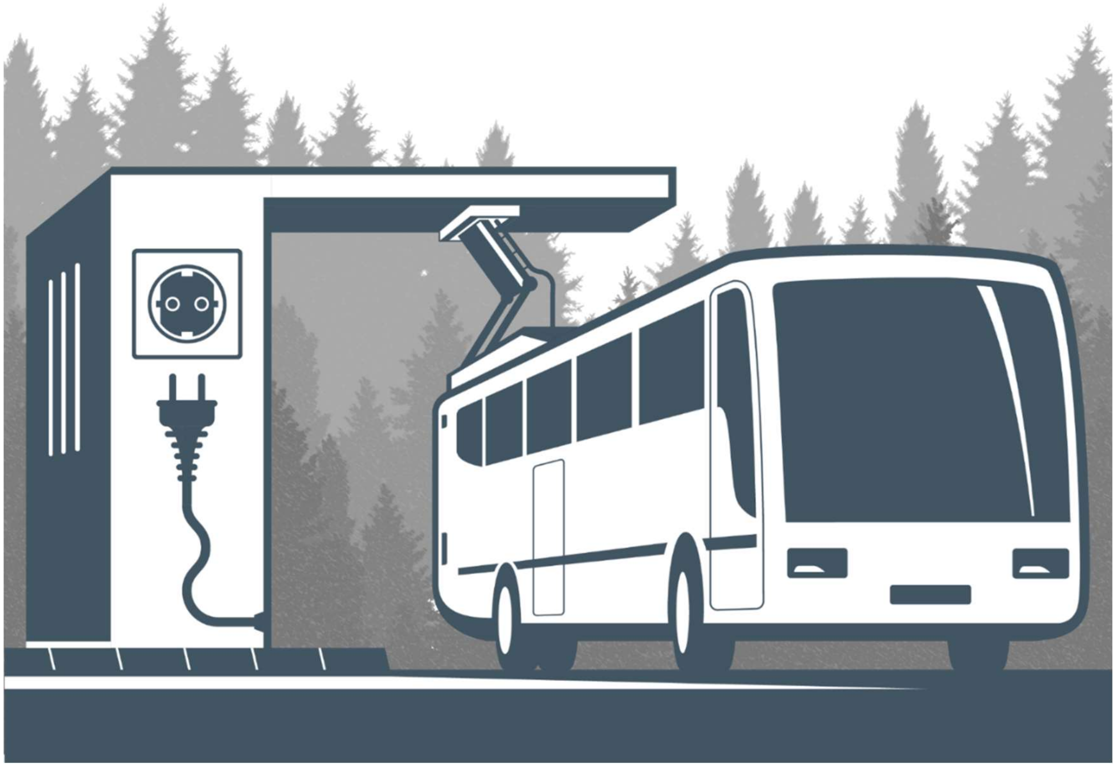

Vehicle Electrification Transition Plan for Aroostook Regional Transportation System (ARTS)

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1. Executive Summary

Aroostook Regional Transportation System (ARTS), the transit agency serving the northernmost county in Maine, is currently considering transitioning its fleet to battery electric and hybrid vehicles. To effectively plan for this transition a thorough analysis was conducted to develop a feasible strategy for the agency. This report summarizes the results of the analysis for asset configuration, emissions, and the costs associated with the transition.

Through this analytical process, ARTS has expressed a preference for fleet and infrastructure asset configurations that will provide a feasible transition to hybrid and battery electric drivetrain technologies while supporting the agency's operational requirements and financial constraints. The selected configuration maintains the agency's current fleet size of 21 vehicles, replacing four vans, three cutaways, and two school buses with electric vehicles. Because of the rural nature of ARTS's service area and the lack of market availability for hybrid or electric vehicles in the vehicle classes ARTS operates, the remainder of the fleet is assumed to remain fossil fuel powered for the foreseeable future. To support the battery electric vehicles, the agency also plans to procure, install, and commission two level 2 charging stations at the Houlton Fire Department facility in Houlton, Maine, and seven level 2 chargers and three fast chargers at the main storage facility in Presque Isle, Maine, once it is reconstructed.

One of the primary motivations behind ARTS's transition to battery electric vehicles is to achieve emissions reductions compared to their existing fossil fuel operations. As part of this analysis, an emissions projection was generated for the proposed future fleet. The results of this emissions projection estimate that the new fleet will provide up to a 39% reduction in emissions compared to ARTS's existing operations.

The conclusion of the analysis is that although battery electric vehicles are not yet ready for complete replacement of ARTS's fleet, the agency would benefit from beginning the transition with a small pilot. These vehicles offer the potential for the agency to greatly reduce emissions, and gain the required skillsets and operating experience for future electrification once the technology advances further. Therefore, ARTS is encouraged to proceed with the strategy as described in this transition plan.

