric vehicle,
- appliances or loads,
- or the electrical grid.

Reasons for incorporating VGI charging include:

- reducing peak demand,
- generating additional revenue,
- and better resiliency of the system.

An EV can be described as a mobile battery energy storage system, or a battery on wheels. As such, it is a distributed energy resource that can return energy back into the grid. This can help create additional capacity for the grid during peak times of the day to avoid brown outs or require extra generation at the power plant. Typically, peak times for electric utilities are as follows:

- Residential: 6:00am-10:00am, 5:00pm-9:00pm
- Commercial: 10:00am-5:00pm

In the middle of summer and winter, the peak demands are at their highest due to the increased use of air conditioning and heating, respectively. During peak times, the electrical grid can be strained and lead to brownouts. Utilities are adding sources of generation to lower dependence and emissions from typical coal-fired, hydroelectric, and/or nuclear generating plants. These additional sources may be solar, wind, or other alternative energies. Utilities are also increasing their usage of BESS to hold energy generated by alternative energy sources that do not need to be used immediately or energy that can be stored from the grid in off-peak hours. This stored energy can be utilized by utilities during peak hours to lessen the strain on the grid and reduce the amount of energy needing to be generated at the main plants.

VGI can turn battery electric vehicles into additional distributed energy resources. Distributed energy resources are small-scale energy sources that are geographically distinct from the main generating power plant, such as rooftop solar and batteries. When battery electric vehicles (BEVs) are used to put energy back into the grid, it is known as vehicle to grid (V2G). When V2G is utilized, it is for one of two purposes: to reduce peak demand on the local facility electrical system or to generate revenue.

Transit agencies can utilize their fleets for V2G, but several factors need to be considered prior to implementation:

1. Dwell time of the battery electric buses. First, each bus's time in the depot should be used to charge its battery to the charge level required for its routes the following day. If the bus is sitting at the depot for additional time beyond its charging, there may be an opportunity for V2G.
2. Schedule for the battery electric buses to dwell at the depot. Since most bus depots will be subject to electric rate schedules that have on-peak and off-peak rates for energy use, it makes financial sense to optimize when buses are charged. Whenever possible, buses should be charged during off-peak hours so that the cost to charge is minimized. If buses dwell at a depot during on-peak and off-peak hours, and there is sufficient time to charge in the off-peak, V2G can be accomplished during the on-peak hours. The advantages to V2G during on-peak hours are reducing peak demand on the grid and revenue generation. When electricity is sold back to the utility during on-peak hours, the utility typically pays the higher peak rate. This is how part of the V2G business model works – buy low, sell high: charge vehicle battery at off-peak prices, sell back energy from the battery at on-peak prices.
3. Electric utility agreements need to be in place for VGI. Transit agencies need to understand what the electric utilities will and will not allow for VGI charging and what is required for VGI charging. An interconnection application will be required. This application will let the utility know what amount of energy is being proposed to connect to their system and where it is located. The interconnect application process may take several months for the utility to review and approve.

Many transit agencies may find that their bus schedules will not allow for the additional depot dwell time to make V2G feasible. Time is the most limiting factor in the transit sphere. However, if time is available for buses to implement VGI charging, transit agencies should at least investigate the opportunity to see if it is right for them. The positive effects of VGI charging are:

- reduced peak demand;
- revenue generation/reduced electrical bill;
- and increased resiliency.

Microgrids

VGI charging allows the battery of an EV to be an energy source, rather than just a load. And as an energy source, the vehicle's BESS can provide supplemental support to facility's electrical system and grid as described previously. But when there also other sources of generation available, they can be interconnected to create a reliable system that sees the electrical system uptime maximized and the strain on the grid minimized.

The National Renewable Energy Laboratory (NREL) defines a microgrid as "a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid." The EV's BESS, solar panels, generators, utility connections, etc. are the load and resources. They are wired and networked together and programmed to operate efficiently with respect to the grid. When used in conjunction with the utility electric grid, the microgrid is operating in grid-connected mode.

Microgrids can also operate in island mode in which these distributed energy sources can operate the system when the grid is off-line. This typically happens during major storm events or extreme temperatures. The microgrid controller recognizes the utility is offline and the other energy resources become the main power source. Sources like solar panels and generators generate power that can be used immediately. Batteries can store the energy generated by these other sources (or the grid) when not immediately needed so that the energy can be utilized at a future time. Batteries can also help bridge short spans when there is a utility blip or peak shave to reduce strain on the utility grid.

Microgrids can help customers meet their carbon emission reduction goals. Customers usually do not have a say in how their power is generated, but utilizing microgrids allows for the customer to do so. Utilizing microgrids means incorporating renewable energy sources that are not fossil fuel based. Microgrids can also help reduce the amount of fossil fuels the main utility source generates, especially at peak hours. By offsetting fossil fuel generated power with green energy generated power, customers' power needs are met, and carbon emissions are reduced.

Many utilities will purchase excess generated power from their customers. This potential for revenue from the renewal energy sources of the microgrid can help lower the cost of the microgrid and give it a more reasonable return on investment. There can be significant costs for microgrids, especially if none of the distributed energy sources are already in place. According to a 2018 NREL study[1], microgrids can cost $2,000,000-$4,000,000 per megawatt. And based on transit type facilities and usage, the cost is likely to be in the upper half of that range.

For the purposes of battery electric buses and the transit agencies transition to their use, microgrids should only be employed: where the transit facility is mission critical; if the agency has a carbon emission reduction goal to meet; and/or where distributed energy sources are already existing. If the facility houses an emergency operation center, traffic operation center, etc, and downtime is unacceptable, there may be a case for a microgrid. The main reason microgrids are not a solution for every transit facility currently is the cost to deploy the microgrids.

If the agency already has distributed energy sources in place, is designing them into new facilities, or has grant money to fund these energy sources, the microgrid costs will be reduced and make for a more affordable solution. A functional microgrid can be as simple as a canopy/roof solar feeding into the facility's main switchboard and a generator being an emergency source on an automatic transfer switch. As the number and size of the distributed sources increases and the controlling mechanism increases in complexity, the cost of the microgrid will increase. Customers should consult with a professional engineer to determine if a microgrid is a viable solution for them, and if so, what size and complexity of microgrid.

Shared Fueling and Charging Infrastructure

Agencies should consider options for sharing charging and fueling infrastructure where possible to help reduce the capital costs of infrastructure. Though many transit agencies want to share infrastructure, a limited survey of industry partners representing both Battery Electric Bus (BEB) and Fuel Cell Electric Bus (FCEB) technologies revealed that there are very few examples of transit agencies successfully turning these desires into reality. Several hurdles to implementation were identified that agencies should consider if they want to pursue shared charging and fueling infrastructure.

[1] Giraldez, Julieta, Francisco Flores-Espino, Sara MacAlpine, and Peter Asmus. 2018. Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5D00-67821. https://www.nrel.gov/docs/fy19osti/67821.pdf.

BEB

- Often agencies do not overlap geographically, so there is limited potential to share on-route charging infrastructure. Northern Virginia is the primary exception, though the Northern Virginia Transportation Commission is addressing the potential for shared infrastructure through its ZEB strategic planning process.
- Depot charging requires several hours and scheduling needs preclude transit agencies from staggering their use of depot-based charging infrastructure.
- Sharing charging infrastructure with private businesses or the public would require physical separation of charging infrastructure at depot charging facilities. In Glasgow, First Bus has agreements with parcel delivery service (DPD) and the local police department to allow them to charge their vehicles in a fenced off part of the depot during the day.

FCEB

- Fuel cell electric vehicles are still a developing technology and there is a lack of standardization of fueling pressures. The best opportunities for FCEBs to share infrastructure are with other heavy vehicles such as tractor trailers and garbage trucks. Commercially available buses fuel at a pressure of 350 bar, but other heavy vehicles may fuel at either 350 or 700 bar.
- FCEB fueling infrastructure requires a relatively large footprint, similar to that of CNG. Agencies wanting to share fueling infrastructure would have to be proximal enough to fuel buses at another agency's facility without incurring a cost-prohibitive amount of deadhead mileage.
- Agencies may have differing comfort levels with grey, blue, and green hydrogen that could make joint fuel sourcing difficult.

If these obstacles can be addressed, the following existing technology may facilitate the sharing of infrastructure.

Discrete Radio Frequency Identification (RFID) tags can be assigned to individual vehicles across coordinating agencies/jurisdictions to allow charging or fueling infrastructure to track charging or refueling by agency. This may require some coordination of fleet management systems to ensure that vehicle RFID lists are automatically updated on a regular basis. Not only could transit agencies use this technology to share fueling infrastructure among themselves, but there are potentially opportunities for agencies with near major truck corridors to generate revenue by becoming a charging/fueling station for long-haul zero-emissions trucks.

Green hydrogen fuel can be produced from floating solar arrays. Opportunities may exist to coordinate with regional water reservoir managers to utilize floating solar arrays to reduce reservoir evaporation while producing green hydrogen that can be used by transit agencies.

Several cities share their charging stations with employees and/or the public, which can help generate operating revenue and leverage their infrastructure investments. This model could be used by agencies that operate smaller (<15 passengers) vehicles that utilize the same charging infrastructure as personal vehicles. Agencies can own the charging stations and contract technical support and maintenance with charging vendors. However, two other models, sharing ownership with the vendor, or full vendor ownership and operation, can provide flexibility, especially when sharing the fleet charging stations with private customers as shown in **Table 1**.

Table 1: Charging Infrastructure Operating Models

Model	100% Agency Owned and Operated	Shared with Vendor	100% Vendor Owned and Operated
Description	Agency purchases and installs the charging stations and keeps 100% of the charging and clean fuel credit revenue	Agency purchases equipment, vendor installs and operates stations; agency and vendor share ownership	Vendor purchases equipment and operates; agency or vendor pay for construction
Charger Maintenance	Via a maintenance contract; equipment provider provides driver support	Vendor provides technical support, maintenance, and operation	Vendor provides technical support, maintenance, and operation
Agency Staff Role	Potentially to issue work orders and financial reporting	Pay fees to vendor	Pay fees to vendor
Revenue Option 1	100% agency; agency sets price at charging station	Split: agency keeps station revenue; vendor keeps CFS credits	Split: agency and vendor each have a percentage of revenue
Revenue Option 2	N/A	Vendor pays agency a fee and retains all revenue	100% vendor

If an agency chooses shared or vendor-owned models, vendor contracts may require that the agency install only that vendor's charging stations during the term of the contract. If an agency chooses to own and operate the charging stations, each charging station vendor offers an optional maintenance contract that includes repairs from vandalism or accidents, and software/ hardware updates. Agency staff may expect to maintain wiring, breakers, panels, and meters.

Alternatively, Rural transit providers, that typically operate smaller vehicles within larger service areas could make use of public charging infrastructure, rather than arranging for their own charging infrastructure on-site. Agencies and localities should be proactive in including transit providers in planning the deployment of new charging infrastructure for light-duty vehicles. Technology and charging-use agreements between agencies and vendors could allow charging priority for transit vehicles at these facilities to ensure service reliability.

HYDROGEN CHECKLIST

Agencies planning for FCEB implementation can utilize the checklist below as a guide to what tasks need to be accomplished. Planning for implementation can be an iterative process. The order of some checklist items may change as the agency develops a transition plan that best meets its evolving needs.

1. Estimate of how many FCEB buses to purchase and at what time
2. Determine whether the agency will use green, blue, or grey hydrogen and whether the agency is willing to begin with one type and transition to a more environmentally sustainably produced hydrogen as supply becomes available
3. Determine the manufacturer and model of FCEB to purchase
4. Select on-site or off-site fuel production
5. Select hydrogen fuel delivery method (if produced off-site)
6. Determine amount of on-site fuel storage required
7. Assess space needs and code requirements for fuel storage and fueling infrastructure
8. Preliminary fueling infrastructure design and environmental review
9. Retrofit maintenance bays to accommodate FCEBs
10. Order vehicles
11. Complete construction of fuel storage and fueling infrastructure
12. Train workforce

Every agency will have unique requirements impacting the choice of fueling technology. Suppliers of hydrogen infrastructure, with experience supporting deployments of fuel cell buses in the United States, include the following companies below in **Table 2**. This list is not meant to be exhaustive and new suppliers will emerge as the FCEB and the broader hydrogen market mature.

Table 2: Hydrogen Infrastructure Suppliers and Contacts

Supplier	Fueling Technology
Air Products	• Gaseous hydrogen delivered in tube trailer • Bulk delivery of liquid hydrogen • On site reforming of natural gas
Air Liquide	• Gaseous hydrogen delivered in tube trailer • Bulk delivery of liquid hydrogen • On-site SMR or electrolysis
Linde Group	• Bulk delivery of liquid hydrogen • On-site electrolysis
Proton OnSite	• On-site electrolysis
Nuvera	• On-site reforming of natural gas
Trillium	• Turnkey hydrogen station (equipment, gas supply, operation & maintenance)

Vehicle Counts and Timeline

Agencies will need to determine early in the transition process how many FCEBs they plan to accommodate at which facilities and what the timeline is for transition. This information will used to determine which hydrogen fuel infrastructure options are most appropriate for the agency and to ensure that infrastructure investments are made with long-term cost-effectiveness in mind.

Green, Blue, or Grey Hydrogen

Hydrogen is an invisible gas, but the hydrogen fuel industry uses different color names to describe how hydrogen fuel is produced. This naming convention helps hydrogen fuel consumers gauge the environmental friendliness differently produced fuel options. **Figure 1** describes each of the color naming conventions in detail. As the hydrogen industry evolves, the color naming conventions may change. Green, blue, and grey are the most discussed types of hydrogen for most agencies.

Green	Blue	Grey
• Hydrogen produced by electrolysis of water, using electricity from renewable sources like wind or solar. No CO_2 emissions are produced.	• Hydrogen produced from fossil fuels where the CO_2 is captured and either stored or repurposed.	• Hydrogen extracted from natural gas using steam-methane reforming. This is the most common form of hydrogen production.

Figure 1: Hydrogen Naming Conventions

Fuel providers may not offer hydrogen produced using all three of these methods. As the hydrogen fuel market continues to mature, there will be more options available to agencies for sustainably produced hydrogen. Agencies may begin piloting FCEBs using more readily available grey hydrogen before transitioning to green as more renewable hydrogen production facilities come online. Periodic contact with fuel providers is recommended to stay updated on the availability of different types of hydrogen.

Vehicle Manufacturer and Model

Different manufacturers of FCEBs provide different fuel tank capacities and may fuel at different pressures. These factors impact estimates of the amount of hydrogen fuel needed for operations and the specifications of the pressurization and fueling infrastructure.

On-site or Off-site Fuel Production/Fuel Delivery Method/Fuel Storage

Hydrogen can be produced at large, centrally located facilities, then transported to the point of end-use; small facilities near the end point of use; or produced on-site. An agency's preferred source of hydrogen fuel will be influenced by the amount of fuel needed and delivery distance. **Figure 2** below is a graphic that explains the preferred method of supplying fueling stations with hydrogen.

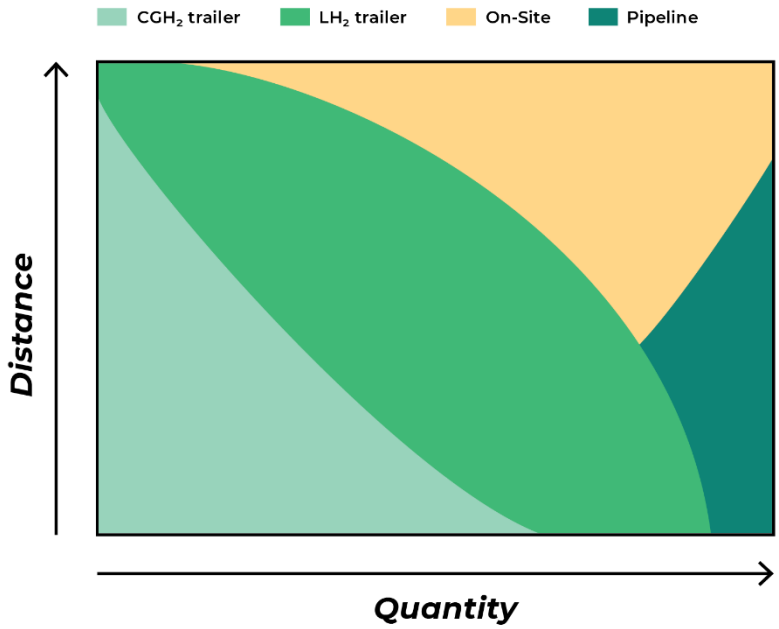


Figure 2: Preferred Method of Supplying Fueling Stations with Hydrogen

On-Site Production

A process called electrolysis can be used to produce hydrogen on-site. The hydrogen can be stored on-site until it is required for fueling. If the electricity used to power electrolysis is renewable, this method of hydrogen production will not produce any greenhouse gas emissions. This method can be a good option for properties that have limited options for fuel delivery and that plan to scale their use of FCEBs enough to recoup the investment in on-site production. Mass Transit District (MTD) in Urbana, IL has successfully implemented on-site electrolysis powered by an 8-acre solar array on a neighboring property.

Hydrogen can also be produced on-site using a Steam Methane Reformation (SMR) process that derives hydrogen from natural gas. This process will always generate emissions, though Renewable Natural Gas (RNG) offers an opportunity to limit these emissions.

Off-Site Production

For demonstration or low-volume projects, compressed gaseous hydrogen can be delivered in tube trailers. Trucks transport the tubes to the agency's facility from a centralized production location. This option reduces the need for capital intensive permanent infrastructure, but the gas comes in low volumes and requires frequent delivery. It also arrives to the facility at lower pressure than liquid hydrogen and will require additional compression at the fueling station on-site.

Agencies that anticipate scaling to large numbers of FCEBs and have limited space for on-site production would benefit from liquid hydrogen delivery and storage. Liquid hydrogen has a higher energy density than gaseous hydrogen and thus can be more cost-effective agencies needing to fuel larger numbers of vehicles. Equipment is required at the agency fueling facility to vaporize the liquid into a high-pressure product for FCEB fueling.

Table 3 below provides an overview of the factor's agencies should consider when evaluating potential hydrogen supply sources.