2. Introduction

As part of its efforts to reduce emissions to slow the effects of climate change, the State of Maine has developed a "Clean Transportation Roadmap", which encourages Maine's transit agencies to transition their bus fleets to hybrid and battery electric vehicle technologies.

Additionally, the Federal Transit Administration (FTA) currently requires that all agencies seeking federal funding for "Zero-Emissions" bus projects under the grants for Buses and Bus Facilities Competitive Program (49 U.S.C. § 5339(b)) and the Low or No Emission Program (49 U.S.C. § 5339(c)) have completed a transition plan for their fleet. Specifically, the FTA requires that each transition plan address the following:

+ Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions.
+ Address the availability of current and future resources to meet costs for the transition and implementation.
+ Consider policy and legislation impacting relevant technologies.
+ Include an evaluation of existing and future facilities and their relationship to the technology transition.
+ Describe the partnership of the applicant with the utility or alternative fuel provider.
+ Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emissions vehicles and related infrastructure and avoid displacement of the existing workforce.

In response to the State of Maine's Roadmap and the FTA requirements, the Aroostook Regional Transportation System (ARTS), in association with the Maine Department of Transportation (MaineDOT) and its consultant Hatch, have developed this fleet transition plan. In addition to the FTA requirements, this transition plan also addresses details on ARTS's future operating plans, vehicle technology options, building electrical capacity, emissions impacts, resiliency, and financial implications.

3. Existing Conditions

ARTS is a transit agency providing demand-response transit service throughout Aroostook County, including Presque Isle, Houlton, and Fort Kent, Maine, in addition to operating a school bus service. The agency currently owns and operates a fleet of twenty-one passenger vehicles, all of which are gasoline or diesel powered.

Section Summary

- ARTS operates scheduled school bus service and an on-demand/flex service with a twenty-one-vehicle fleet
- On-demand vehicles operate for up to eight hours a day on widely varying routes due to unpredictable user demand.

Table 1 Current Vehicle Roster

Vehicle Type/Roster Number	Number of Vehicles	Procurement Date/Age	Projected Retirement Timeline
Braun Entervan	2	2011	4 yr / 100,000 mi
Braun Entervan	3	2016	4 yr / 100,000 mi
Chrysler Pacifica	1	2021	4 yr / 100,000 mi
Chrysler Voyager	1	2021	4 yr / 100,000 mi
Chevy Glaval Titan II	2	2017	5 yr / 150,000 mi
Freightliner Thomas MVP EF	1	2013	7 yr / 200,000 mi
Freightliner Thomas MVP EF	2	2014	7 yr / 200,000 mi
Ford Champion 230R	3	2016	7 yr / 200,000 mi
Ford E450SD	2	2023	7 yr / 200,000 mi
Ford Transit	1	2019	4 yr / 100,000 mi
Freightliner Thomas 191TSO	1	2023	7 yr / 200,000 mi
Freightliner Thomas C2	1	2021	7 yr / 200,000 mi
GMC G4500	1	2022	7 yr / 200,000 mi

School Bus Service

+ School bus service runs from 6-9 am and 1:15-4:30 pm

On-Demand Services

+ Services are offered on Presque Isle, Houlton, and Fort Kent.
+ Services run for about 8-9 hours a day from 8 am to 4:30 pm.
+ The Presque Isle services start and end at the ARTS office in Presque Isle.
+ The Houlton services start and end the service day at the fire station.
+ Fort Kent services start and end the service day at the driver’s home.

The ARTS facility in Presque Isle is a legacy location. Although it continues to meet the agency's needs, ARTS recognizes that it will require upgrades, particularly if electric vehicles are to be introduced. This analysis assumes that the facility is reconstructed in 2029 in advance of the first EVs being deployed in Presque Isle in 2030.

4. Vehicle Technology Options

Section Summary

- Manufacturers' advertised battery capacities do not reflect actual achievable operating range
- Considering a broad range of vehicles may help ARTS lower procurement cost

As discussed in Section 3, ARTS's revenue service fleet is composed primarily of cutaways, vans, and school buses. All three categories of electric vehicles may have limitations that the gasoline versions do not have. For example, because of the weight of the battery, one vendor's electric van can accommodate eight ambulatory passengers and only one wheelchair (as opposed to two on a gasoline van) while staying under GVWR limits. Shifting from an electric cutaway vehicle or school bus (shown in Figure 1 and Figure 2) to 30' transit buses would potentially allow greater operating range and passenger capacity; however, such a shift would have cost and maintenance implications for an agency like ARTS. In general, though, Hatch recommends that ARTS consider a broad range of vehicles in its future procurements, enabling maximum competition and potentially lowering cost.

Figure 1 Electric Cutaway Vehicle

Figure 2 Electric School Bus

There are not any hybrid cutaways, vans or school buses currently available in the US market. There are, however, a number of battery electric vehicles that are similar to what ARTS operates currently. For battery electric vehicles, battery capacity can be varied on many commercially available vehicle platforms to provide varying driving range. For this study, battery electric cutaways were assumed to have 125 and 160 kWh battery capacity, vans to have a 118 and

85kWh battery capacity and school buses to have 246 kWh battery capacity, which are representative values for the range of batteries offered by the industry.

5. Infrastructure Technology Options

There are two primary types of chargers that are applicable to ARTS's fleet – level 2 chargers, which are common in consumer applications, and DC fast chargers, most often applied toward heavy-duty vehicles. These differ in several key respects, primarily the type of power supplied.

Power distributed by electrical utilities, both at high voltages in long-distance transmission lines and low voltages in conventional wall outlets, is alternating current (AC), while batteries on vehicles use direct current (DC). Smaller vehicles, that require lower power levels, generally accept both types of power and have onboard rectifiers to convert AC input to DC. Accepting AC power reduces the cost of charging equipment. For larger vehicles the required rectifier would be too heavy, so the conversion to DC is conducted within the charger. This has a significant impact on the power levels each type of charger supplies.

The charging power provided by Level 2 chargers can range from 3.1kW to 19.2kW. Typical consumer grade chargers incorporate 6.24 kW of power while commercial grade chargers are available at 19.2 kW charging rates. Examples of such a system are shown in Figure 3.

Figure 3 Example Commercial Level 2 Charging Systems (Source: FLO & Blink)

DC fast chargers, which can provide up to 450 kWh of power, typically come in two types of configurations:

1. Centralized
2. De-centralized

A de-centralized charger is a self-contained unit that allows for the charging of one vehicle per charger. The charging dispenser is typically built into the charging cabinet. In contrast, in a centralized configuration, a single high-power charger can charge multiple vehicles through separate dispensers. The power is assigned to the dispensers dynamically based on the number of vehicles that are charging at the same time. An example of a centralized charging system is shown in Figure 4.

Figure 4 Example Charging Systems (Source: ABB): Charging Cabinet (System) and Three Dispensers (Charge Boxes)

6. Route Planning and Operations

Section Summary

- Electric vehicles do not offer comparable operating range to gasoline vehicles – so detailed operations modeling is needed
- Shorter on-demand service runs can be electrified with available electric vans and cutaways

ARTS's current operating model is similar to that of many demand-response transit agencies across the country. Each vehicle leaves the garage (or driver's home) at the appropriate time in the morning, operates nearly continuously for as long as necessary, and then returns to the overnight parking location. ARTS can assume that the vehicles can operate for as long as they are needed. This assumption will remain true for hybrid vehicles, which have comparable range to gasoline vehicles, but may not always be valid for electric vehicles, which have reduced range, particularly in winter months. (Vans and cutaway shuttles typically do not have auxiliary heaters to reduce the power required for heating, like transit buses; in addition, icy road conditions and cold temperatures degrade electric vehicle performance in the winter). Therefore, battery electric vehicles may not provide adequate range for a full day of service, year-round, particularly if recommended practices like pre-conditioning the vehicle before leaving the garage are not always followed.

ARTS's on-demand service operates between 8:00 AM and 4:30 PM on an on-demand basis. The vehicles typically do not have long down-times between pick-ups. Therefore, to avoid significant impacts to operations, the electric demand-response vehicles will need to have enough range for a full day of service without repeated top-up charging. Another potential issue is that in some cases, ARTS vehicles are parked overnight at the drivers' home to avoid lengthy deadheads to the depot. Doing so with electric vehicles would pose challenges with charging compatibility and reimbursement of drivers and is best avoided, at least in the short term.

6a. Operational Simulation

To assess how battery electric vehicles' range limitations may affect ARTS's operations, a simulation was conducted. A simulation is necessary because vehicle range and performance metrics advertised by manufacturers are maximum values that ignore the effects of cold winters, gradients, road congestion, stop frequency, driver performance, and other factors specific to ARTS's operations. As mentioned above, it was not necessary to simulate hybrid operations because there are no hybrid vehicles currently available in the market, and even if there were they would offer the same range as the existing internal combustion fleet.