Table 3: Hydrogen Supply Alternatives

Topic	Compressed Gaseous H_2	Liquid H_2	On-Site SMR	On-Site Electrolysis
Overall	Good for volumes <125kg/day	Excellent for large volumes	Good for large volumes	Can be good for large volumes
Distribution Costs	High; price drastically affected by location	Nominal; range flexibility	None	None
Price Volatility	Cost dependent on fuel prices but can be set with contract	Cost dependent on fuel prices but can be set with contract	Cost dependent on maintenance and CNG/RNG costs	Cost dependent on maintenance and electricity costs
Infrastructure Costs	Lower	Higher	Depends on production capacity	Depends on production capacity
Carbon Emission Reductions	Renewable hydrogen available at higher cost	Renewable hydrogen available at higher cost	RNG available at higher cost	Renewable energy is available at higher cost or renewable energy infrastructure can be installed on-site

Source: Ballard Power Systems

Space Needs and Code Requirements

In coordination with determinations about the type and scale of hydrogen fueling infrastructure, agencies should engage in preliminary site planning to determine the space requirements of fueling in structure, where the infrastructure will be sited, and what, if any, subsequent changes are needed to the facility to maintain operational effectiveness.

Preliminary Design and Environmental Review

Agencies will need to budget and plan time for preliminary design of fueling infrastructure and addressing any environmental review requirements that would be triggered by using federal funding for fueling infrastructure.

Retrofit of Maintenance Facility

Hydrogen is a Class 2 flammable gas, which requires specific safety elements. Agencies that currently use CNG fuel will require minimal modifications. Local codes may require additional features and agencies should contact their local jurisdictions and emergency response services during the project planning process to understand local requirements.

Hydrogen Detection System

A hydrogen detection system should be installed to detect dangerous build-ups of gas and to ensure that ventilation is working as planned. These detection systems can be multi-stage with combinations of flashing lights and audible alarms that activate at different levels of gas detection.

Defueling System

A defueling system is necessary to remove fuel from buses after an incident or during certain maintenance and repair procedures. This system can either transfer the hydrogen to a storage tank, vent it outside into the air, or both.

Adequate Ventilation

Hydrogen is lighter than air and rises when released. This can lead the gas to pool at the highest point of the maintenance shop, creating an ignition hazard. Agencies should ensure that ventilation systems meet ventilation requirements for a Class 2 flammable gas.

Vehicle Order

Careful consideration should be given to the timing of vehicle orders to avoid having the vehicles arrive prior to completion of fueling and maintenance construction activities. Vehicles sitting in the depot unable to be refueled could cause operational challenges.

Fueling Infrastructure Construction

Agencies should plan to complete construction of fueling infrastructure and maintenance facility retrofitting before vehicle delivery.

Workforce Training

Agencies should include adequate time for hiring and workforce training in their implementation schedule. More information on this topic can be found in Technical Memo #3.

MEMORANDUM

To: Daniel Wagner
Virginia Department of Rail and Public Transportation (DRPT)

From: Emma Sexton
John Jackson
Kimley-Horn and Associates, Inc.

Date: October 2, 2023

Subject: Technical Memorandum #2: Data Collection and Study Review

INTRODUCTION

The following memorandum documents the findings of Task 4: Data Collection and Study Review associated with the Virginia Department of Rail and Public Transportation (DRPT) "Modernizing Transit Fleets: A Guide to Low- and Zero-Emissions Buses" project.

The **Modernizing Transit Fleets Project** aims to create a comprehensive resource guide and toolkit for Virginia's transit agencies that wish to transition their fleets to low- and zero-emission vehicles. This project builds on the analysis conducted through the Virginia Transit Equity and Modernization Study and addresses six identified short- and long-term needs to advance the transition to low- and zero-emission buses throughout the Commonwealth.

This memorandum contains three primary sections of research: Project Background, Goals & Policy Synthesis, and Best Practices & Resources. The content of this document will serve as the basis for the eventual toolkit guide.

PROJECT BACKGROUND

Virginia Transit Equity and Modernization Study

The Virginia Transit Equity and Modernization Study was initiated by House Joint Resolution 542. It evaluated various planning and implementation topics, some of which related to low- and zero-emissions bus fleets. The study team developed reports covering each of the following topics: **Feasibility and Cost Analysis of Transitioning the Commonwealth's Fleet to Electric Technology**, **Utility Readiness**, and **Obstacles to Implementation**. The findings in the reports informed the actions and recommendations outlined in the Virginia Transit Equity and Modernization Study: HJ 542 Final Report[1] and are summarized below. The Modernizing Transit Fleets Project directly addresses six outcomes and recommendations of

[1] An executive summary of the HJ 542 Final Report for the Virginia Transit Equity and Modernization Study can be found here: Virginia Transit Equity and Modernization Study: HJ 542 Final Report Executive Summary.

the Virginia Transit Equity and Modernization Study relating to low- and zero-emissions buses, consisting of the following:

- **Establish statewide goals for zero-emission transit vehicles and a transition plan to convert transit agency fleets.**
- **Conduct recurring assessments of innovation in the zero-emission transit vehicle industry.**
- **Develop implementation resources for agencies to assist with their fleet transition planning.**
- **Establish guidance for on negotiating technology contracts.**
- **Align MERIT (Making Efficient and Responsible Investments in Transit) program funding with zero-emission goals.**
- **Expand opportunities for technology funding and implementation assistance.**

The Virginia Transit Equity and Modernization Study emphasized that *establishing statewide goals for zero-emission transit vehicles and a transition plan to convert transit agency fleets* is an imperative first step in advancing low- and zero-emissions fleet transitions. Statewide goals should ensure that benefits are shared, consider the availability of data, align with established statewide and federal emissions targets, and consider phased fleet replacements. As outlined in the **Feasibility and Cost Analysis of Transitioning the Commonwealth's Fleet to Electric Technology** report, there is an opportunity to avoid 1.74 million metric tons of GHG emissions by 2045 with a complete statewide fleet transition, and total savings of approximately $268 million.

The Virginia Transit Equity and Modernization Study also identified a need to *develop implementation resources for agencies to assist with their fleet transition planning.* To successfully implement modern technologies, transit agencies must financially prepare for capital and maintenance costs, train their workforce, and foster new partnerships with equipment manufacturers and utility companies. The development and distribution of best practices for navigating modern technologies and mitigating potential obstacles can ease this paradigm shift. For example, the **Utility Readiness** report outlines a process to coordinate with utility companies that begins with setting the electrification goals and assess technology, conduct an exploratory meeting with electric utility companies, and identify funding sources and optimize rates. The Virginia Transit Equity and Modernization Study also proposes another action to distribute effort and reduce duplicative efforts by *establishing guidance for agencies negotiating technology contracts.*

Multiple Virginia Transit Equity and Modernization Study outcomes intend to support agencies in identifying funding sources, *expand opportunities for technology funding and implementation assistance* and *align MERIT program funding with zero-emission goals.* As noted in the **Obstacles to Implementation** report, low- and zero-emission busses are not a drop-in replacement for existing internal combustion engine (ICE) vehicles. Thus, transit agencies must develop a realistic replacement schedule that accounts for the variety of costs incurred during through the implementation process to accurately pursue funding.

The Virginia Transit Equity and Modernization Study also recommends *conducting reoccurring assessments of innovation in the zero-emission transit vehicle industry*. Annual data sharing of data can help to position agencies to best leverage new and updated technology. Data could include progress of deployment, utility rates, route and blocking data, fleet information (e.g., energy storage by bus,

inoperability of buses and chargers), facilities information (e.g., utility rates, pricing), and available models and fueling infrastructure.

The above summary focuses on outcomes directly relevant to the Modernizing Transit Fleets Project, though there are a variety of other recommendations that support the modernization of transit statewide.

Survey Results

Throughout the Virginia Transit Equity and Modernization Study, two surveys were conducted to garner feedback from agencies across the Commonwealth. The first survey, conducted Summer through Fall of 2021, intended to gather feedback about the status of agencies planning and operations across the seven project topic areas (adequacy of infrastructure, accessibility, electrification, emerging technology, safety, and system engagement and governance). All 39 agencies responded to the survey. Relevant results are captured below:

- **Question 23:** Does your agency currently operate any zero emissions transit buses or paratransit vehicles (ZEBs)?
  - **8%** (3 of 39 agencies) responded **"yes"**
  - **92%** (36 of 39 agencies) responded **"no"**
  - **Question 23a**: If no, what are your immediate concerns about integrating ZEBs into your fleet? *(multiple selection question)*
    - **78%** (28 of 36 agencies) selected **"Additional Funding"**
    - **58%** (21 of 36 agencies) selected **"Impact to Operations"**
    - **42%** (15 of 36 agencies) selected **"Understanding"**
    - **42%** (15 of 36 agencies) selected **"Training"**
    - **22%** (8 of 36 agencies) selected **"No concerns"**
    - **6%** (2 of 36 agencies) selected **"Other"**
- **Question 24**: Has your agency defined a goal to convert your fleet to ZEBs?
  - **18%** (7 of 39 agencies) responded **"yes"**
  - **82%** (32 of 39 agencies) responded **"no"**
  - **Question 24a**: If yes, what is the goal?
    - **43%** (3 of 7 agencies) selected **"Convert the entire fleet to ZEBs"**
    - **29%** (2 of 7 agencies) selected **"Conduct a pilot for ZEBs"**
    - **29%** (2 of 7 agencies) selected **"Convert a portion of the fleet to ZEBs"**
    - **Question 24b**: Do you have a documented ZEB fleet transition plan or electrification plan?
      - **29%** (2 of 7 agencies) responded **"yes"**
      - **71%** (5 of 7 agencies) responded **"no"**

- **Question 24c**: What are the primary motivations for electrifying your fleet? *(multiple selection question)*
  - **86%** (6 of 7 agencies) selected **"Reduction in emissions"**
  - **43%** (3 of 7 agencies) selected **"Improvement in rider perception"**
  - **43%** (3 of 7 agencies) selected **"Cost savings"**
  - **29%** (2 of 7 agencies) selected **"Legislative mandate"**
  - **29%** (2 of 7 agencies) selected **"Reduction in noise pollution"**
  - **14%** (1 of 7 agencies) selected **"Other"**

- **Question 24a**: If no, is your agency discussing or considering how to approach a ZEB policy?
  - **47%** (15 of 32 agencies) responded **"yes"**
  - **53%** (17 of 32 agencies) responded **"no"**

- This indicates that **44%** (17) of all agencies are not even at the stage of considering or discussing electrification of their fleet.

The second survey, conducted in Spring of 2022, gathered feedback from agencies regarding their priorities related to the Virginia Transit Equity and Modernization Study actions and recommendations. Only 13 agencies responded to the survey, the relevant findings of which are captured below:

For one of the survey questions, agencies were asked to **"rank all Transit Electrification action items according to your agency's priority level,"** to which each action item received the following average priority level amongst agencies, where one is lowest priority and six is highest priority:

- **5.3** / **6** – Develop implementation resources for agencies to assist with fleet transition planning
- **5.0** / **6** – Allocation of funding that aligns with electrification goals
- **4.2** / **6** – Statewide goals for electrifying transit vehicles and a transition plan to convert
- **4.6** / **6** – Recurring assessment of innovations in the zero-emissions transit vehicle industry

The results indicated that, above all, agencies highly value the development of implementation resources to assist them with fleet transition planning and the allocation of funding that can support agencies achieve their electrification goals.

GOALS & POLICY SYNTHESIS

A synthesis of goals and policy related to low- and zero-emissions transit, emissions reduction, transit electrification, and decarbonization are summarized in the following sections at a federal, regional, state, and transit agency level.

Statewide Priorities

Documents reviewed include documentation of DRPT grant programs and guidelines, as well as statewide plans to gauge the extent to which consistent policies and priorities related to fleet modernization and vehicle electrification were established and incorporated into various transportation planning processes. The following documents were reviewed as part of this process:

- DRPT Grant Program Policies and Guidelines
- DRPT Multimodal System Design Guidelines
- VDOT Resilience Plan
- Virginia Coordinated Human Services Mobility Plan
- Virginia Electric Vehicle Infrastructure Deployment Plan
- Virginia Electric Vehicle Readiness Study
- Virginia Statewide Integrated Mobility Initiative
- Virginia Transportation Plan (VTrans)
- Commonwealth of Virginia Clean Energy Policy
- 2022 Virginia Energy Plan

The predominant finding from this review is that while there are many and varied efforts throughout Virginia toward sustainability in the forms of vehicle electrification, carbon reduction, etc., they are not guided by established guidelines, policies, or priorities at the statewide level. From the documents reviewed, there does not appear to be officially adopted statewide targets, actions, or deadlines for vehicle electrification, carbon reduction, or overall resiliency.

The clearest indication that the Commonwealth of Virginia is investing in low- and zero-emissions transit is the existence of various DRPT grant programs to support funding of fleet electrification efforts for transit agencies in Virginia.

In addition, the Commonwealth previously established §45.2-1706.1, Commonwealth Clean Energy Policy, which recognized that addressing climate change requires the reduction of greenhouse gas emissions across the Commonwealth's economy sufficient to reach net zero emission by 2045 in all sectors (electric power, transportation, industrial, agricultural, building, and infrastructure sectors). However, the code has since been retracted.

While there are no clear directives from the Commonwealth that require transit agencies to transition their fleets by a specified date or achieve a certain emissions reduction goal, the development of this guide will assist agencies (and DRPT) in being poised to act strategically, swiftly, and in advance of any state requirements.

Timeline of Milestones and Targets

Various document types were consulted to construct a comprehensive timeline of milestones and targets related to low- and zero-emissions transit fleets in Virginia. Documents reviewed, shown in **Table 1**, include all available Zero-Emission Vehicle Transition Plans, Transit Strategic Plans, and Transit Development Plans for transit agencies operating in Virginia. Each document associated with Virginia transit agencies was examined to identify key milestones or decision points related to each agency's fleet transition.

Table 1. Reviewed Documents Associated with VA Transit Agencies

Transit Agency	Transit Development Plan (TDP)	Transit Strategic Plan (TSP)	Zero-Emissions Bus (ZEB) Study
Alexandria Transit Company (DASH)	X		
Altavista Community Transit	*Not found*		
Arlington Transit (ART)	X		X
Bay Transit	X		
Blacksburg Transit	X		
Blackstone Area Bus System	*Not found*		
Bristol Virginia Transit	X		
Central Shenandoah Planning District Commission (BRITE)	X		
Charlottesville Area Transit (CAT)	X		
Danville Transit	X		
District Three Public Transit (Mountain Lynx)	*Not found*		
Fairfax City University Energy Saver (CUE)	X		
Fairfax Connector	X		
Farmville Area Bus	*Not found*		
Four County Transit	*Not found*		
Fredericksburg Regional Transit (FXBGO!)	X		
Graham Transit	*Not found*		
Greater Lynchburg Transit Company		X	
Greater Richmond Transit Company	X		
Greensville-Emporia Transit	*Not found*		
Hampton Roads Transit		X	X
Harrisonburg Department of Public Transportation	X		
Jaunt	X		X
Lake Country Area on Aging	*Not found*		
Loudoun County Transit	X		
Mountain Empire Older Citizens	*Not found*		
OmniRide (PRTC)		X	X
Petersburg Area Transit		X	
Pony Express (Town of Chincoteague)	*Not found*		
Pulaski Area Transit	X		
RADAR	*Not found*		
Radford Transit	X		
STAR Transit	*Not found*		
Suffolk Transit		X	

Valley Metro (Greater Roanoke Transit Company)	X		
Virginia Railway Express[a]	X		
Virginia Regional Transit	X		
Washington Metropolitan Area Transit Authority (WMATA)[b]	X[c]		X[d]
Williamsburg Area Transit Authority	X		
Winchester Transit	X		

[a] *Virginia Railway Express operates rail service and is therefore not applicable to this study.*
[b] *WMATA is not an agency under the guidance of DRPT but has two facilities and some routes in Northern Virginia.*
[c] *WMATA's TDP was not reviewed, rather, the routes that operate in Northern Virginia were included in Arlington Transit's TDP.*
[d] *Only WMATA's facility conversions/retrofits for ZEBs and full fleet electrification goal are included in the timeline below.*

In addition, federal documentation was reviewed to determine any federal goals, targets, or milestones associated with low- and zero-emissions transit, emissions reduction, transit electrification, and decarbonization. The following documents were reviewed:

- U.S. National Blueprint for Transportation Decarbonization
- USDOT Climate Action Plan
- Global Drive to Zero (Webpage)

Based on the review associated with this memorandum, the timeline shown in **Figure 1** includes known transit agency transition milestones or goals, federal milestones or goals, and global milestones or goals related to bus electrification. The intent of this timeline is to show the trend of planned fleet electrification efforts across Virginia, and how those align with federal and global efforts. The timeline is not comprehensive of significant milestones across the United States but serves to provide a high-level snapshot of the currently planned fleet transition milestones that have been established across Virginia's transit agencies (as explicitly reflected in zero-emissions bus plans), across the backdrop of any notable goals and milestones across the country and globe.

The timeline is a snapshot in time and will change as more agencies begin planning and establishing explicit goals/milestones for low- or zero-emissions fleet transitions. It reflects that only a few agencies across Virginia have established plans for transitioning their fleets to low- or zero-emissions buses. Keeping track of explicit goals and milestones across Virginia transit agencies will aid DRPT in identifying opportunities to support agencies or foster collaboration and partnership across agencies, where timelines allow.

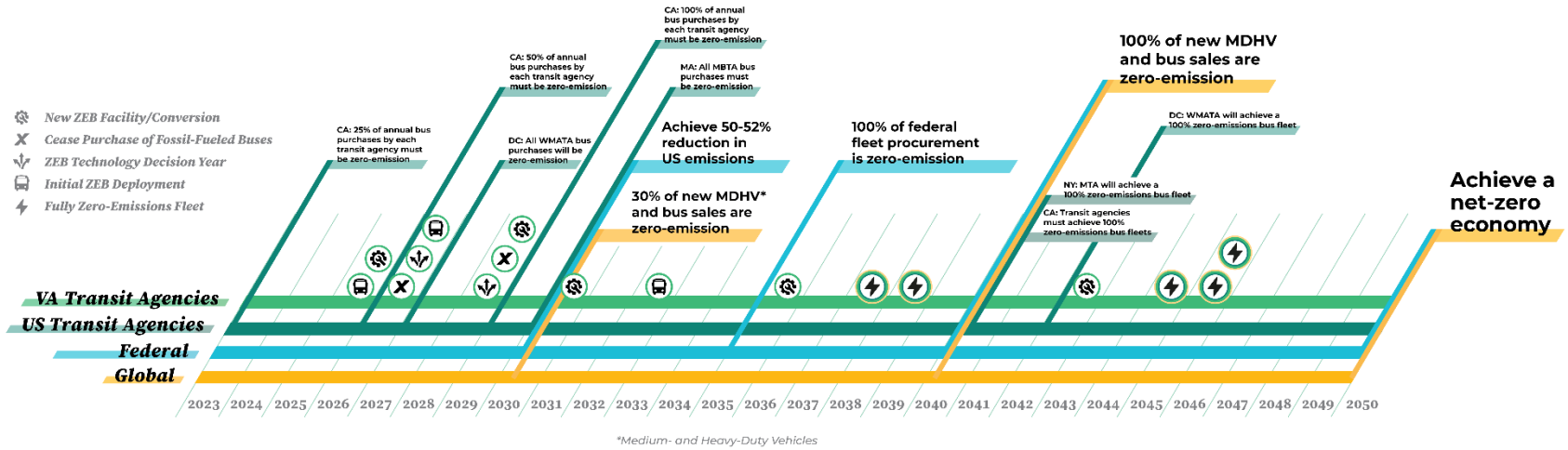


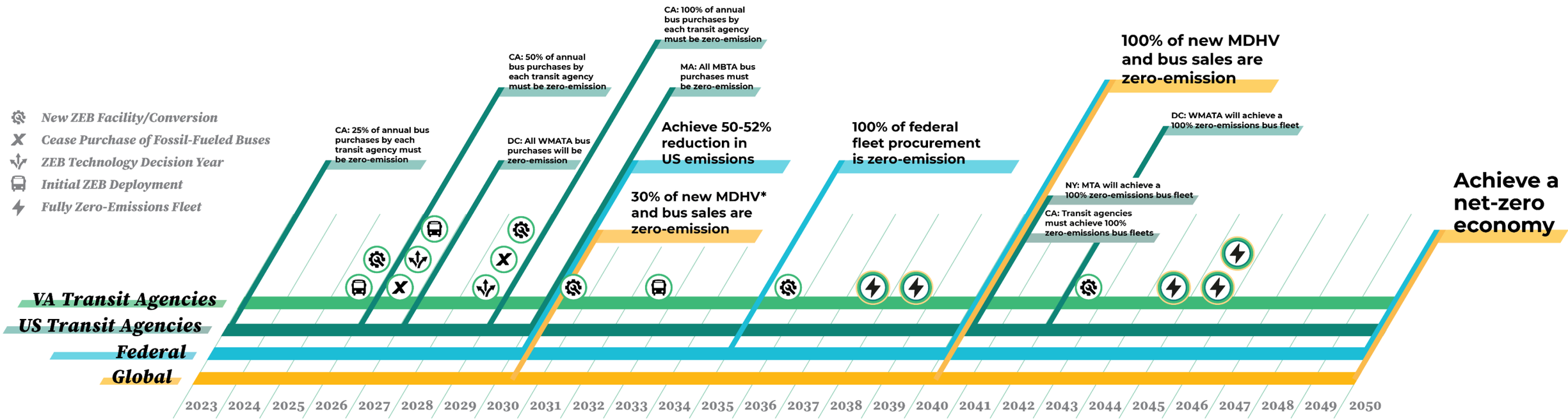
Figure 1. Timeline of Low- and Zero-Emissions Milestones

Low- and Zero-Emissions Transit Opportunities

Based upon the compiled timeline, there are various opportunities for collaboration and coordination amongst agencies and with DRPT, which should be evaluated on an ongoing basis, as more Virginia transit agencies develop goals for fleet electrification and implementation timelines. To evaluate opportunities on an ongoing basis, it may be of value to establish a regular touchpoint through which DRPT can inform agencies of the state of the alternative fuels market and allow agencies to exchange status updates on fleet electrification or emissions reduction efforts.

All agencies—especially small urban and rural agencies—have the opportunity to collaborate with transit agencies in the surrounding area on utilities coordination and fueling/charging solutions. Coordination with adjacent agencies in the fleet electrification planning process may allow for strategic decision making on alternative fuel selection. For instance, hydrogen fuel may be more viable for an agency to adopt if a shared hydrogen fuel hub were developed in coordination with surrounding agencies adopting the same alternative fuel for bus propulsion.

In addition, DRPT may assist agencies by coordinating bulk purchases of low- and zero-emissions buses when planned procurement timelines align amongst agencies. This would potentially alleviate the fleet transition burden on smaller urban and rural agencies.



*Medium- and Heavy-Duty Vehicles

BEST PRACTICES & RESOURCES

Some statewide agencies across the United States have recognized the opportunity to guide and equip transit agencies in their state with the roadmap, tools, and resources to pursue planning and implementation of low- or zero-emissions fleets. California, Oregon, Colorado, and New York are among those who have published such guides. The project team reviewed the four aforementioned guides and invited the associated statewide agencies to participate in interviews to capture lessons learned from the guide development process and use.

General tools are external mechanisms that are used to measure an important section of the guide. An example of this would be a website that can calculate vehicle emission rates. The calculated data can be used in the guide to display the impacts of zero emission transit. These tools are available for anyone to use for any general reason. State specific tools are tools or templates that are offered more state-specific use. For example, a state specific template could be a template that assists transit grant fund applications.

Peer Guide Overview

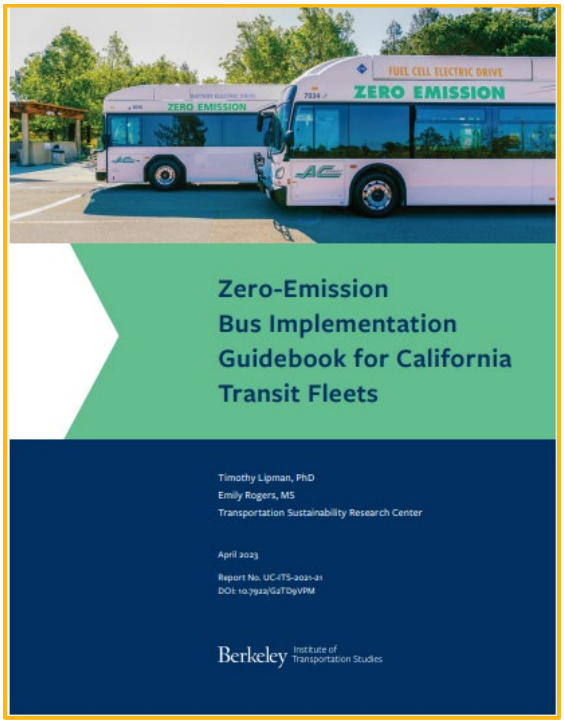
Table 2 presents the details of the peer guides or toolkits that were reviewed.

Table 2. Overview of Peer Guides or Toolkits Reviewed

State	Guide Title	Published	Publisher
California	Zero-Emission Bus Implementation Guidebook for California Transit Fleets	2023-04	UC Berkeley Institute of Transportation Studies
Colorado	Transit Zero Emission Vehicle Roadmap	2021-11	Colorado Department of Transportation (CDOT)
New York	Deploying Battery Electric Buses at Scale	2021-12	New York State Energy Research and Development Authority (NYSERDA)
Oregon	Guide to Transit Electrification	2023-04	Oregon Department of Transportation (ODOT)
Minnesota	N/A	N/A	Minnesota Department of Transportation (MnDOT)

California

The California Zero Emission Bus Guide is formatted as a guidebook. The guidebook outlines California's zero emission transition process. The guide has 41 total pages including references and graphs while also including valuable information about the necessary steps for a successful zero emission transition. The guide focuses on Zero Emission Bus deployment, performance, and fuel solutions.



General Tools

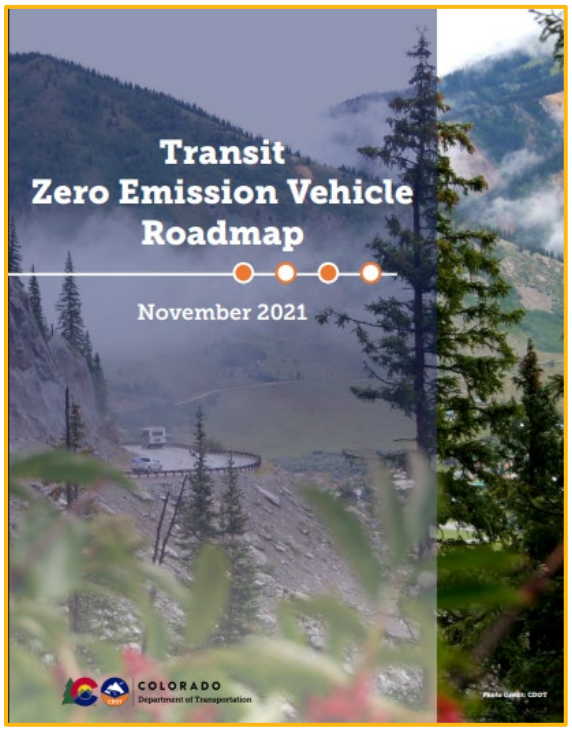
- None

State Specific Tools

- Funding Finder - CALSTART Rebate Finder (fundingfindertool.org)
  - The CALSTART Funding Finder Tool is designed to help stakeholders search and filter for Medium-and-Heavy-Duty Alternative Fuel Vehicle and infrastructure programs in the state of California.

Colorado

The Colorado Zero Emission Vehicle Roadmap is formatted as a report and a visual guide. This guide outlines the transition process using graphs and tables but serves the same purpose as other transition guides. The roadmap has 25 slides and focuses on financial/utility factors that should occur to achieve their transit electrification goals.



General Tools

- Transit ZEV Roadmap Financial Analysis Tool
  - The goal of the Zero-Emission Transit Vehicle Transition Template is to help transit agencies be more competitive for state and federal funding opportunities. It is intended for those transit agencies that are just starting to plan for their ZEV transition. The document lists key elements for transit agencies to consider and provides space to organize a plan.

State-Specific Tools

- Zero Emission Transit Vehicle Transition Template
  - The transit ZEV financial model uses information from the 2018 Colorado Fleet Inventory, available national ZEV model research and existing ZEV procurement and operating experience from Colorado transit agencies. The goal of the financial model is to create a tool to assess the range of ZEV transition scenarios for the 2022-2050 timeframe.

Interview Takeaways

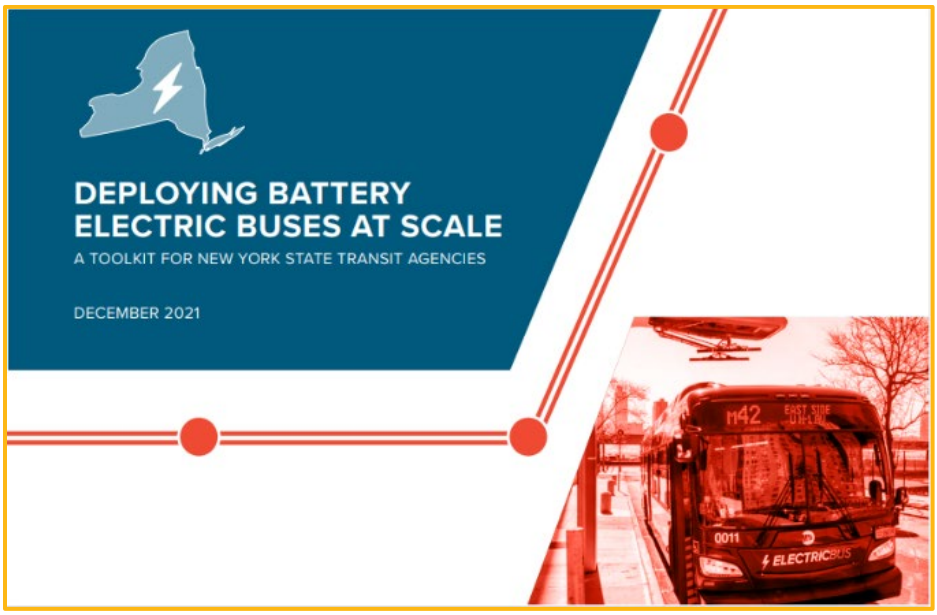
Interviewee: Michael King, Assistant Director of Electrification & Energy

Takeaways:

- CDOT is not only supporting transit agencies, but has recently began operating transit service, providing a unique dual perspective as transit agency supporter and transit provider.
- Geographically, Colorado faces significant challenges to electrification such as large elevation changes, extreme temperatures, and long-distance routes.
- The Colorado Transit ZEV roadmap was developed in response to the following two goals included in the 2020 Colorado EV Plan: (1) 1,000 transit zero-emissions vehicles by 2030, and (2) 100% zero-emission transit fleet by 2050. It should be noted this a goal, not a mandate.
- The roadmap was developed over the course of a year and summarizes how the state can potentially achieve the goals listed above.
- The content and format appear to be useful to agencies and other audiences (local governments, elected officials)—providing national and state context for transit fleet electrification especially proved useful in helping readers understand that fleet electrification is possible. Other key topics include financial modeling, workforce training resources, and funding opportunities.
- Following initial publication and promotion, there was strong interest in the roadmap, primarily from agencies already transitioning their fleet to zero-emissions vehicles.
- CDOT intends to update the roadmap in 1-2 years. Lessons learned and desired changes in the future include:
    - A more robust and intuitive financial modeling tool.
    - Greater elaboration on workforce challenges and opportunities.
    - Discuss risk mitigation.
    - Touch on hydrogen fuel (previously omitted due to not being produced in CO currently).

New York

New York's Battery Electric Bus Deployment Guide has the format of a toolkit. The toolkit is broken down into detailed stages detailing the process of deploying electric buses across New York. The toolkit includes strategies to help transit agency staff and stakeholders target their planning efforts effectively to make fleet electrification easier.



General Tools

- CALSTART Infrastructure Planning Tool: A Transit Fleet's Guide to Successful Electric Bus Charging
  - This tool from CALSTART helps provide quick and simple guidance on the planning required to implement electric charging at bus depots and helps assess your infrastructure needs to successfully deploy an electric bus fleet.
- CTE Fleet Transition Planning Services
  - CTE provides zero-emissions fleet transition planning services that consider vehicle and service requirements, fleet procurement timelines, infrastructure assessments, vehicle, and facility capital costs, operating and maintenance cost impacts, and emission benefits.
- BP Pulse Fleet Electrification Services & Infrastructure Estimator Tool
  - The infrastructure estimator online tool helps estimate EV charging infrastructure procurement and installation costs.

State-Specific Tools

- Advanced Transportation Funding Programs Locator

- Identifies federal, state, and local incentive programs that are available to assist fleet operators in the deployment of clean vehicles and equipment, and new infrastructure.

Interview Takeaways

Interviewees:

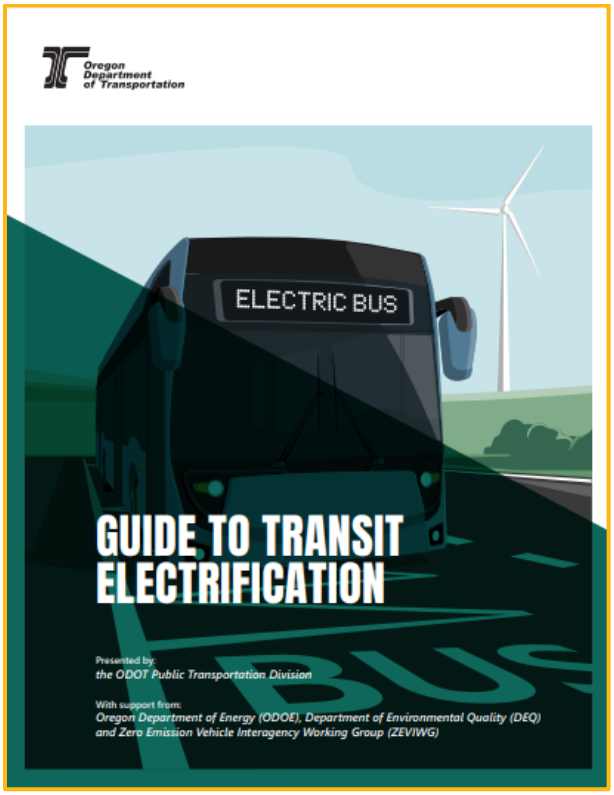
- Richard Mai, NYSERDA Clean Transportation Senior Project Manager
- Anna Shulman, NYPA e-Mobility Program Coordinator

Takeaways:

- NYSERDA and NYPA have worked closely together to help the 5 largest non-MTA transit agencies in New York develop electrification master plans.
- NYSERDA is happy with the format of the toolkit, as it allows agencies to jump in at whatever stage of the process they are in, which varies greatly from agency to agency. Case studies proved particularly useful in providing agencies comfort that other agencies have successfully started transitioning their fleet.
- The toolkit was developed over the course of one year and was created to help transit agencies gauge where they are at in the electrification process. Should an agency choose to, they can move forward with a full engineering analysis with NYPA.
- Due to the static nature of the toolkit, one challenge is that the toolkit information can become quickly outdated.
- The toolkit received very positive feedback upon initial publication and promotion, but NYSERDA is unable to track its usefulness to agencies since publication.
- Desired changes for a potential future iteration of the toolkit include:
  - Update funding programs.
  - Update case studies.
  - Provide more information on utility contacts.
  - Provide information on existing conditions of utilities.

Oregon

Oregon's Transit Electrification guide was formatted as a report and webpage. The guide was 35 pages long and summarizes lessons learned from transit agencies in Oregon that have already piloted or deployed electric buses. It incorporates information from state, national and international studies on electric buses. The guide also provides advice and links for transit agencies that are interested in electrification. This edition of the guide addresses battery electric buses, which are propelled by electric energy stored in batteries and periodically recharged.



General Tools

- Funding Finder - CALSTART Rebate Finder (fundingfindertool.org)

State-Specific Tools

- None

Interview Takeaways

Interviewee: Ryan Phillips, Public Transportation Climate Specialist

Takeaways:

- The ODOT Guide to Transit Electrification was created as a direct outcome of a governor mandate to develop the guide. There are no current plans to update the guide.