Hatch conducted a route-specific electric vehicle analysis for many agencies in Maine by generating drive cycles. The full geography (horizontal and vertical alignment), transit infrastructure (location of key stops), road conditions (vehicle congestion, as well as traffic lights, stop signs, crosswalks, etc.), and use of the wheelchair lift were modeled, and the performance of the vehicle was simulated in worst-case weather conditions (cold winter) to create a drive cycle. To find a drive cycle best suited for ARTS's services, Hatch used previously generated drive cycle results for Maine routes (on-demand routes from Regional Transportation Program) that are similar in speed and geography to ARTS's routes.

As discussed in the previous section, the resultant runs were evaluated against a common electric cutaway with 125 or 160 kWh battery capacity, a van with 85 or 118 kWh, and a school bus with 246 kWh battery capacity. Two types of safety margins were subtracted from the nominal battery capacities of the vehicles. First, the battery was assumed to be six years old (i.e. shortly before its expected replacement). As batteries degrade over time, their capacity decreases. To account for this, the battery capacity was reduced by 20%. Second, the vehicle was assumed to need to return to the garage before its level of charge falls below 20%. This is both a manufacturer's recommendation – batteries have a longer life if they are not discharged to 0% – and an operational safety buffer to prevent dead vehicles from becoming stranded on the road. Combining these two reduction factors yields a usable battery capacity of 64% of the nominal value (80 and 102 kWh for the cutaways, 76.8 and 54.4 kWh for the vans and 157 kWh for the school bus). Finally, as the industry is advancing quickly and technology continues to improve, a 3% yearly improvement in battery capacity was assumed.

The electric vans expected to be procured for the initial pilot were based on vehicles available on the market as of this writing; further procurements will be governed by the performance of the initial vehicles. Clearly, if battery electric technology advances faster than anticipated, or if the existing fleet proves reliable and can outlast its 7-year lifespan, more demand-response service will be available for electrification. Conversely, if technology develops more slowly or the existing fleet requires replacement sooner, a pilot deployment may remain the practical limit for the foreseeable future.

Table 2 below presents the mileage and energy requirements for ARTS's operations. Green shading denotes those runs that can be operated by the specified vehicle and red shading denotes those that cannot operate in all conditions and for all mileages seen in daily service.

Table 2 Energy Requirements by Run

Block	Mileage	Vehicle Class	EV Range (miles) with 30 min fast charging	Mileage Shortage/Excess
Presque Isle (on-demand)	75–100	85 kWh van	93	-7 to +18
		118 kWh van	110	+10 to +35
		125 kWh cutaway	89	-11 to +16
Fort Kent (on-demand)	75–100	85 kWh van	93	-7 to +18
		118 kWh van	110	+10 to +35
		125 kWh cutaway	89	-11 to +16
Houlton (on-demand)	75–125	85 kWh van	93	-32 to +18
		118 kWh van	110	-15 to +35
		125 kWh cutaway	89	-36 to +16
School bus	150-175	160 kWh cutaway	140*	-10
		246 kWh school bus	161*	-14 to +11

*2 hour fast charging assumed

6b. Operational Alternatives

To avoid impact on ARTS operations, the most viable service model replaces the vehicles on shorter runs with electric vehicles, with all other runs being operated by fossil fuel vehicles. ARTS currently uses CTS Trip Master software to support operational routing. The software developer is currently developing a range-conscious routing feature as of this writing that will help ARTS choose the best runs on which to assign electric vehicles. The choice of vehicle for subsequent procurements will be heavily influenced by the performance of the pilot fleet: the farther the vehicles are able to travel during harsh winter conditions, the more of ARTS's operations are feasible for electrification once supporting facilities are upgraded to allow charger installation.

Recharging the vehicle midday using a fast charger can provide more mileage for each vehicle. Although this analysis assumes a 30 minute charge time – roughly equivalent to a driver lunch break – this duration can be adapted to match the length of the daily trip and the time available between scheduled pickups. The feasibility of this would depend on the vehicle's distance from the ARTS depot or other charging location.

Another option, not considered here in detail, involves using larger transit and school buses rather than cutaway vehicles. Because larger buses have more room for batteries on the roof or under the floor, they typically have longer range than cutaway vehicles. In this case, larger buses would be able to fully operate any of ARTS's routes, without needing to recharge. Adopting larger buses would also allow ARTS to increase capacity on the routes, if desired. However, larger buses are significantly more expensive, are less maneuverable on narrow streets, and would require additional training for ARTS staff to operate and maintain. They may also be significantly over-designed for the small passenger numbers that some of ARTS's vehicles may transport at any one time. Because of these drawbacks, this option is not considered further.

Hybrid vehicles, however, would provide a good balance between the advantages of lower-emission vehicles and the range required for longer routes. Operations would be able to remain exactly as they are today, since hybrid vehicles have comparable range to gasoline-powered ones. Unfortunately, as of this writing there are no hybrid vans, school buses, or cutaways available on the market. Hatch recommends that ARTS continue to monitor the industry to determine if a new vendor enters the market, as hybrid vehicles would substantially reduce ARTS's carbon emissions without posing challenges with vehicle range.

7. Charging Schedule and Utility Rates

Developing a charging schedule is recommended practice while developing a transition plan as charging logistics can have significant effects on fleet operations and costs incurred by the agency. From an operational perspective, charging vehicles during regular service hours introduces operational complexity by requiring a minimum downtime for charging that – unlike a driver lunch break – cannot be deferred or relocated. ARTS's operating practices and fleet composition dictate that vehicles will be charged only overnight, with the exception of once-daily mid-day charge windows to prolong range.

Section Summary

- The local utility has proposed a new rate structure for charging EVs which will include cost penalties for charging during peak demand periods
- As a result, a charging schedule was developed to help ARTS charge its vehicles economically

ARTS's current electricity rates are determined by Versant's 'Eco' rate table, as shown in Table 3. Under this rate table ARTS pays flat "customer" and "public policy" charges monthly, regardless of usage. There are also several categories of charges that scale linearly with the amount of energy consumed during the month; these total $0.120107 per kWh.

Versant's other district, the Bangor Hydro District, has adopted a 'B-1 Eco' utility rate which offers discounted pricing on services used exclusively for electric vehicle charging. Although the Maine Public District within which ARTS falls has not yet adopted a similar charging schedule, it may do so in the future. Although the 'B-1 Eco' rate does not require electric vehicle chargers to be metered separately, other utilities nationwide have begun imposing such requirements on their EV-specific rates. To provide maximum future flexibility, ARTS should install its electric vehicle chargers under separate metering, particularly for larger installations where the additional customer charge will be outweighed by the energy cost savings.

Table 3 below outlines the differences between the 'Eco' rate, which is restricted to demand of 50 kW or less, and the 'E-S' rate, which ARTS would fall under once past the 50 kW threshold. The 'E-S' rate structure would provide ARTS with a lower energy cost, but would introduce a demand-based charge calculated depending on the site's peak usage. If using this rate class, ARTS would need to use a charge management system, or manually organize its charging schedules, to prevent large power draws from occurring by many chargers simultaneously.

Table 3 Utility Rates Structure Comparison

	Current ECO Rates	E-S Rates
Customer Charge	$23.55 per month	$81.59 per month
Public Policy Charge	$25.07 per month	$678.64 per month
Delivery and Energy Charge	$0.120107 per kWh	$0.009064 per kWh
Demand-Based Charge	-	$21.82 per kW per month

Accordingly, while charge management will not significantly affect ARTS's utility bill for the initial two-van deployment in Houlton, for which a power consumption graph over time is shown in Figure 5, once the main facility is expanded for electric vehicles – and the agency surpasses the 50 kW rate class threshold – arranging charge times to minimize energy costs will become critical, as shown in Figure 6 and Figure 7. Although there is no difference in the total energy consumed between these two scenarios, the un-optimized scenario's 278 kW peak demand will incur a monthly demand charge of $6,065.96, and the optimized scenario's 120 kW peak demand will incur only $2,618.40. Using charge management to distribute vehicle charging throughout the overnight layover (as opposed to conducting fast charging as soon as the vehicles return to the depot), and scheduling vehicles to be at the depot for midday charging at different times (as opposed to all taking lunch breaks at the same time) will significantly reduce the cost of vehicle charging. In this example, this change alone would save ARTS over $40,000 annually.