- It is unclear if or how useful the guide has been to agencies following publication. Some agencies have noted it inspired funding applications, but there has been no discrete tracking of use. There appears to have been minimal promotion of the guide.
- One limitation of the guide is that is lacks thorough instruction for rural transit providers, however, this fits the context of transit in Oregon, where 90%+ of all transit trips happen in three primary cities (Salem, Eugene, and Portland).
- Other initiatives that have been started to support agencies include: establishing an Electrification 101 session for providers to gain exposure and foundational knowledge, creating a peer-to-peer network for agencies to connect and discourse with one another in the midst of various stages of transition, developing a template for agencies to use for 5339(b) and (c) funding applications, and developing a net-zero pilot program and guide for 5 transit agencies in the state.
- Future guides would benefit from acknowledging the net greenhouse gas emissions reduction that can come not only from transit electrification, but also transit use, as increased ridership is reflective of overall VMT reduction.
- In addition to this guide, the state has also developed an alternative fuels guide for hydrogen (Hydrogen Pathway Study) and a general electric charging guide.
- Notable challenges agencies are facing include: acquisition and procurement or low- and zero-emissions buses, the administrative burden of fleet transitions, and lacking sufficient funding to support low- or zero-emission fleet transitions.

Minnesota

The Minnesota Department of Transportation (MnDOT) does not currently have a statewide guide for transit agencies on preparing for and/or deploying low- or zero-emissions buses. However, MnDOT and the state are known for their commitment to aggressive greenhouse gas emissions reduction goals. In addition, Metro Transit (Minneapolis/St. Paul) shares a commitment to greenhouse gas emissions reduction of which one strategy is bus fleet electrification. They currently operate 114 40-foot hybrid-electric buses primarily on the BRT C-Line, and have 8 40-foot electric buses that will be used on local routes as soon as 2023. Therefore, an interview with MnDOT was deemed beneficial to determine the status of transit fleet transitions to low- or zero-emissions buses across the state.

Interviewee: Mark Nelson, Interim Director for Office of Transit and Active Transportation

Takeaways:

- MnDOT supports and represents transit agencies outside of the Metro Transit area, consisting of 7 small urban agencies and 28 rural agencies.
- At present, there is no documented guidance on fleet transitions for the transit agencies that MnDOT supports, nor is there any documented guidance in development.
- There are three small urban agencies that have started transitioning their fleets to low- or zero-emissions vehicles: Duluth is already on the second generation of electric buses in their fleet, Rochester will run a fully articulated battery electric BRT, and St. Cloud has been using CNG buses in their fleet for 5 years.
- Given the challenges associated with northern climate in Minnesota, MnDOT is comfortable encouraging agencies to consider low-emissions alternative fuels that perform better than battery electric technology in the local climate (i.e., propane), as this still aligns with greenhouse gas emissions reduction goals.
- Overall, many utilities have shown interest in being involved in fleet transitions. Relationships between agencies and utilities are fostered by MnDOT requiring a letter of support from utilities to be included in funding applications.

Static Resources

Table 3 presents the static resources presented in each state guide that was reviewed. Each external reference provides useful instructions, data, and information for a successful transit electrification guide. It should be noted that there was no overlap in the resources presented within in each guide.

Table 3. Static Resources in Peer Guides

Resource Name	Publisher	State Guide			
		California	Colorado	New York	Oregon
Battery Electric Buses—State of the Practice	TCRP			X	
Bus Electrification	New Flyer			X	
Bus Testing Report	Penn State College of Engineering			X	
Driving The Future	BYD Motors			X	
Electric Buses in America	Frontier Group				X
Electric Bus	CTA				X
Electrifying Transit: A Guidebook for Implementing Battery Electric Buses	NREL			X	
Fleet Assessment Services	Joint Utilities of New York			X	
Fuel Cell Electric Bus Evaluations	NREL	X			
Guidebook for Deploying Zero-Emission Transit Buses	TCRP			X	
Helping Transit Agencies Adopt Clean Technologies	Zero Emission Bus Resource Alliance				X
ICT Rollout Plans	CARB			X	
Investment in Publicly Accessible EV Charging in the United States	Atlas Public Policy			X	
Our Projects	CTE	X			
Powering The Shift to Electric	Proterra			X	
Public Transit Community	NYPTA			X	
State of Sustainable Fleets 2023	The State of Sustainable Fleets			X	
Taking Commercial Fleet Electrification to Scale: Financing Barriers and Solutions	Global Commercial Vehicle Drive to Zero			X	
The International Association of Public Transport	Advancing Public Transport			X	

Zero Emission Bus	APTA			X	
Zero Emission Mission	CTE			X	
Zero-Emission Bus Evaluation Results: King County Metro Battery Electric Buses	FTA				X
Zero-Emission Battery Electric	Gillig			X	
Zeroing in on ZEBs - The Advanced Technology Transit Bus Index: A ZEB Inventory Report for the United States and Canada	CALSTART	X			

Funding Opportunities

Funding is a key foundation upon which the ability for transit agencies to transition fleets rests. As demonstrated in the results of a transit agency survey as part of the Virginia Transit Equity & Modernization Study, 78% of transit agencies that are not currently operating ZEBs cite "additional funding" as one of the primary concerns about integrating zero-emissions vehicles into their fleets. Alternative fuel buses—particularly those that are fully electric, or hydrogen fueled—are significantly more costly than traditional diesel fuel buses. Therefore, agencies must depend more heavily on external funding mechanisms to support fleet transitions. In addition to the list below, **Table 4** provides an overview of the funding opportunities available to transit agencies in the Commonwealth of Virginia and the respective applicability of the funding source to various aspects of low- and zero-emissions fleet transitions.

Federal Sources

- **Federal Grants for Buses and Bus Facilities Competitive Program [5339(b)]** – Assists in the financing of buses and bus facilities capital projects, including replacing, rehabilitating, purchasing/leasing buses or related equipment, and rehabilitating, purchasing, constructing/leasing bus-related facilities.
- **Federal Low or No Emission Vehicle Program [5339(c)]** – Supports state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses, including acquisition, construction, and leasing of required supporting facilities.
- **Congestion Mitigation and Air Quality (CMAQ) Improvement Program** – Provides funds to States for transportation projects designed to reduce traffic congestion and improve air quality, particularly in areas of the country that do not attain national air quality standards.
- **Carbon Reduction Program (CRP)** – Provides funds to States for projects designed to reduce transportation emissions, defined as carbon dioxide (CO2) emissions from on-road highway sources.
- **RAISE Discretionary Grants** – Helps project sponsors complete critical freight and passenger transportation infrastructure projects that they may not have had the funding to conduct prior to passage of President Biden's infrastructure law.
- **Capital Investment Grants (CIG) Program** – A discretionary grant program administered by the FTA that funds transit capital investments for heavy rail, commuter rail, light rail, streetcars, and

bus rapid transit. Depending on the scale of the project, one to two phases must be completed in advance (Project Development and Engineering).

State Sources

- **Capital Assistance (MERIT)** – After a prioritization process, resources are assigned to capital projects and investments in the categories of state of good repair, minor enhancement, and major expansion.
- **Demonstration Project Assistance (MERIT)** – A competitive program that supports local efforts to improve transit reliability, access to housing and employment centers, and public transportation mobility options, including new service or technology and innovation.
- **Technical Assistance (MERIT)** – Supports studies, plans, research, data collection, and evaluation projects to help improve public transportation services, including providing technical analysis and guidance on operations, service delivery, customer service, expansions of service, and program delivery.
- **Public Transportation Workforce Development Program (MERIT)** – Supports expenses to increase awareness of public transportation as a career choice for aspiring managers, maintenance and operations staff, marketing employees, and other specializations within public transportation and commuter assistance agencies.
- **Operating Assistance (MERIT)** – Funding for operating expenses for eligible public transportation services.
- **SMART SCALE** – Helps Virginia meet its most critical transportation needs using limited tax dollars. It evaluates potential transportation projects based on key factors like how they improve safety, reduce congestion, increase accessibility, contribute to economic development, promote efficient land use, and affect the environment.

Regional Sources

Northern Virginia

- **I-395/I-95 Commuter Choice** – Reinvests Express Lanes toll revenues in public transit and other transportation improvements (e.g., maximize person throughput, improve mobility, support new and diverse travel options, enhance safety and reliability) along the I-66 and I-395/95 corridors in Northern Virginia.
- **General Northern Virginia Transportation Authority (NVTA) Funding** – A dedicated funding stream for transportation projects in Northern Virginia, required to be used solely for transportation purposes.

Central Virginia

- **Central Virginia Transportation Authority (CVTA) Funding** – Provides new funding opportunities for priority transportation investments across the region.

Hampton Roads

- **Hampton Roads Regional Transit Fund** – Dedicated transit funding for the Hampton Roads service area, to be used for core and connected regional network of inter-jurisdictional, high-frequency bus service, related infrastructure, rolling stock, and support facilities.

Table 4. Funding Opportunities and Respective Applicability

Funding Opportunity Name	Administer of Funding	Funding Applicability				
		Low- or Zero-Emissions Vehicles	Facilities	Workforce Development	Charging Equipment	Feasibility/ Implementation Plan
Federal						
Federal Grants for Buses and Bus Facilities Competitive Program [5339(b)]	FTA	X	X			
Federal Low or No Emission Vehicle Program [5339(c)]	FTA	X	X	X	X	
Congestion Mitigation and Air Quality (CMAQ) Improvement Program	FHWA / FTA	X			X	
RAISE Discretionary Grants	USDOT	X	X		X	
Capital Investment Grants (CIG) Program	FTA	Only applicable to new or extended BRT separated guideways				
State						
Capital Assistance (MERIT)	DRPT	X	X			
Carbon Reduction Program (CRP)	VDOT	X	X		X	
Demonstration Project Assistance (MERIT)	DRPT	X			X	
Technical Assistance (MERIT)	DRPT					X

SMART SCALE	CTB	X[a]	X[a]		X[a]	
Public Transportation Workforce Development Program (MERIT)	DRPT			X		
Operating Assistance (MERIT)	DRPT					
Regional						
I-395/I-95 Commuter Choice	NVTC	X	X		X	
General NVTA Funding	NVTA	Not specified				
Hampton Roads Regional Transit Fund	HRTAC	X	X		X	
Central Virginia Transportation Authority (CVTA) General Funding	CVTA		X		X	X

[a] Applicable to capacity expansion only

Based upon the applicability of the presented funding sources to various elements of low- and zero-emissions transitions, it should be noted that the elements of transition planning and implementation that have the fewest opportunities for funding are *workforce development* and *feasibility studies/implementation plans*. There may be opportunity for existing funding streams to broaden criteria.

Market Overview and Drivers

There are numerous low- and zero-emissions bus and charging technologies available for transit agencies to utilize to work towards or achieve goals related to fleet composition or emissions reduction. **Figure 2** lists the various low- and zero-emissions bus propulsion technologies available on the market today.

Low-Emissions	Zero-Emissions
• Compressed Natural Gas (CNG) Bus • Liquified Natural Gas (LNG) Bus • Renewable Natural Gas (RNG) Bus • Hybrid-Electric Bus • Propane (LPG) Bus	• Battery Electric Bus (BEB) • Fuel Cell Electric Bus (FCEB)

Figure 2. Low- and Zero-Emissions Bus Propulsion Technologies

For more information, visit the U.S. Department of Energy's (DOE) Alternative Fuels Data Center, which is regularly updated on the application of alternative fuels to public transit vehicles. According to the U.S. DOE, BEBs are currently the most widely available technology (30+ models), followed by CNG buses (20+ models) and hybrid-electric buses (15+ models).

State Contract

The Commonwealth of Virginia holds a state procurement contract that includes diesel-fuel buses, CNG buses, hybrid-electric buses, BEBs, and FCEBs. It should be noted that the state procurement contract can be difficult to navigate, therefore, agencies are recommended to engage with original equipment manufacturers (OEMs) and/or DRPT about procurement if necessary. It should be noted that Virginia has an open cooperative agreement for their state contract, which allows agencies in other states to procure using the Virginia state contract. The following manufacturers of low- or zero-emissions buses—ranging from 29' to 60' vehicles—are included on the state contract:

- **Gillig**: 35'-40' Battery Electric Buses, 29'-40' CNG Buses, 35'-40' Hybrid Buses (Contract Link)
- **New Flyer**: 35'-60' Hybrid Buses, 35'-60' Battery Electric Buses, 40'-60' FCEBs, 35'-60' CNG Buses (Contract Link)
- **ENC**: 32'-40' CNG Buses, 40' Battery Electric Buses, 40' FCEBs (Contract Link)

In addition to 29' to 60' buses, the Commonwealth also holds state contracts for the following low- and/or zero-emissions smaller vehicle types:

- **Raised Roof Vans**: Battery Electric (Contract Link)
- **BOC / Cutaway**: Soon updated to include CNG, Propane, and Hybrid
- **Low Floor BOC / Cutaway**: Battery Electric (Contract Link)

Not all low- and zero-emissions bus manufacturers sell the associated charging infrastructure for their vehicles, which means compatibility between charging/fueling equipment with alternative fueled vehicles should be verified by manufacturers.

For a point of comparison, the Washington state transit bus procurement contracts include the following low- and zero-emissions bus manufacturers:

- **BYD**: 30'-60' Electric Buses
- **El Dorado**: 30'-40' Hybrid Buses, 30'-40' CNG Buses, 40' FCEBs
- **Gillig**: 35'-40' Hybrid Buses, 30'-40' CNG Buses, 35'-40' BEBs
- **MCI**: 45' CNG Buses, 45' BEBs
- **New Flyer**: 35'-60' Hybrid Buses, 35'-60' CNG Buses, 35'-60' BEBs, 40'-60' FCEBs

MEMORANDUM

To: Daniel Wagner and Tiffany Dubinsky (DRPT)

From: Russell Pildes, Sam McCormally (Foursquare ITP)

CC: John Jackson (Kimley-Horn and Associates, Inc.)

Date: February 22, 2024

Subject: DRPT Modernizing Transit Fleets Workforce Development Guide Final Memo

DRPT ZEB TRANSITION WORKFORCE DEVELOPMENT MEMORANDUM

Introduction

Adopting low and zero-emission vehicles will require agencies to upskill their workforces to meet the evolving requirements of new equipment, technology, and processes. This memo investigates the workforce-related elements of the transition to low and zero-emission vehicles and will identify the skills that operators and mechanics will need, how agencies can provide training, and how agencies should structure their transitions to low and zero-emission buses considering their workforce needs.

Adopting a new vehicle technology requires considerable investment and planning. The transition to low and zero-emission vehicles by transit agencies across Virginia and the country is being spurred by record levels of federal support. In addition to federal finance supporting the purchase of new transit vehicles, fueling infrastructure, and workforce development; federal agencies and partner organizations are developing guidance and providing support to agencies to tackle the considerable technical and managerial challenges associated with new vehicle technology.

Despite this support, many agencies do not have sufficient guidance on how they can ensure their workforces have the requisite skills and certifications to operate, maintain, and plan service for vehicles powered by batteries, natural gas, and hydrogen fuel cells. The challenge of adopting low and zero-emission vehicles is exacerbated by the pre-existing transit workforce shortage.[1] Agencies across the country of all sizes report a years-long difficulty recruiting and retaining transit operators and mechanics. These challenges are likely to grow as agencies seek to attract and retain workers with new and in-demand skills. As a result, agencies will need to plan to ensure their workforces can support the deployment of low and zero-emission fleets.

[1] American Public Transportation Association. “Transit Workforce Shortage.” Washington DC, March 2023. https://www.apta.com/wp-content/uploads/APTA-Workforce-Shortage-Synthesis-Report-03.2023.pdf.

The content in this memo will be incorporated into a corresponding chapter of the Zero-Emission Transition Guidebook to help agencies navigate the workforce dimension of their transition to low and zero-emission vehicles. First, it provides context related to federal and state policy, as well as the market for transit workers. Second, it provides guidance for designing a program to train new and existing workers, including considerations for vehicle type and agency size and capability. Lastly, it outlines ways that DRPT, the Virginia Community College System, and other state agencies can support the expansion and enhancement of the state's transit training ecosystem through interagency coordination. A step-by-step agency toolkit for addressing low and zero-emission vehicle workforce issues supplements this memo in the appendix.

Understanding the Workforce Transition

The coming transition from conventional fossil-fueled vehicles to electric buses will test the public transportation industry in ways that will certainly seem new. As this memo discusses at length, the technical skills required of operators and mechanics will change, operations and planning roles will interact in new ways, and relationships between agencies and labor will evolve to adapt to conditions that they have never encountered before.

However, technological changes have revolutionized transit in the past, too. Automatic transmissions in the 1940s, direct injection diesel engines in the 1990s, and automated vehicle location systems in the 2000s each changed how operators, mechanics, and planners performed their work, even as providing mass transportation remained fundamentally the same. Agencies and workers will continue to work together to adapt their activities to new tools and requirements.

There are both technical and labor relations aspects to the workforce transition to low and zero-emission vehicles. Low and zero-emission buses are different from conventional buses in important ways that will require extensive new training for operators and mechanics, especially related to safety. Likewise, the low and zero-emission transition poses several attractive opportunities to protect the existing workforce from economic hardship caused by rapid technological changes while also appealing to a new generation of transit workers as the industry continues to face general labor shortages. Agencies and their workers both stand to gain from proactive cooperation to structure the future of transit together.

This memo summarizes the major elements of the zero-emission transition that will affect workers. Later sections of this memo explore the specifics affecting operators, mechanics, supervisors, and planners under different propulsion technologies; and discuss how agencies and workers can work together to best position themselves throughout.

Policy, Administrative, and Funding Context

Federal Context

Through the Bipartisan Infrastructure Law (BIL), the Inflation Reduction Act (IRA), and other prior legislation, the federal government has increased the amount of funding available for decarbonizing ground transportation. Applicants for these clean transit programs must submit a comprehensive Zero-Emission Fleet Transition Plan to qualify for funding. These plans must include, among other elements, details on how the agency will prepare its workforce to operate, maintain, and plan service around a new type of vehicle.

The Federal Transit Administration (FTA) directs agencies to consider how they will assess the skills of existing workers, provide, and pay for necessary training, and ensure that the economic opportunities stemming from adopting new vehicle types are distributed equitably. Agencies who propose to use their awards to support the transition to low and zero-emission buses must use five percent of the funds they receive for workforce development and training.[2] Thus, workforce planning is a crucial requirement for agencies hoping to take advantage of related program funds.