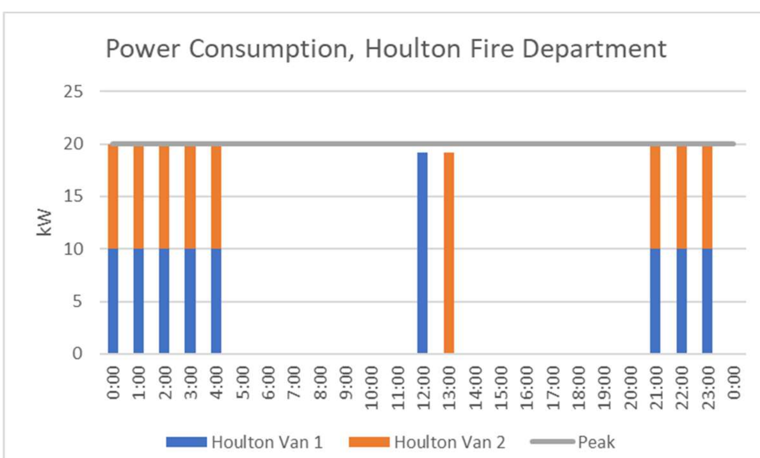

Figure 5 Power Consumption, Houlton Fire Department

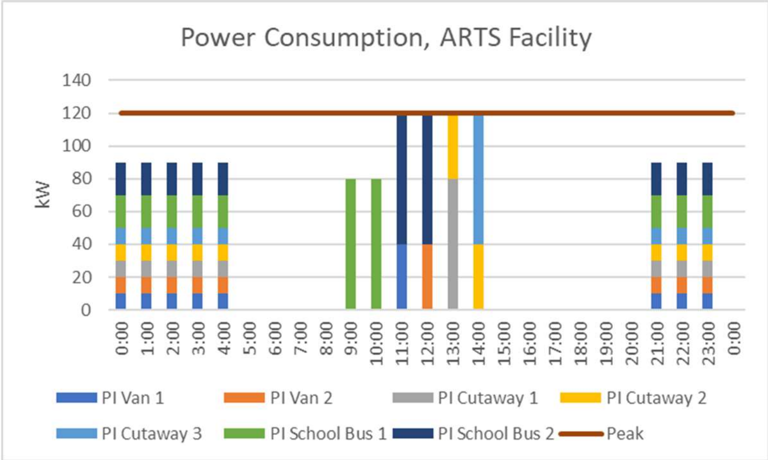

Figure 6 Optimized Power Consumption, ARTS Facility

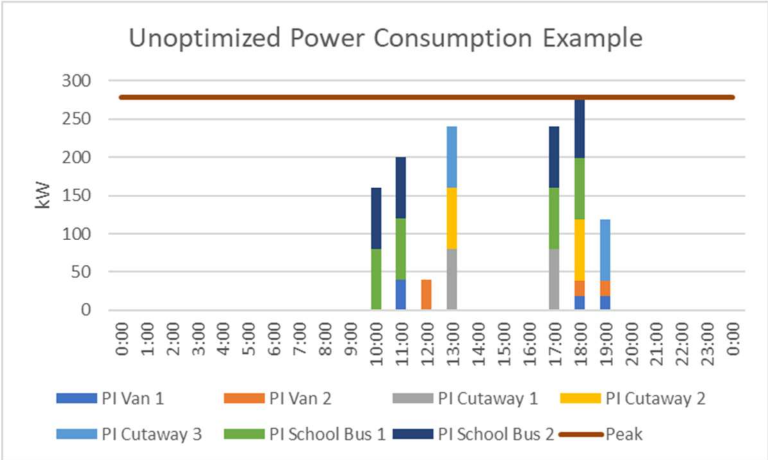

Figure 7 Unoptimized Power Consumption Example

8. Asset Selection, Fleet Management, and Transition Timeline

> ***Section Summary***
>
> - Hatch recommends procuring two electric vans to enter service in 2025, with seven other EVs purchased when the ARTS facility is renovated by 2030
> - Hatch recommends installing level 2 chargers at the Houlton Fire Department
> - Once the ARTS facility is renovated, ARTS should install both level 2 and DCFC chargers there

With operational and charging plans established, it was then possible to develop procurement timelines for infrastructure and vehicles to support those plans. ARTS, like almost all transit agencies, acquires vehicles on a rolling schedule. This helps to keep a low average fleet age, maintain stakeholder competency with procurements and new vehicles, and minimize scheduling risks. However, this also yields a high number of small orders. For any commercial vehicle procurement – and especially for a newer technology like electric vehicles – there are advantages to larger orders, such as lower cost and more efficient vendor support. ARTS is encouraged to seek opportunities to consolidate its fleet replacement into larger orders, either by merging orders in adjacent years or by teaming with other agencies in Maine that are ordering similar type of vehicles. This is particularly true for the first order of electric vehicles, where the inevitable learning curves are best handled with a larger fleet rather than a single vehicle.

As an additional complication, ARTS currently operates a mix of cutaways and vans on its demand-response services. The vehicle market in these classes is small, and most manufacturers do not offer electric versions; the vendors that do often have range, passenger capacity, or vehicle availability limitations. Although alternatives like 30’ transit buses are more expensive and require advanced maintenance skills, keeping a wide range of options open will help ARTS procure vehicles as efficiently as possible. To maintain a fair comparison, however, this analysis assumes that the existing fleet will be replaced approximately as expected by ARTS with vehicles of the same class.