At least four other FTA formula funding sources require applicants to ensure that financial assistance must have a "fair and equitable" impact on employees, including in the provision of paid training and re-training programs. Those programs include:

- Bus and Bus Facilities Formula Program (49 USC 5339a)
- State of Good Repair Grants (49 USC 5337)
- The Urbanized Area Formula Grants (49 USC 5307)
- Formula Grants for Rural Areas (49 USC 5311)

Discretionary programs will also play an important role in financing the low and zero-emission transition for transit agencies. FTA's Low or No Emission Vehicle Program (sometimes rendered as "Low-No") provides billions of dollars each year to transit agencies to facilitate the transition from diesel buses to those powered by batteries, hydrogen, and natural gas.[3] In addition, the Bus and Bus Facilities Discretionary Program requires applicants to have a compliant zero-emission transition plan in place that discusses the impacts on workers.[4]

Through these mechanisms, FTA provided $226 million to Virginia transit agencies in 2021.[5] Thus, agencies should be aware that a substantial amount of funding, both discretionary and formula, require zero-emission transition plans that specifically address the workforce transition. Specific provisions for this planning are discussed later in this document.

Transit agencies may also be able to think creatively about how to make use of transportation finance programs outside of the transit ecosystem to the benefit of all parties. For example, VDOT administers the state's apportionment of the National Electric Vehicle Infrastructure (NEVI) Formula Program. NEVI was established to support the creation of a commercial network of electric vehicle chargers for passenger vehicles. However, the program gives states leeway to determine what types of programs are eligible for funding: Virginia's NEVI plan for 2023 already includes guidelines related to the training of workers to install and maintain electric vehicle chargers, which could also be used to support training transit agency mechanics who service electric bus equipment.[6] Other cooperative ventures with other state agencies, including the Departments of Energy and Labor, as well as local organizations, may yield greater benefits than if working independently towards similar ends.

In this collaborative spirit, the United States Departments of Transportation and Energy have established the Joint Office of Energy and Transportation to provide funding and technical assistance for transportation decarbonization efforts. In 2022, the Joint Office issued a Notice of Intent to support the development of a workforce capable of installing and maintaining electric

[2] https://www.transit.dot.gov/bus-program
[3] 49 USC 5339c; see also https://www.transit.dot.gov/lowno
[4] https://www.transit.dot.gov/funding/grants/fact-sheet-buses-and-bus-facilities-program
[5] National Transit Database.
[6] https://afdc.energy.gov/laws/12973

vehicle infrastructure.[7] Although intended primarily to support the creation of commercial and public charging infrastructure, this funding could go to support the creation of a workforce with skills relevant to transit agencies operating low and zero-emission fleets.

Transit agencies should explore all available options to make use of federal funding available for the zero-emission transition. Whether the programs themselves focus on transportation or not, the funding may be useful for developing workforce skills throughout the commonwealth.

Virginia Policy Context

Virginia's state government and other bodies are engaged in low and zero-emission workforce transition planning through several mechanisms.

Some of the most important elements of the Virginia workforce development apparatus are the Commonwealth's community colleges and the Virginia Community College System (VCCS). The community colleges operate semi-autonomously across the state, and their mission is to provide practical education in their respective regions in part based on input from local employers who serve on program advisory committees. This process is well-established, including for automotive training programs. Transit agencies that do not currently participate in this advisory committees should consider playing an active role in the future to establish both upskilling pathways for the existing workforce as well as avenues for new workers to join their staffs. DRPT planners and program managers can recommend help facilitate agency participation in these committees.

In the more traditional realm of transit administration in Virginia, DRPT and several other Virginia agencies also have missions funding sources related to transit workforce issues, including the Department of Environmental Quality, the Department of Labor, the Department of Education, and the newly created Department of Workforce Development and Advancement. The supportive policies and programs are myriad: these and other groups are developing channels for coordination to support low and zero-emission transit worker training programs, but many of these initiatives are in early stages and not yet available for use.

Virginia state agencies could support transit workforce training in the following ways:

- Developing a one-stop clearinghouse of information on clean transportation technical support and finance, including for workforce development.
- Working with local community colleges and VCCS to develop apprenticeship programs.
- Identifying opportunities for VCCS to include electric vehicle supply equipment (EVSE) certifications in the Fast Forward program.
- Coordinating with Virginia Board of Workforce Development to explore including EVSE-related roles in the list of high-demand occupations.

Virginia's electric utilities may also be a resource for agencies attempting to meet their workforce needs. Virginia's State Corporation Commission report on low and zero-emission buses includes recommendations for electric utilities to develop Transportation Electrification Plans and provide fleet advisory services.[8] Utility development in power generation, transmission, and storage is the bedrock on which the zero-emission transition will occur. As

[7] See, for example, the Ride and Drive Electric research and development program: https://eere-exchange.energy.gov/FileContent.aspx?FileID=88430856-63f2-453f-8794-7f3c96c53980

[8] Commonwealth of Virginia State Corporation Commission. Policy Proposals Governing Public Electric Utility Programs to Accelerate Widespread Transportation Electrification in the Commonwealth of Virginia. 2022.

supportive policies are finalized and implemented, transit agencies should work with utilities to see what assistance they can provide during the zero-emission transition process including for workforce development and training.

Economic Context

As agencies consider their workforce needs for the transition to low and zero-emission vehicles, they will need to understand the financial implications for them as well as for the workers who they wish to hire and retain. While wages, cost of living, and labor pool sizes vary from region to region, agencies should have a general understanding of the availability of potential zero-emission transit workers implicated by the transition and the compensation they will expect. This section provides an overview of employment and wages in the four occupation categories[9] most relevant to transit agencies transitioning to zero-emission vehicles:

- ***Bus drivers (transit and intercity).*** These are traditional operations workers who will need to train on new equipment and who will need to learn driving techniques that extend the ranges of their vehicles. Their work will appear to change the least, but training related to safety protocols with new equipment as well as familiarity with the vehicles themselves will be essential.
- ***Bus and truck mechanics and diesel engine specialists***. These workers build, maintain, and service transit vehicles. The work of transit agency mechanics will change in substantive ways as vehicles change over from those powered by fossil-fuel engines to zero-emissions technologies. Agencies that have not already transitioned to diesel-electric hybrid engines will need to upskill their existing workforce to catch up to those who already have high-voltage experience.
- ***Electricians and plant maintenance***. These workers are responsible for the electrical infrastructure of a transit agency's facilities. While many transit agencies already employ electricians to keep their facilities running smoothly, this role's prominence will grow as the volume and complexity of electrical systems at transit facilities expands. Likewise, they may be called upon to spend more time in the field if mid-route refueling/recharging facilities become commonplace. Plant maintenance workers will need to operate and maintain new fueling infrastructure, depending on the fuel(s) selected for the transition.
- ***Facility managers***. As with electricians, the proliferation of electrical systems in transit facilities will change the needed expertise among facility managers. In addition, changing circulation patterns and pull-in/out procedures with new vehicles may require additional backgrounding to successfully manage transit operations.

Total Employment by Sector

The number of bus drivers and mechanics in Virginia has remained relatively stable over the last decade, though employment among drivers has declined slightly; the rate of this decline has grown since 2020 (Figure 1). These trends for these two roles are mirrored in data for the entire United States, reflecting a shared experience among transit agencies over this period.

Several factors are likely responsible for the overall reduction in bus operators. Foremost, this workforce shedding aligns with the reports of many transit agencies, both in Virginia and across the county, of an increased difficulty in hiring operators. The problem is so acute, in fact, that 85 percent of agencies report that the transit workforce shortage is impacting their ability to provide

[9] These categories come from the North American Industrial Classification System (NAICS).

service.[10] Major issues that make it difficult to hire and retain workers include the grueling personal experience operating a bus, difficult work-life balance, and a lack of childcare; agencies are likewise hobbled in their recruitment and retention efforts by a complex regulatory framework and intense competition from other transportation and logistics companies.

All these factors were in play prior to the onset of the COVID-19 pandemic in 2020. However, the decrease in operators since 2020 is likely related to the effect the pandemic had on both transit service provision as well as operators' working conditions. Many transit agencies across the United States implemented service cuts and reduced staffing at the pandemic's onset. In addition, many frontline workers could not or would not continue in their roles for a variety of reasons, and either separated or retired in large numbers.[11]

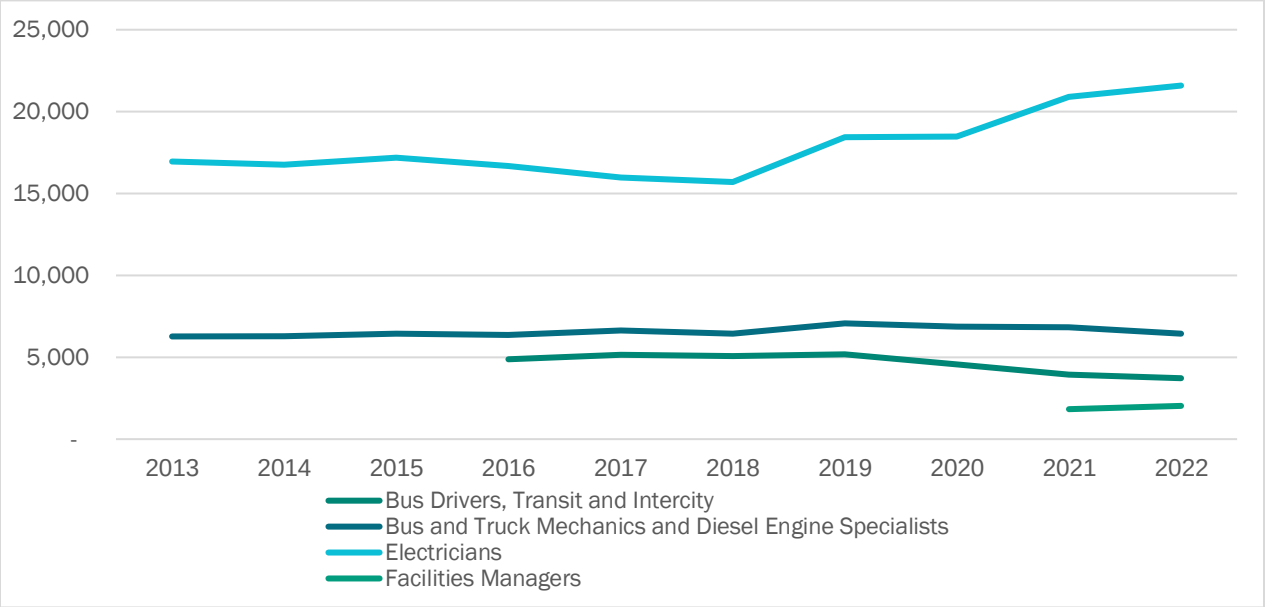
Notably, employment among mechanics has remained relatively stable over the same period at around 6,000 workers, and likely did not suffer the same decline because of those roles' reduced exposure to the general public during the height of the pandemic.[12] The difference between operators and mechanics may lay in the differences in working conditions, especially the physical, emotional, and safety impacts of interacting with the public during this period.

By contrast, the number of people employed as electricians (not exclusive to those employed by transit agencies) has increased (Figure 1 and Figure 2). While initially declining slightly from 2013-2017, Virginia added nearly 6,000 electricians between 2018 and 2021, an increase of over 35 percent. As of 2022, over 22,000 people are employed as electricians in Virginia. This rising employment is mirrored in national trends exactly: 27 percent growth between 2013-2022.

This suggests that while Virginia is not experiencing a unique growth in electrician employment, demand for these workers, and therefore the employment outlook in this sector, remains strong. This may already be driving up local wage rates for certified electricians, a trend that a sharp increase in demand and an anticipated sectoral retirement cliff will surely exacerbate.[13]

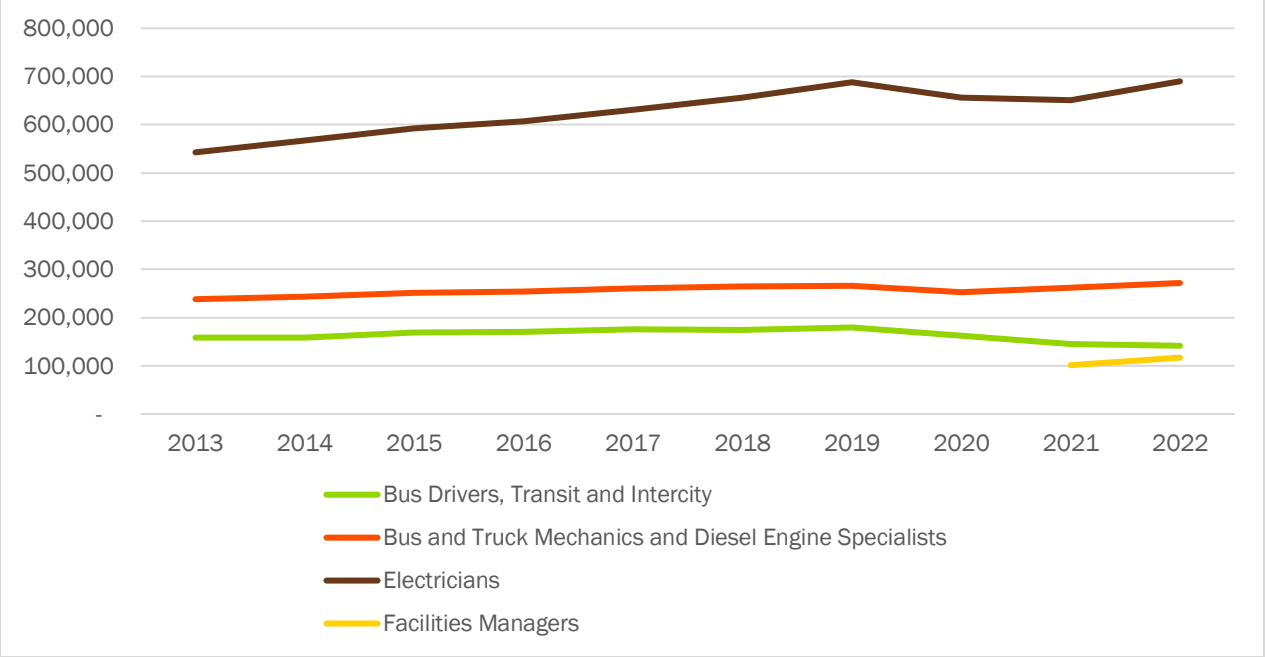
[10] Ibid., APTA Transit Workforce Shortage Synthesis Report (2023).
[11] Transit Workforce Shortage, American Public Transportation Association., 2022.
[12] The project team notes that this category includes roles outside of transit agencies; employment among transit mechanics may have declined more during the pandemic, but this is not visible in aggregate data and would vary considerably from agency to agency.
[13] Ramkumar, Amrith, Dan Lyon. "U.S. Faces Electrician Shortage as It Tries to Go Green." The Wall Street Journal, March 23, 2023. https://www.wsj.com/story/us-faces-electrician-shortage-as-it-tries-to-go-green-1b990742.

Figure 1: Virginia Total Employment by Select Occupations



Source: Occupational Employment and Wage Statistics, United States Bureau of Labor Statistics, 2013-2022.

Figure 2: U.S. Total Employment by Selected Occupations



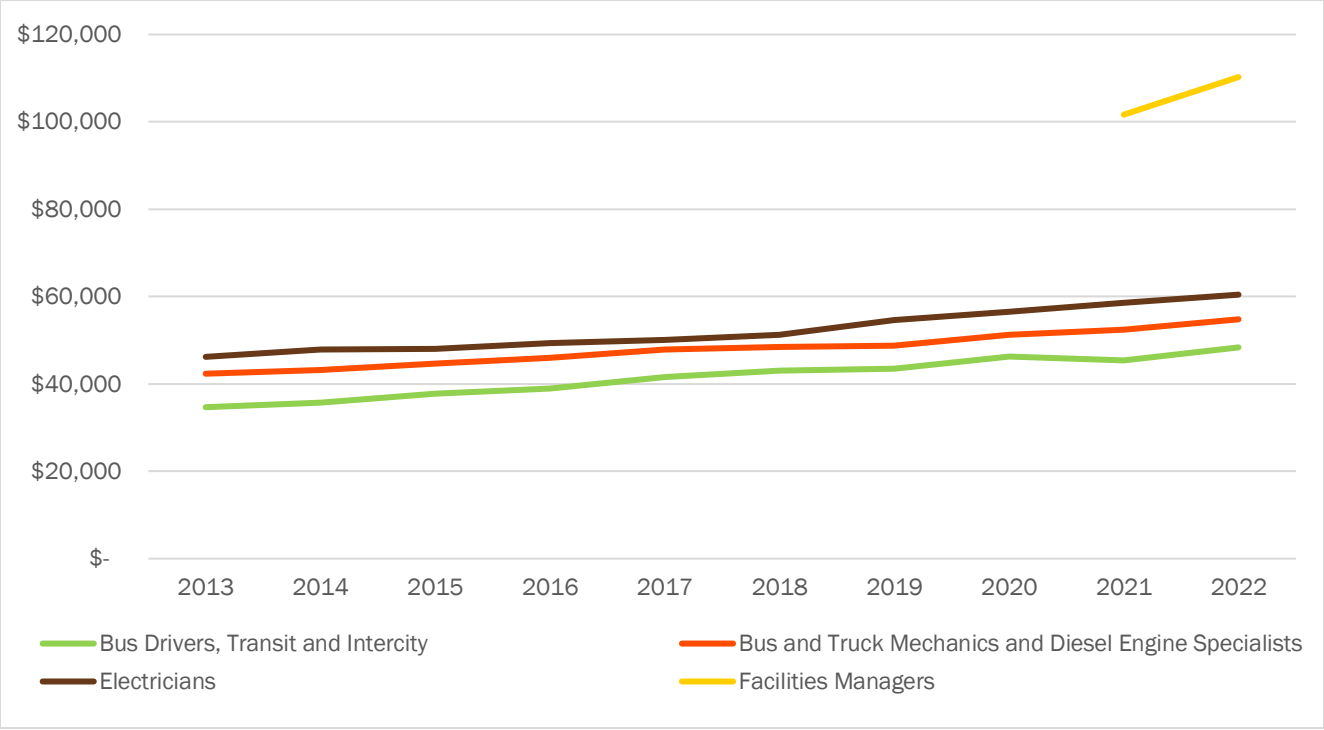
Source: Occupational Employment and Wage Statistics, United States Bureau of Labor Statistics, 2013-2022.