With respect to infrastructure procurements, the ARTS main building at 24 Houlton Road will eventually need to be expanded to accommodate an electrified fleet. Although the cost of one charger itself is more or less constant regardless of how many are being purchased, the additional costs such as utility feed upgrades, duct connections, structural modifications, and civil work make it economical to install all the support infrastructure at once. When additional electric vehicles arrive and more chargers are required, the only work that should be necessary is installation of the chargers themselves. A detailed engineering design will be required to develop an accurate estimate of the costs of this reconstruction, particularly as other elements of the facility will likely be upgraded as well. In the interim, ARTS should defer procurement of most infrastructure for the main facility until the reconstruction is finished, to avoid rework and operational difficulties during the project. Only a single level 2 charger should be installed at the main facility during this time, to allow charging of the two electric vans while they are undergoing maintenance.

ARTS should also install level 2 chargers at the Houlton Fire Department to charge the two pilot electric vehicles that will be based there. Although this will require negotiating payment and maintenance contracts with the fire station, as it is not ARTS property, this will let the agency gain EV operating experience before the main facility is reconstructed. Some agencies prefer installing additional chargers to provide spare capacity and allow for charger maintenance outages; given the small scale of the pilot deployment, this additional expense would likely not be justified. Table 4 provides a summary of the proposed vehicle and infrastructure procurement schedule:

Table 4 Proposed Fleet and Charging System Transition Schedule

Year	Vehicles Procured	Infrastructure Procured	Vehicles Replaced
2025	Two electric vans Three diesel school buses	Two level 2 chargers (Houlton Fire Department) One level 2 charger (Presque Isle)	401, 402 505, 508, 525
2026	Three gasoline vans		403, 404, 405
2027	Four gasoline cutaways		501, 506, 507, 510
2028			
2029	One gasoline van	Main depot reconstruction (assumed)	406
2030	Two electric school buses One diesel school bus Two electric vans Three electric cutaways	Seven level 2 chargers (Presque Isle) Three 80 kW DCFC (Presque Isle)	601, 602 605 407, 530 503, 511, 512

Hatch recommends a robust testing program for the pilot order of electric vans on operating cycles across ARTS's service area year-round. Although doing so will likely require additional drivers and vehicles (to swap out for the EVs if they exhaust their range), this experience will help ARTS understand electric van operation across different geography (hilly vs flat), environments (short distance in-town vs long distance rural), and weather conditions (winter vs summer) to inform future decisions on fleet electrification. If some downtime in vehicle operation is available, ARTS can also consider using public chargers available in Presque Isle, Caribou, Houlton, and Fort Kent; the knowledge gained about charger location and reliability/availability will let the agency better plan for vehicle range extension and operational resiliency. Finally, spreading electric vans out will ensure that the benefits of electric vehicles (elimination of tailpipe emissions, reduced noise, etc.) are distributed equitably across the county. This may also prove valuable from a Title VI perspective, particularly as county demographics continue to change over the coming years. Rotating the electric vehicles across the region will ensure that no area is disproportionately negatively impacted by ARTS emissions.

9. Building Spatial Capacity

Section Summary

- The existing 24 Houlton Road facility is unsuitable for installation of level 2 chargers, except for maintenance
- The Houlton Fire Department has ample space for outdoor charging

ARTS's main storage and maintenance facility is located at 24 Houlton Road in Presque Isle. The building is used for administration, vehicle maintenance, and vehicle wash, with vehicles stored in the outdoor parking lot. The facility does not have a gas station but does have space for chargers. In addition to the Presque Isle facility, ARTS has a dedicated space in the Houlton Fire Department's parking lot at 99 Military Street in Houlton, which is used as an overnight layover area for two vans. This site is not owned by ARTS, and no inspections or maintenance are performed there. Other vehicles, particularly in Fort Kent, are stored at the homes of their drivers. As at Houlton, these locations are for storage only.

Because of the impending reconstruction of the Presque Isle facility, the most suitable location for the required chargers is at the Houlton fire station. As shown in Figure 8, the facility should have sufficient space to accommodate these needs. Until reconstruction is complete, the Presque Isle facility will only need to accommodate a single charger, to be used during maintenance and for training.

Figure 8 Houlton Fire Department, With Space for Chargers (Source: Google Maps, April 2024)

Assuming the initial pilot is successful and ARTS considers continued electrification, additional chargers would be needed in Presque Isle to accommodate van, cutaway, and school bus vehicles. The facility has sufficient space to accommodate outdoor charging, as shown in Figure 9. Indoor charging would ease winter operations (by reducing the need for snow-clearing) and extend the life of the charging equipment; ARTS is encouraged to include expansion of the existing building (or at least an overhead canopy) to encompass the charging area. As shown in Figure 10, the current facility can easily accommodate the one proposed charger for use during maintenance.