Compensation by Sector

Compensation is a strong indicator of an industry's ability to attract and retain workers. Both nationally and in Virginia, the occupations implicated in the transition to zero-emission vehicles have all shown modest wage growth over the past ten years (Figure 3). The wage increase shown for facility managers, who saw a more substantial wage increase during the two years since the category was established, should be treated with caution because little data is available to estimate a trend.

In 2022, electricians earned approximately $60,000 per year, on average. Mechanics earned slightly less, about $55,000 per year; and bus drivers earned slightly less than that, about $48,000 per year. However, bus drivers' wages have increased by 40 percent over since 2013, ten percentage points more than each of the other two occupations. These represent real wage increases, as inflation over this period was approximately 27 percent.[14] This increase has been steady as well: bus drivers saw an average of one percentage point more wage growth per year over the period than the other occupations.

Figure 3: Average Wage by Selected Occupations, Virginia



Source: Occupational Employment and Wage Statistics, United States Bureau of Labor Statistics, 2013-2022.

[14] Calculated using Bureau of Labor Statistics historical consumer price index data. See: https://data.bls.gov/timeseries/CUUR0000SA0

Conclusions from Comparison of Employment and Compensation

Transit agencies' most acute labor needs involve bus operators and mechanics; as agencies adopt electric vehicles, their need for electricians will grow as well. These professions are experiencing related but distinct labor market trends. In the case of operators, the decrease in total employment comes at a time when many agencies are having trouble finding enough operators to provide service. The rising wages of operators over this period suggests that agencies are responding to this shortage by increasing compensation.

In the case of mechanics, changes in wages and employment have been more modest. However, agencies have reported that hiring mechanics is a challenge as well, suggesting that wage growth for mechanics is unlikely to abate even before accounting for pay raises associated with upskilling.

The electrification of the U.S. economy has dramatically increased demand for electricians. Although wage growth for electricians have been modest as well, the boom in jobs for electricians suggests that employers may need to raise pay to attract workers. The blurring of the line between mechanics and electricians as high-voltage vehicle systems proliferate will complicate this.

Lastly, the recently added category of workers known as "facilities managers" have a higher compensation than other transit workers, with a higher rate of growth, although amount of data to support this observation is limited.

Across all four professions, transit agencies should expect wages to climb, meaning that hiring qualified workers is going to cost more over time. To find enough qualified workers, agencies will need to improve both recruitment and retention by increasing pay, improving working conditions, and upskilling existing workers.

Understanding the Low and Zero-emission Transit Training Ecosystem

Operators and mechanics will need the most substantial formal retraining during the transition to low and zero-emission vehicles. That training can be provided in a variety of different venues, each with its own implications in terms of cost, timeframe, and the degree of relevance to the day-to-day work at the agency itself. This section outlines guidance and practical steps transit agencies can take to prepare a resilient workforce for the zero-emission transition.

How Should Agencies Transition to Low and Zero-emission Buses?

Guiding Principles

Our engagement with transit industry professionals through the Transit Workforce Development Technical Working Group revealed several principles that transit agencies, and their workers should use to guide their transition planning with respect to workforce development to ensure a smooth transition.

Carefully Manage Labor Relations

The low and zero-emission transition will challenge the relationships between agencies and their workers, in part because of the uncertainty associated with the changes. The uncertainty will dissipate with time as public transportation providers and OEMs gain more experience.

However, to assuage concerns about the zero-emission transition, agencies should engage with workers and labor organizations early and often as agencies plan for a ZE fleet transition.

Despite the potential for challenges between agencies and workers, the low and zero-emission transition poses several attractive opportunities to protect the existing workforce from economic hardship caused by rapid technological changes while also appealing to a new generation of transit workers as the industry continues to face general labor shortages. Agencies and their workers both stand to gain from proactive cooperation to structure the future of transit together.

Workers will view technological changes and the effects they will have on job satisfaction both positively and negatively. Low and zero-emission vehicles offer a few clear benefits to mechanics specifically, among them that these vehicles are simply cleaner to work on. Fewer liquid lubricants and no soot means that the image of a mechanic with dirty coveralls and greasy fingernails will no longer apply – this will benefit existing workers as well as appeal to a new generation of younger employees who would otherwise avoid a career transit because of those working conditions. Younger workers may also find the electronic- and data-intensive aspects of zero-emission transit operations intriguing.

Nevertheless, the existing workforce cannot simply be discarded. Their institutional knowledge of operations, maintenance, and planning makes them essential to a smooth transition from one vehicle technology to another. Furthermore, the incremental cost of additional training is likely lower than acquiring a new worker *and* providing that training. However, retaining existing workers' experience will require investment in upskilling. This process may be difficult, as training resources may remain scarce for some time and late-career workers, especially mechanics, may struggle at first to acquire new skills.

Agencies can take steps to ensure that necessary retraining does not also displace the existing workforce by assessing skill aptitude and streaming workers who require more time to acquire certain skills into appropriate roles while they work towards full retraining. For example, long-time diesel engine specialists who require more time to shift to battery-based vehicles may continue to work on mechanical or body systems until they qualify on higher voltages.

For many public transportation providers, anti-displacement provisions will involve cooperation between agencies and organized labor. Both groups only stand to gain from employee continuity, and both groups will have to work together to guide the transition to low and zero-emission operations along a smooth trajectory to full implementation.

Approach Fleet Transitions as an Opportunity for Workforce Development

The transition to low and zero-emission vehicles is an opportunity to both invest in the current workforce and to expand transit agencies' ability to attract their workers of the future. Due to the ongoing worker shortage and impending retirement cliff among many operations and maintenance staffs, transit agencies must work towards both to ensure uninterrupted high-quality transit service in the communities they serve.

The existing transit workforce has an enormous wealth of experience with providing transit service that cannot simply be replaced. Though many transit agencies are in the process of adapting to make space for a new generation's workplace expectations, pre-existing knowledge of vehicle maintenance, field operations, dispatch, and planning is essential to ensuring that the zero-emission transition is seamless for passengers. Agencies and their workers should look at the transition as a moment of great investment in the current workers, involving upskilling and

increasing competence in the workforce. They should look for ways to support their existing workers through their evolution to zero-emission operations through clear training requirements, providing sufficient training resources, and working together to ensure smooth labor agreement revisions.

Every transit worker will require some training to upskill into their roles for low and zero-emission transit operations. However, many veteran employees – especially mechanics – may view the changes as significant to overcome because of how long they have been working on conventional vehicles. Their experience with transit service provision is indispensable, but managing their transition will look different than for workers with more willingness or aptitude to shift their skills to zero-emission systems. Agencies should employ three strategies to balance the roles of new and veteran employees and ensure that the existing workers can remain part of the transit workforce.

- ***Fill low and zero-emission positions by retraining existing staff as well as recruiting new hires.*** Emphasizing internal advancement will prevent displacing existing workers and demonstrate the agency's goodwill towards its employees and may boost retention in and of itself. In the process of assessing skills gaps, agencies and their workers should include an evaluation of how many future roles will go unfilled by existing workers and link those findings to subsequent strategies for recruitment and retention.

- ***Ensure training requirements and opportunities are accessible well ahead of time.*** Workers emphasized that they can more effectively upskill the existing workforce if they are aware of the competence expectations in advance for various roles. Their ability to rise to the occasion increases if it is clear what training resources are available to achieve the necessary competences, and where the sources of training requirements originate (e.g., a standards or regulatory body). Agencies and their workers should work together with appropriate state agencies to develop a centralized source for this kind of information and announce updates routinely. The forthcoming DRPT Action Plan will include a process for compiling information about training requirements and opportunities.

- ***Plan to accommodate workers with different interests and skills.*** Workers will have different interests, skill levels, and different aptitudes for learning low and zero-emission-specific systems. Agencies should invest in the professional development of their workers by having a plan for utilizing all interests and skill levels. This includes providing pathways for existing workers who do not show immediate aptitude or interest in new vehicle systems to continue to work productively on other more familiar ones (e.g., brakes and suspension), as well as ways for these workers to transition into other agency roles such as supervisory positions.

Likewise, agencies should also view the transition to low and zero-emission vehicles as an opportunity to become a more attractive workplace to workers of the future. Transit agencies continue to face a worker shortage, a situation only made more competitive by an increased demand for high-voltage skills. To ensure adequate staffing, agencies should plan for higher wages and retention bonuses, which will be necessary to attract and keep higher-skilled workers, either new recruits or upskilled existing workers.

The skills required to work on low and zero-emission vehicles, particularly zero-emission buses (ZEBs), are likely to become increasingly in-demand as the transportation sector decarbonizes. Candidates who may not have considered a career in the transit industry before may be more

interested now that the roles will have less interaction with dirty combustion engines and involve more data- and electronics-focused work. Agencies and their workforce leaders should pursue all available avenues for recruiting and retaining new workers, including apprenticeship programs, and engaging with their local community colleges to promote transit roles.

Adopt a Phased and Iterative Approach to Fleet Deployment

Changing a transit fleet's operations from conventional fuels to low and zero-emission systems will involve operators, mechanics, planners, and administrative support staff adapting what they already know about their role to new circumstances. This will involve new skills, new equipment, and new processes to the same work, and it may not be immediately clear what skills, equipment, and processes workers will need to do their jobs. Likewise, administrative processes for delivering transit service, as well as acquiring and providing training, will also need time to appropriately evolve, especially if they involve new relationships with community colleges or apprenticeship programs.

To mitigate complications from upheaval, deploy low and zero-emission transit incrementally and iteratively where possible. This will make time and space for people get used to the new equipment, allowing all parties to identify issues up and down the organization that can then be contained and resolved in stages. Agencies should consider how they can phase their transitions and incorporate feedback from each phase into a process of continuous improvement in all aspects, from vehicle design to training to service planning to dispatch.

Have an Administrative Process for Addressing Skills Gaps

Applying the principles above will have little effect if the agency cannot account for existing resources and make plans for the future. Agencies and their workers should collaborate to develop strong processes for inventorying existing roles and their skills, characterizing how those may change (in quantity and in substantive scope), and then acquiring appropriate training and recruitment resources to fill identified gaps.

Robust training administration will especially help with managing differences among different transit agency work units. On one hand, operations staff, including drivers, dispatch, and planners will all be equally unfamiliar with new technologies, methods, and skills as their peers during deployment. Entire cohorts of these work units will need to learn new ways of performing their work functions, and so agencies may plan to upskill them as large groups.

Conversely, maintenance workers will have varying levels of familiarity and aptitude with new systems, such as high voltage electricity. Agencies will need to plan more granularly for addressing maintenance skills gaps, considering individual workers' development pathways and whether recruiting new employees will be necessary to make up for shortfalls after existing capacity is considered. Agencies and workers across agency units should cooperatively develop processes for upskilling and productively addressing capacity shortages that make sense for their expected needs as the transition progresses.

The Nitty Gritty: How to Design Training Programs or Otherwise Meet Your Agency's Training Needs

To put a new vehicle technology into service, agencies must identify the skills needed for each employee role, assess the existing skill level of the agency's workforce, and develop a training program to fill any skill gaps that exist.

Low and zero-emission buses are different from conventional buses in several important ways. BEBs and FCEBs both use high-voltage systems that will require extensive new training for operators and mechanics, especially related to safety. Some transit agencies may already be familiar with high voltage systems if they operate diesel hybrid-electric buses, but staff may still need to enhance their skills to cover even higher voltages.

Importantly, mechanics who have worked on low voltage or non-electrical mechanical systems may have to complete high-voltage training to work on the same system for an electric bus, depending on the vehicle specifications. Relatedly, operators will also have to expand their awareness of electrical safety. While operators are not likely to make repairs in the field, they must be prepared to identify and react to incidents that may occur in normal service situations, such as thermal runaway on BEBs.

Agencies and workers will need to work together to determine skills needs, aptitudes, and gaps as they prepare for low and zero-emission bus deployment. Agencies that decide to pursue low-emission vehicles, such as natural gas, on the path to full electrification will have to do this with respect to both the near-term fuel as well as the long-term fuel, as natural gas vehicles also require specialized equipment and training.

Regardless of the path chosen or how it changes, workers will need preparation and support to ensure uninterrupted service for the public. While some bodies such as Automotive Service Excellence (ASE) and the American Public Transportation Association (APTA) have begun to publish training curricula and associated certifications, the industry and original equipment manufacturers (OEMs) have not yet standardized equipment or skill needs. For the foreseeable future, agencies should approach low and zero-emission workforce skilling the way they already approach conventional vehicle skill training: on an OEM-by-OEM basis. Working with the OEMs and especially with local community colleges will allow agencies to develop training programs to certify operators and mechanics on the particulars of individual buses and refueling/recharging equipment.

Roles and Skills

What follows is a list of the skills for each role by fleet technology. Agencies will need to do a workforce inventory to determine which skills their workers already have.

Battery Electric Buses

Battery electric buses (BEBs) are currently the most common choice for agencies transitioning away from diesel-powered fleets. However, agency workers need to develop new skills to successfully manage, operate, and maintain a BEB fleet. **Table 1** shows trainings required of each category of transit agency workers; the specific skills required of each role are discussed below. Agencies will need to ensure that all workers receive training on high voltage safety and awareness. Because BEBs have more limited ranges than other fuel technologies, and because fueling these vehicles takes much longer, their adoption has a greater impact on aspects of transit service, like planning.

Operators

Training should consist of both classroom and hands-on activities to cover the following:

- **Operation.** Drivers should become familiar with the vehicle dashboard and warning signals, as well as correct procedure when a warning signal is initiated. Drivers should be trained on how to understand and respond to readings such as state of charge, remaining operating

time, and estimated range. Drivers should be aware of how to safely power down a bus.

- **Driving Habits.** FTA recommends training drivers on optimal driving habits, including regenerative braking, optimal acceleration/deceleration, hill holding, and roll back. Operators will need training on "one-pedal driving," the practice of accelerating and stopping using only the accelerator pedal, thereby maximizing the amount of electricity captured through regenerative braking. While electric buses generally handle the same as their fossil-fueled counterparts, operators may require additional training in smoother acceleration and braking, as more aggressive driving will deplete batteries more quickly. Additionally, drivers should be trained to operate with caution around pedestrians and cyclists as BEBs produce less noise compared with conventionally fueled vehicles.[15]
- **Charging.** APTA recommends that operators be familiar with charging depot locations, processes, procedures, and hazards associated with the fueling process. Drivers should receive training on foundational electric principles.[16]
- **Safety.** Operators should be trained on potential hazards of battery chargers, as compared to conventional fuels, including electrocution, arcing, and short circuit fires. Operators should be familiar with locations of emergency cutoff switches and fire response equipment.

Mechanics

Mechanics must be prepared to service all-electric propulsion and auxiliary systems and troubleshoot the on-board diagnostic systems. In addition, safety training is needed to prepare mechanics for safe handling of high voltage systems, include the handling, storage, and disposal of batteries. Safety training should focus on unique hazards associated with battery chargers, specifically the presence of high voltage cables and battery-specific fire hazards.[17]

Potential areas of supplemental training may include multiplex systems, entrance, and exit doors, wheelchair ramps, brake systems and axels, air systems, front and rear suspension steering, body, and structure, towing and recovery, propulsion systems, high voltage systems, depot chargers, and HVAC.

Mechanics will have a range of prior experience and training with electrical systems.

Operations Support

Personnel supporting operations, including supervisors, facility managers, and dispatchers, must receive proper training to understand new demands and expectations of operators to provide them with the necessary support. This includes an understanding of potential incidents and proper responses for road calls. Additionally, managers should be familiar with safe operation of facility chargers and must develop a charging protocol that optimizes energy costs while meeting service requirements. This protocol should be adaptable and scalable as the fleet expands, considering factors such as the optimal timing for bus charging, the sequence of charging, and the allocation of staff to plug/unplug buses and reposition, as necessary.

Dispatchers and schedulers will also require training to understand how low and zero emission vehicle ranges, refueling equipment, and operator driving behavior affect their work on service design and day-to-day decision-making. Some agencies may house these functions in planning departments, so staff preparing transition plans should make sure not to overlook them.

[15] TCRP Guidebook for Deploying Zero-Emission Transit Buses (2021)
[16] TCRP Guidebook for Deploying Zero-Emission Transit Buses (2021)
[17] TCRP Guidebook for Deploying Zero-Emission Transit Buses (2021)

Planning and Monitoring
Service planners should be equipped to consider the performance and limitations of BEBs to make efficient use of buses within the service area, monitoring and making decisions based on the following metrics:

- Cost per mile (fuel and maintenance)
- Energy Performance (kWh/mile)
- Availability (days when the bus(es) were capable of being put into service)
- Utilization (days when a bus is available and put into service)
- Comparison to diesel fleet (e.g., mileage, operating hours, cost per mile)
- Emissions reductions (e.g., greenhouse gas and Clean Air Act criteria pollutant emission reductions)

Table 1: Training Topics by Transit Agency Role

	OPERATOR	MECHANICS	OPERATIONS SUPPORT	PLANNING AND MONITORING
High voltage safety and awareness	X	X	X	X
Range and battery management	X		X	X
Dashboard controls	X	X		
Condition reporting and road calls	X		X	
Incident scenarios and response	X		X	
Charger equipment components		X	X	
Common failure modes		X	X	
Failure response and reporting		X	X	
Battery and propulsion system components		X		
Performance monitoring and reporting				X

Natural Gas

As with BEBs, agencies switching from diesel to natural gas buses (compressed or liquid, CNG or LNG, respectively) will require training to operate the new technology. Natural gas buses have many similarities with diesel buses, and despite some modifications to the exhaust system, natural gas engines have largely the same appearance and maintenance requirements as diesel ones.[18] However, the process of fueling natural gas buses necessitates the establishment and upkeep of dedicated fueling stations, and operators and mechanics must be trained for safe refueling. All agency workers should be trained on the safety hazards associated with the flammability of natural gas, along with high pressure storage.[19] Training needs by role are specified below.

Operators
Driving a natural gas vehicle is similar to driving diesel vehicles, so operators will require less retraining for natural gas than for other low and zero-emission bus technologies. The Natural

[18] https://afdc.energy.gov/vehicles/natural_gas_maintenance_safety.html
[19] https://afdc.energy.gov/vehicles/natural_gas_safety.html

Gas Vehicle Institute offers a 40-minute online training on operating natural gas buses including safe fueling of natural gas vehicles.[20]

Mechanics
As mentioned, natural gas and diesel buses have many of the same maintenance requirements. The most important areas of difference are:

- The ignition systems of natural gas vehicles are more sensitive than conventional buses and require more careful monitoring and more frequent maintenance.[21]
- Natural gas vehicles require more frequent replacements of brake and suspension components due to the increased vehicle weight.[22]

Plant Maintenance Staff
Natural gas fueling and fuel-storage are the areas where workers will need the most retraining. Staff will need to be trained for fuel tank inspection and refueling equipment maintenance.[23]

Liquified Propane Gas (LPG)

Though more popular for heating buildings and fueling non-road vehicles (e.g., farm equipment), propane has remained of interest as an on-road alternative fuel. Its high-octane rating and resulting ability to be used in spark ignition engines makes it possible for propane-fueled vehicles to drive similarly to diesel buses.[24] Since propane is gaseous at atmospheric temperature and pressure, it is stored under pressure as a liquid both onboard and in storage tanks at refueling sites. As with natural gas and other pressurized fuels, agency staff will need training to safely operate and maintain both the vehicles and the refueling infrastructure.[25] The Propane Education and Research Council offers training and capacity building resources for operators, mechanics, and fleet managers.[26]

Operators
LPG vehicles drive similarly to diesel buses, and therefore will require less operator retraining than for some other low and zero-emission bus fuels. Agencies should seek appropriate resources to ensure operators are familiar with safe operation and refueling procedures.

Mechanics
LPG buses use spark-ignited internal combustion engines similar to gasoline engines, and therefore will be familiar to many conventional mechanics. Maintenance facilities will likely remain similar as a result. However, LPG is stored under pressure and therefore must be handled carefully. Agencies should work with their local fire marshal and propane suppliers to develop appropriate protocols for storage and tank evacuation when working on LPG vehicles.

[20] https://ngvi.com/course/natural-gas-vehicle-driver-and-fueling-e-learning/
[21] https://afdc.energy.gov/vehicles/natural_gas_maintenance_safety.html
[22] https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2011-7.pdf
[23] https://afdc.energy.gov/vehicles/natural_gas_maintenance_safety.html
[24] https://afdc.energy.gov/fuels/propane_basics.html
[25] https://afdc.energy.gov/fuels/propane_infrastructure.html
[26] See for example: https://propane.com/safety/safety-articles/fleet-garaging-requirements/

Plant Maintenance Staff
LPG fueling and fuel storage differ the most from diesel vehicles, and therefore workers associated with these functions will need the most retraining. Staff will need to be trained for fuel tank inspection and refueling equipment maintenance.[27]

Hydrogen

FCEBs share traits of both BEBs and natural gas vehicles. Like BEBs, hydrogen-powered vehicles have electric drivetrains and batteries, which have implications for driver behavior and also pose safety concerns in the form of high voltage systems. Like natural gas and LPG vehicles, hydrogen fuel is stored as a liquid under pressure. However, hydrogen behaves differently than other liquid fuels and requires substantial differences in the balance-of-plant[28]. Agencies will need to implement changes to their training programs to ensure the safe operation of hydrogen vehicles and safe handling of fuels. All employees operating hydrogen-related vehicles or equipment will need training on the characteristics how to respond to hydrogen leaks or fires.

The key skills required of different categories of workers to work on hydrogen systems include:

Operators
- Similar to diesel-hybrid buses and BEBs, hydrogen-powered buses use batteries to recapture energy from braking and use that energy during acceleration events and to smooth out power delivered from the fuel cell. Hydrogen bus operators will require training on how to take advantage of regenerative braking to maximize their vehicles' ranges.[29]
- Operators will also need training on the hazards specific to hydrogen systems, including the hazards associated with high-voltage systems, hydrogen leaks, and hydrogen fires.
- The hydrogen-related portions of bus operator training are estimated to take between half a day and two days.[30]

Mechanics
- Considering the volatility and flammability of compressed hydrogen fuels, maintenance of FCEBs requires particular focus on preventative maintenance, along with inspections, leak detection and cooling mechanisms.[31]
- As with BEBs, mechanics working on hydrogen buses will need to be familiar with how to safely service high-voltage systems.

Plant Maintenance Staff
- Workers will need training on how to operate and maintain hydrogen compressors and storage tanks.
- Plant maintenance staff will also need to be trained on how to test and maintain safety

[27] https://afdc.energy.gov/fuels/propane_infrastructure.html
[28] Balance-of-plant refers to the collection of equipment involved in transmitting, storing, and transforming energy in a power plant or other setting, such as a transit agency facility. The balance-of-plant of a facility with BEBs would include the charging infrastructure, energy storage systems, and power distribution equipment including transformers, as well as other systems.
[29] "Operator's guide to fuel cell bus deployment." Fuel Cells and Hydrogen Joint Undertaking. 2019. https://www.fuelcellbuses.eu/sites/default/files/documents/JIVE_2_D2-1_Operators_Guide_to_FCB_Deployment_final.pdf
[30] Ibid.
[31] https://afdc.energy.gov/files/u/publication/fc_bus_status_2020.pdf?2346ae0806

systems, like hydrogen sensors and ground-fault detectors.[32]

Designing Training Processes and Programs

Role of Original Equipment Manufacturers (OEMs) in training

OEMs generally provide operator and mechanic training as part of vehicle procurement. Such training tends to reflect the most detailed and up-to-date information about the specific vehicles going into service. OEM-provided training can take two forms. OEM representatives can train agency mechanics directly, which provides workers with an opportunity to ask questions and receive guidance directly from the OEM personnel. However, agencies also need to find a way to train workers on an ongoing basis. For this reason, agencies can also adopt a "train-the-trainer" approach, whereby OEM representatives train agency staff to train workers who will require training after the initial training sessions are completed.

Use-cases for OEM-provided training:

- Upskilling operators and mechanics at the time of fleet transition.
- Using a 'train-the-trainer' approach to supplement an agency's in-house operator-training program.

In-House Training

Agencies can also seek to provide training on low and zero-emission vehicles via their in-house training programs. These will be especially useful for upskilling their existing workers, as agency partners including OEMs may have already trained staff who can train others. Agencies can also offer apprenticeships and mentorships, which can provide a key role in bridging the gap between the skills learned in a mechanic technical school or other third-party training venue.

Labor representatives told us that apprenticeship programs and mentorship programs, including those run and funded by unions, are important for supplementing the skills and training workers receive in classroom programs. However, some transit agencies do not have the staff time or expertise to upskill mechanics directly to work on new fleet technologies.

Use cases for in-house training include:

- Regular operator training, perhaps supplemented with 'train-the-trainer' support from OEMs.
- Mechanic continuing education programs, e.g., for new mechanics with some experience but who are unfamiliar with low and zero-emission vehicles or the specific fleet technology in use.
- Apprenticeships and mentorships for mechanics and operators to familiarize new workers with an agency's specific equipment and working practices.

Outside Education Institutions

While agencies will be able to provide some training for low and zero-emission vehicles in-house with the support of OEMs, in many cases the best course may be to partner with an outside educational institution, for a few reasons:

- Some agencies are unlikely to be large enough for it to make sense to keep a trainer on staff full-time.

[32] "TCRP 219: Guidebook for Deploying Zero-Emission Transit Buses." National Academies. 2021. http://nap.nationalacademies.org/25842

- Agency-provided training programs may be appropriate for current, veteran mechanics, but not new hires, who may need more comprehensive training.

Community colleges are a key resource for agencies. The Virginia Community College System (VCCS) and the state's technical schools were established specifically to support the state's workforce by providing two-year degrees and diplomas in a variety of subjects, as well as non-degree training and certifications. They provide resources for preparing candidates for roles within agencies, and certifications such as the Virginia Inspectors Licenses examination (i.e., those meeting the requirements of 19 VAC 30-70-9). VCCS and community colleges already offer traditional automotive and electrical trades certificate programs, and so represent a significant resource to the state in developing a home-grown zero-emission transit workforce.

Crucially, Virginia's community colleges also have experience in developing courses in response to the needs of local employers and have program advisory committees set up for precisely this purpose. Agencies can join these committees to being the discussion of introducing both general and manufacturer-specific courses.

Agencies may also be able to partner with other career-development programs funded by the state to help workers get necessary skills.[33] Private trade and vocational schools, such as Tidewater Tech in Norfolk, VA, also provide workers with skills related to the transition to low-emission and zero-emission fleets.[34] Lastly, agencies have already begun assisting one another through trainings and demonstrations. Ongoing peer exchange among agencies, facilitated by DRPT or other entities, may help develop best practices among the commonwealth's transit agencies.

Use-cases for training provided by outside educational institutions include:

- Mechanic training for workers new to the profession, where the extent of education exceeds the time and material resources available to the transit agency.
- Training to upskill mechanics on new fleet technology, including both general and manufacturer-specific training, where transit agencies are not well positioned to provide the latest information directly.

Role of State Agencies in Supporting the Transition

Recent federal and state policy action has expanded Virginia state agencies' mission to include not only clean transportation but also to ensure the existence of a robust workforce development apparatus supporting those investments. Virginia's transit agencies, workers, and local partners are not alone in developing the low and zero-emission transit workforce: other state agencies, including the Department of Transportation (VDOT), the Department of Energy (VDOE), the Department of Environmental Quality (VDEQ), the Department of Labor and Industry (VDOLI), and the Department of Workforce Development and Advancement (VDWDA) can support the workforce component of the transition to low-and zero-emission vehicles through coordinated support to training programs.

Some of these agencies have a historical relationship to clean transportation, but few have direct experience with workforce development. Nevertheless, in this context they have similar

[33] https://virginiacareerworks.com/workforce-credential-grant/
[34] https://news.tcc.edu/on-the-road-to-success-thanks-to-drivenow-program/

policy goals and different levers at their disposal, as well as the presence of peer organizations that are focused on workforce development, including the Virginia Community College System. Together, this suggests that cooperation can unlock even greater benefits for the transportation workforce in Virginia.

Coordinating the activities of many disparate state agencies will require considerable effort, including relationship-building and perhaps executive or legislative action. However, these agencies and their partners can take meaningful action today. The remainder of this section summarizes recommendations for state agencies to support transit workforce development.

Establish a State Transportation Workforce Development Working Group

Many of state agencies are in unfamiliar territory when it comes to transitioning to low and zero-emission transportation. VDOT, VDEQ, and VDOE have policy mandates and funding to electrify the power grid and the transportation system, but workforce development is a non-traditional mission. Conversely, VCCS and VDOLI are primarily focused on workforce development in general, but traditionally react to employer expressions of interest rather than make leading investments that today's clean transportation policy environment favors. The path forward lies squarely between the two situations, indicating an opportunity for integration and centralization that would maximize the effectiveness of related programs.

The potential upside is as great as the agencies' willingness to work together. For example, the Federal Highway Administration has delegated to VDOT the ability to determine if a workforce development program qualifies for NEVI formula funding, and VDOE's federal electrification funding may but does not need to incorporate workforce training. These opportunities can enable a cohesive statewide electrification strategy across the entire surface transportation system, but only if state agencies cooperate. Virginia's new Department of Workforce Development and Advancement, inaugurated in July 2023, may make an ideal home for centralizing this coordinated function in the form of an inter-departmental working group. The Virginia Department of Labor and Industry could also be an appropriate lead for the working group.

Create a Statewide Low and Zero-emission Training Program

State agencies should work together to develop a unified low-and-zero-emission training program. Labor organizations and workers benefit from specific requirements clearly communicated in advance, so that they can prepare for changes and communicate in turn with their training partners. The state agency working group should empower transit agencies, their workers, and their partners to meet the training needs of the zero-emission transition.

At a minimum, this should consist of enumerated lists of required skills to work on specific systems at different experience levels, and training curricula to achieve those skills. APTA and FTA's Transit Workforce Center have begun publishing training resources, as have other organizations such as ASE. However, agencies and workers in Virginia have hesitated to make use of these, unsure of how to evaluate whether a given training resources or certification will sufficiently qualify their workforce in the eyes of state agencies. Virginia can provide certainty by backing a unified suite of skills and training resources in a single clearinghouse. This one-stop hub can also provide guidance to transit agencies for establishing successful apprenticeship programs, as well as other relevant partnerships.

Providing a single information source will eliminate ambiguity and will provide agencies and workers a foundation on which to structure their own local solutions. These may include unique

partnerships with nearby technical schools and high school programs, which could not develop age- and experience-appropriate curricula without proper guidance.

Centralization has several benefits for state agencies as well. Agencies with delegated federal authority, such as VDOT and VDOE, can pool their workforce development resources for greater effectiveness instead of developing duplicative training systems. Likewise, partnerships with DRPT, VDOLI, DWDA, and VCCS will ensure that training needs are communicated proactively to those who can deliver resources – this will help mitigate current issues with trainer availability, for example. It may also be possible to develop statewide universal certifications for common electrical and hydrogen fuel systems that organizations not specific to transit can use.

Streamline Equipment Procurements and Fill Training Resource Gaps

As Virginia's state public transportation agency, DRPT will continue to play a significant role in marshalling resources for to support transit providers. Based on stakeholder conversations and other research for this guidebook, DRPT should direct some of its funding to low and zero-emission vehicle implementation, reserving some specifically for workforce development. Such assistance could come in the form of both technical assistance and demonstration projects, as well as helping to coordinate the actions of agencies across the state government.

Technical Assistance Activities

DRPT provides a range of technical assistance support to transit agencies in Virginia. It can expand its workforce-related support in several ways, including:

- ***Working with smaller agencies and community colleges to develop internship programs.***
  Smaller transit agencies often have fewer resources and lack the external worker support foundation provided by a labor organization. DRPT can foster workforce development at small agencies by working with these agencies and their local community colleges to develop internship programs. These are each critical to expanding the transit workforce in places with smaller labor pools, including for planning and administrative roles that could be filled by younger workers who may not yet be eligible for mechanic or operator roles.

- ***Developing templates for apprenticeship programs and provide tailoring support as agencies adapt programs to their own contexts.***
  Apprenticeship programs are invaluable to technical professions. They offer employees the chance to learn hands-on work on the job, often enabling them to earn a wage in the process. Apprenticeships also allow workers to transition into new roles and may not require extensive classroom experience that some prospective workers might not be suited to. However, the hands-on nature of apprenticeships at transit agencies makes them specific to the agencies' contexts: the specific vehicles and equipment in one place may not transfer to another.

  DRPT can assist agencies' development of apprenticeships and apprenticeship programs by developing frameworks from which agencies can build programs to suit their contexts; DRPT can also help them tailor these for maximum effectiveness. This program is already in development.

- ***Facilitating coordination between agencies that might rely on the same community college.***

Transit agencies and community colleges have shared interests in the zero-emission transition, and both face resource constraints of their own kinds. In situations where multiple transit agencies operate in the same region as a single community college, the agencies may find themselves competing for resources.

DRPT can ensure that agencies reach their workforce development goals, and likewise support the long-term health of partnerships with community colleges, by convening affected organizations and facilitating coordination between them. This could expand to communication outside the affected region and equalizing resources where surpluses may exist.

- ***Providing funding to support agency strategic planning efforts that address the need to readjust staffing levels and responsibilities, as well as training and certification of workers.***
  The zero-emission transition will require planning at the highest levels and operational training for each and every affected worker. A phased and iterative implementation may reveal that organizations would be better served if they reorganized, which itself will require strategic planning and careful adjustment. However, these difficult changes may appear unattainable in the face of resource shortages, even if the success of the zero-emission transition hinges on their occurrence.

  DRPT can provide financial, technical, and administrative support to transit agencies that specifically targets efforts to prepare and mitigate organizational challenges posed by the transition.

- ***Developing a joint equipment procurement program. In addition to cost savings, community colleges could offer training courses more frequently if a group of agencies purchased the same types of vehicles.***
  The zero-emission transition is in its early stages, and vehicles and infrastructure designs are anything but standardized. The differences between equipment designs means that workers' training may not be compatible between manufacturers, and the volatility in designs even within a single manufacturer's ecosystem means that workers may require frequent retraining. These issues also affect community colleges, which need time adapt their courses to each change, which in turn cascades throughout the automotive education system.

  DRPT can stabilize these training instability issues by expanding its joint procurement program to encourage transit agencies and their partners to purchase similar vehicles with similar specifications. Bulk purchases of standardized vehicles allow DRPT to negotiate better prices on behalf of Virginia's transit agencies, and the universality of certain systems will reduce training costs through the resulting stability. DRPT may also consider extending the joint procurement program to allow community colleges to purchase relevant equipment under certain conditions.

  The effects of consolidation may have knock-on economic benefits for Virginia. For example, long-run prices may drop as manufacturing standardizes and mass production ramps. Furthermore, OEMs may elect to establish manufacturing, service, and administrative facilities in the region as the customer base expands.

Demonstration Activities

DRPT also provides transit agencies in Virginia with technological and equipment demonstration projects, which move physical equipment into the field for practical use. DRPT can expand its workforce-related support through demonstrations in several ways, including:

- ***Acquiring tester buses that agencies could borrow to get hands-on experience to inform their fleet transitions.***
  Transit workers and community colleges both noted that a lack of physical equipment – buses, engines, chassis, etc. – has hampered their ability to train workers effectively. Classroom training is useful but incomplete without hands-on experience. Workers who enter the labor pool without this experience require additional training time once they arrive at an agency, further delaying their ability to productively contribute, and also tying up agency training resources.

  DRPT could fund the purchase of buses and other equipment that could then be loaned to agencies and their partners for defined periods. Use cases span the short- and long-term of the zero-emission transition, including periodic continuing education when other support is unavailable, pilot testing of various new fleet technologies during planning, and for training course development. Buses and equipment could migrate around the state for use by many.

- ***Finance pilot programs to develop statewide standardization.***
  As discussed above, a lack of standardization is a major barrier to the zero-emission transition with respect to training.

  DRPT can support standardization through demonstration projects by purchasing, deploying, and evaluating different equipment configurations to both inform future joint procurement specifications and give piloting agencies the opportunity to learn on new equipment. These projects could span fuel types, including BEBs and FCEVs, and findings could be shared widely among partner agencies across the state government.

Appendix: Workforce Transition Toolkit for Agencies

Fleet transitions have ramifications for every function of a transit agency. This toolkit is intended to help agencies think through the workforce implications of their chosen fleet technology. However, once your agency understands the steps required to equip a workforce to roll out a new fleet, you may find it appropriate to revise the choice of vendor, technology-type, or pace of transition. This tool is meant to be part of an iterative process of fleet transition planning where workforce and other considerations inform one another.

Assessing Training Needs and Workforce Planning

The questions in this section of the toolkit will help agencies identify the skills that will be required to roll out a new fleet and determine which capabilities their current workforce may lack.

Table 2: Assessing Training Needs and Workforce Planning

Key Questions	Considerations	FTA Planning Tool Question

Assessing Skills Needed for New Fleet		**1**
■ What type **of safety-related skills and training** will be required for each category of employees? ■ What skills are needed to maintain the proposed fleet? ■ What skills will be needed to **maintain the proposed fueling equipment**? ■ What skills will be needed to **operate the proposed fleet**? ■ What skills will be needed **to plan, monitor, and support operations** for the proposed fleet?	■ OEMs may be able to provide the learning objectives from their training materials. ■ Agencies may need to consider cross-training with local public safety officials like fire and emergency medical services. ■ Agencies should consider both the skills needed by operations personnel as well as those needed by workers in support roles such as dispatch, planning, and management.	
Assess skills of existing workers.		**2**
■ How does your agency currently **track skills and certifications** on employees? Are there any gaps in your data? ■ What **skills and certifications do current workers have** related to the maintenance, operation, and planning of transit vehicles?	■ You may want to build a spreadsheet of employees and the skills they possess. ■ It may be useful to survey workers to learn about skills and certifications they have earned outside of your agency. ■ Depending on your agency's CBA, surveying workers about their skills may involve coordination with your workers' bargaining unit. ■ Anonymous surveys may elicit more accurate responses and could be used to estimate the amount of training your agency will need to provide.	
Assess gaps between skills of current workforce and those that will be needed.		**3**
■ Based on your assessment of the skills needed to deploy your new fleet and the skills your current workforce possesses, **what skills will your workers need to acquire?** ■ What **types of trainings will be needed** to provide those skills? ■ What **credentials** exist that certify the completion of relevant training courses?	■ As agencies are assessing skill gaps, they should consider the needs of their fleet over the full lifetime of the vehicles. For example, agencies with BEBs will need to monitor battery degradation over time.	

Assessing Training Options

Now that you know what skills you need to acquire, you need to figure out what training resources are available to help you fill the gap.

Table 3: Assessing Training Options

Key Questions	Considerations	FTA Planning Tool Question
Inventory existing training programs.		**4,5**

■ What **types of training** does your agency currently provide **in-house**? ■ Are **there staff at your agency who conduct trainings regularly**; and could their roles be expanded to cover trainings required of the new fleet? ■ Could **existing in-house training programs be modified** to help employees gain proficiency on operating and maintaining the proposed new fleet? ■ What **external trainings** does your agency rely on?	■ Since on-the-job training is such an important component of transit workforce development, agencies should include in their assessment apprenticeships, mentorships, and less formal processes by which mechanics and operators learn the skills they need to do their jobs.	
Assess viability of training options		**4,5**
■ Does the **OEM of the proposed fleet offer the trainings** your workforce requires? ■ Does the **OEM have capacity** to deliver on the timeframe your agency needs? ■ Is there a **community college** in your area that offers transit training courses? ■ Are there **vocational schools** or other institutions that offer transit training?	■ OEM-provided training is subject to the availability of trainers; agencies should be sure that details concerning OEM-provided training, particularly concerning timing, are incorporated into purchase agreements. ■ In some circumstances, agencies have sent working to receive OEM trainings in other jurisdictions to overcome training capacity issues.	

Ensuring Equitable Allocation of Training Resources

Agencies need to make sure they have a workforce that can effectively operate, maintain, and plan for low and zero-emission vehicles. But the transition to buses powered by alternative fuel sources will have impacts beyond the provision of transit service. When considering the workforce component of the fleet transition, agencies must also consider the impacts on worker morale, the relationship with unions, and the distribution of opportunities for training and employment.

Table 4: Ensuring Equitable Allocation of Training Resources

Key Questions	Considerations	FTA Planning Tool Question
Engaging workers and unions		**7**

■ How will your agency **engage workers and their unions** regarding the impact of the new fleet deployment? ■ **How will workers be advised** of new training requirements and opportunities?	■ Changes to the skills required of agency positions may require revisions to CBAs or other interaction with unions. ■ To make sure that workers can take advantage of new opportunities, agencies should provide clarity around new training requirements and ample time to complete them.	
Anti-displacement measures		**6**
■ **How will your agency support workers** who want to be trained? (Consider both administrative and financial support). ■ How will your agency respond **to workers who are not interested in training** on how to maintain and operate low and zero-emission buses?	■ While all mechanics will likely need some training (e.g., concerning safety), there may be opportunities for workers who are less interested in completing a comprehensive training course to continue working; for example, by working on systems like brakes and suspension.	
Recruiting and hiring with equity in mind		**6**
■ How can your agency **expand its recruiting and hiring efforts** to reach a broader range of potential employees?	■ Agencies should seek to expand their recruiting and hiring efforts to make sure all potential workers, particularly those from disadvantaged backgrounds, can participate. ■ The transition to low and zero-emission vehicles will provide new opportunities for the transit industry's workers; it also has the potential to attract new workers who may previously have not considered a career in transit.	

Establishing a Long-Term Program for Meeting Workforce Needs

Upskilling an agency's current workforce to deploy a new fleet is only the first part of the workforce transition. Agencies also must work to ensure that there is an adequate supply of applicants for mechanic and operator positions who are trained in low and zero-emission vehicle technologies. The questions in this section will help agencies develop a strategy for meeting their medium- and long-term training needs.

Table 5: Establishing a Long-Term Program for Meeting Workforce Needs

Key Questions	Considerations	FTA Planning Tool Question
Identify training programs and partners.		**5**
■ What **external training institutions** exist in your area (for example, community colleges and trade schools)? ■ Are there other **nearby transit agencies** with whom your agency could partner for efficiencies of scale in providing training?	■ Virginia Community Colleges maintain Program Advisory Committees, providing employers with opportunities to collaborate on curriculum creation, for example on manufacturer-specific training programs.	
Developing internal training programs		**5**
■ Can you leverage external trainings to build training capacity within your agency? (e.g., **"train the trainer")** ■ Can your agency introduce new **apprenticeship/mentorship programs** to supplement other training courses?	■ Agencies should consider developing internal training capacity to ensure workers have the necessary skills even as the availability of external training resources fluctuates. ■ Unions say apprenticeships and mentorships can help bridge the divide between classroom learning and on -the-job skills. ■ DRPT is working to develop some template apprenticeship programs that will be customizable to fit the local context.	

Funding Workforce Development Programs

This final portion of the toolkit identifies sources that agencies can rely on to fund their workforce development programs. (This section pertains to question eight on the FTA zero-emission fleet transition plan.)

In addition to the sources listed below, several other Virginia state agencies may allocate funding for transit workforce development (see **Role of State Agencies in Supporting the Transition**). Agencies should coordinate with their MPOs as well as with DRPT to take advantage of other vehicle electrification workforce development programs as they become available.

Table 6: Funding Training Programs

Funding Source	Applicability to Workforce Development
Federal	
Bus and Bus Facilities Program 5339(a)	Five percent of total must go to workforce development. This program includes both a formula and discretionary component.
The Urbanized Area Formula Grants (5307)	Funds are available for transit capital and operating assistance and transportation-related planning in urbanized areas, including workforce development. (Note that Formula Grants for Rural Areas (5311) does not support workforce development).
Low or No Emission Vehicle Program - 5339(c)	In addition to five percent of total funds going to workforce development, "0.5% of a request may be for workforce development training and an additional 0.5% may be for training at the National Transit Institute (NTI)."
Rural Transportation Assistance (RTAP)	The National Rural Transit Assistance Program (49 U.S.C. 5311(b)(3)) provides assistance in the design and implementation of training and technical assistance projects and other support services tailored to meet the needs of transit operators in nonurbanized areas. Virginia's RTAP funds are administered by DRPT.
CMAQ	For transit agencies in qualifying areas, CMAQ funds can be used to support transit as well as workforce development.
Virginia	
DRPT Public Transportation Workforce Development Program	DRPT support agencies with costs associated with apprenticeship programs and can be tailored to "any facet of the public transportation industry."
DRPT Technical Assistance	DRPT also supports agencies with the cost of conducting studies and research to support operations, service deliver, and other agency functions.

MEMORANDUM

To: Tiffany Dubinsky and Daniel Wagner, Virginia Department of Rail and Public Transportation (DRPT)

From: Center for Transportation and the Environment (CTE)

CC: John Jackson and Emma Sexton, Kimley-Horn and Associates, Inc.

Date: May 15, 2024

Subject: Memorandum #4

Introduction

The Low or Zero Emission Transition Planning Checklist ("Checklist") was developed to aid transit agencies in preplanning and determining if and when they would initiate a long term low or no emission transition plan. The Checklist provides a series of questions that prompts the agency on suggested activity that should be completed or discussed prior to starting the work to complete the transition plan.

The Checklist was developed based on previous reports created during the DRPT Equity and Modernization Study, consultant industry knowledge, and feedback from Modernizing Transit Fleet project partners. The Checklist outlines the required activities that agencies should perform prior to drafting a low or zero-emission transit vehicle transition plan. The checklist serves as a guide for the agency planning process, which includes understanding the transit agency's service parameters, accessing and understanding fleet data, and exploring the steps needed to address future needs and priorities.

The Transition Plan Data Input Tool ("Tool") is an Excel Spreadsheet comprised of a comprehensive set of worksheets that are designed to guide transit agencies as they work through development of their low or no emission vehicle long term transition plan. The Tool was developed primarily based on the Center for Transportation and Environment (CTE)'s Transition Planning Methodology, which is a complete set of analyses used to inform agencies in converting their fleets to zero-emission. The methodology consists of data collection, analysis, and assessment stages; these stages are sequential and build upon findings in previous steps. For this tool, CTE collaborated with Arcadis to incorporate an emission calculations output tab that aids in estimating emissions per year, infrastructure cost projections, and total cost of ownership inputs. Steps specific to this tool are outlined in **Figure 1:** ZEB Transition Plan Methodology

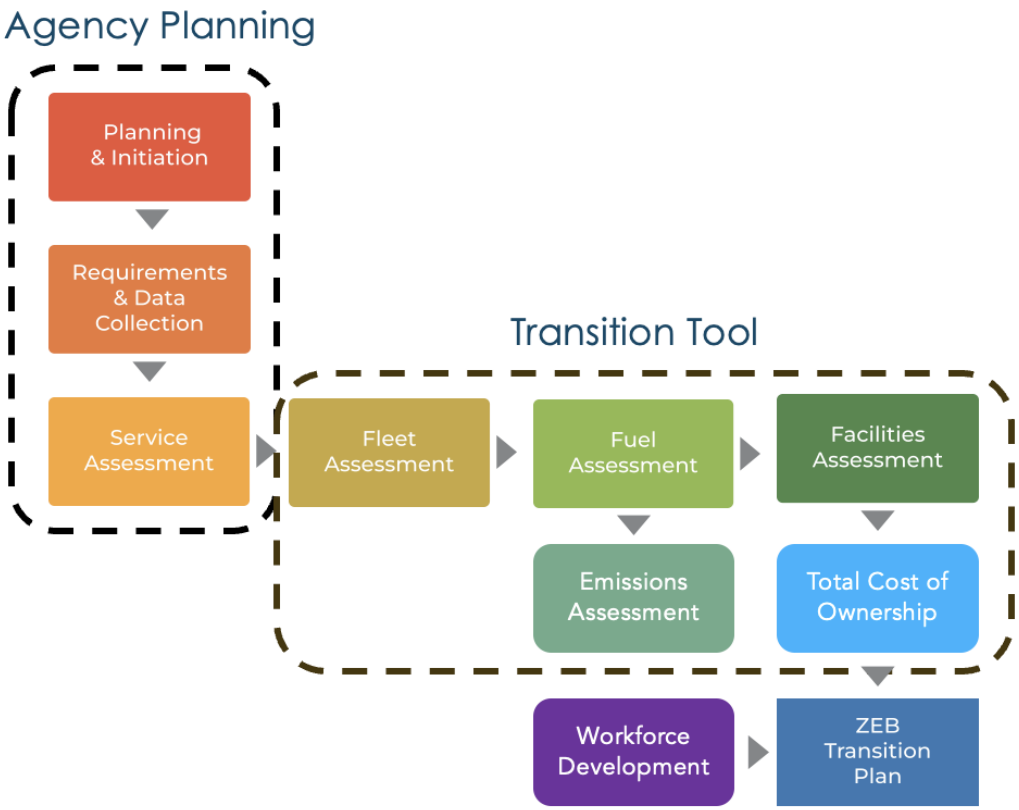


Figure 1: ZEB Transition Plan Methodology

Agency Planning

Agency Planning must take place prior to providing inputs into the Tool. The Checklist should be utilized during the Planning and Initiation stage. During the Planning and Initiation phase, the transit agency should ensure they are involving staff from relevant departments (e.g., planning, procurement, operations, IT, maintenance, and facilities) to provide input into each step of the Checklist. The Checklist will guide agencies through tasks using the following set of questions:

1. Has your agency collected or have access to relevant data and information to support analyses needed for Low- or Zero Emission Bus (ZEB) Transition Planning?
2. Has your agency set fleet transition planning goals based on local priorities, constraints, and regulatory requirements?
3. Has your agency initiated or completed a discussion with the appropriate utility provider or hydrogen supplier?
4. Have you identified funding sources to support the procurement of Low- or ZEBs and fueling infrastructure?
5. Has your agency begun working on the following activities pertaining to Workforce Development?
    a. Research to understand skills needed
    b. Conduct a staffing skills assessment
    c. Begin operator and technician training needs assessment

d. Begin operational planning to identify effects of transitioning to low or ZEB technology
e. Initiate discussion to understand what is needed to obtain and retain employees

6. Have you contacted agencies and/or reviewed published lessons learned from transit agencies that have deployed or are deploying Low- or ZEBs? A short list of agencies are listed below.
    a. DASH and the City of Alexandria
    b. Blacksburg Transit
    c. AppalCart (North Carolina)
    d. King County Metro (Washington State)
    e. Duluth Transit Authority (Minnesota)
    f. StarMetro (Tallahassee Florida)

The remaining tasks outlined in Agency Planning are Requirements and Data Collection activities and conducting a Service Assessment Analysis for a clear understanding of service needs to aid in the agency's low or zero emission technology selection. Once these activities are completed the agency should have an understanding for how to move forward with Low or Zero Emission Transition Planning by completing the inputs in the Tool.

Transition Plan Template

The Tool was developed to aid agencies in the creation of their own transition plans that fulfill the requirements for The Federal Transit Administration (FTA) Low or No Emission (LoNo) Grant Program with a minimum amount of preexisting knowledge. To this end, one of the goals of this tool was to adjust the (CTE's) transition planning methodology to minimize the manual adjustments and "judgement calls." CTE's existing method uses a series of workshops to determine the optimal transition solution based on CTE's technical and industry experience and the agency's unique conditions. CTE's original transition planning tool was designed around this multi-step process and required manual inputs and decisions at each step of the process which makes it unwieldy for first-time users.

The first step to creating the Tool was to determine the desired outputs. The decision was made to minimize the number of outputs to simplify the transition plan development process for the agency. CTE and Arcadis reviewed the FTA LoNo Emission transition plan requirements and determined that the key outputs were the fleet procurement schedule, fleet composition over time, total cost of ownership, and emissions reductions associated with the transition to zero-emission technologies. CTE and Arcadis created charts and tables for each output. As a part of the process, the agency will be instructed to paste the charts into the transition plan report document, and the associated tables are available if the agency requires more details.

After defining the outputs, CTE and Arcadis collaborated to determine how the agencies could use their existing information to create a transition plan that fulfills the requirements for the FTA LoNo Emission Program and any other grant programs or regulations, while conforming to any constraints that the agency may have. Because each agency's situation is unique, a system which allows the agency to define their own transition timeline and technology split year by year is incorporated in the Tool. This solution allows agencies to adjust the timing of their transition based on their available budget, route feasibility, infrastructure, personnel, or any other constraints. This also allows agencies to select the technology that best suits their needs at any given time, which could include a split between battery electric and fuel cell purchases, or a slow phasing in of a new technology to gain familiarity over time.

CTE and Arcadis then worked to determine the inputs that would be required to create the transition plan. One of the key inputs for the agency to provide is their existing fleet. The existing fleet information is comprised of the number of vehicles used for an agency's operation that include in-service and spare vehicles, the current fuel types of vehicles used in an agency's operation (gas, propane, diesel, biodiesel, CNG, etc.), and criteria like vehicle identification number, vehicle length, annual mileage, and cost. Specifically, costs of vehicles, vehicle options, and tax rate for vehicle purchase are called out in the tables. This data is used as a baseline for all future procurements. The existing fleet table includes the first service year, last service year, and expected service life of each vehicle, which is used to determine when each vehicle in the fleet is scheduled to retire.

The final step for a transition plan is determining the costs of each vehicle purchase and infrastructure purchase as well as the annual costs associated with fuel and maintenance for each vehicle in the fleet. The transition timeline and technology split are then used to determine how the vehicle should be replaced. The total cost of ownership assessment uses the fuel type, annual mileage, and fuel consumption of each bus to determine annual costs. CTE and Arcadis created a complete list of fuel types and vehicle lengths that agencies can select and filled in an associated purchase price for each vehicle. Arcadis created a list of infrastructure assumptions including purchases prices. Both the vehicle and infrastructure assumptions are modifiable, with the intention that agencies can input their own prices if they are known or use the preset prices to get an industry-wide estimate.

Next Steps

The project team will provide an overview of the Tool to Bay Transit and Bristol Virginia Transit to kick-off the ZEB Trial Planning phase of the Modernizing Transit Fleets project. A similar overview will be provided to the Technical Working Group to receive feedback that will be used to improve the Tool moving forward. Final edits will be made based on all questions and feedback provided during the testing phase and presented to the DRPT Executive Board at the conclusion of this project in June 2024.