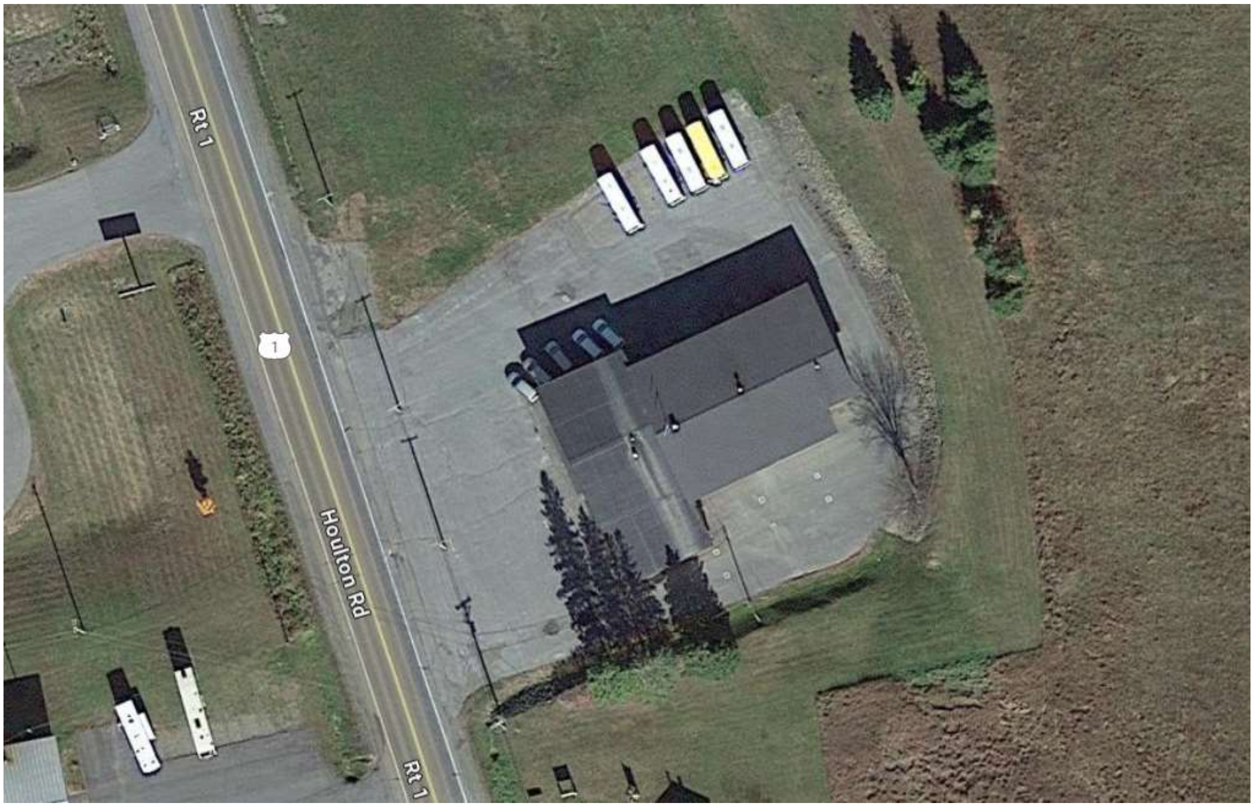

Figure 9 ARTS Facility (Source: Google Maps, October 2020)

Figure 10 ARTS Facility

10. Electrical, Infrastructure, and Utility Capacity

Section Summary

- The electrical service at the ARTS facility will likely need to be upgraded to support long-term vehicle charging needs

Versant is the utility provider for most of ARTS's operating territory. The 24 Houlton Road facility has 240V single-phase electrical service; the building's electrical connection is shown in Figure 11. Because utility information was not available at the time of analysis, a load study will need to be conducted for the facility to confirm availability of spare electrical capacity; however, it is likely that while a single level 2 charger can be accommodated for maintenance charging without electrical upgrades, additional installations will need to be deferred until the electrical feed is upgraded as part of the planned facility reconstruction.

Figure 11 24 Houlton Road Electrical Connection

When designing the new facility, ARTS should consider installing DCFC chargers rather than exclusively adding level 2 chargers. The DCFCs typically require 480V 3-phase input voltage, which is currently not available at the site (the electrical feed is 240V single phase). Hence, a new 480 V utility service will be required. Hatch has confirmed from publicly accessible information that Versant has ample transmission capacity near the ARTS facility, including three-phase power.

At the Houlton Fire Department facility, the proposed two level 2 chargers can likely be accommodated by the building's three-phase electrical service, although confirmation will be needed from the fire department and the electrical utility.

11. Risk Mitigation and Resiliency

Section Summary

- As with any new technology, electric vehicle introduction carries the potential for risks that must be managed
- Although only limited power outage data is available, resiliency options must be considered
- Solar panels in conjunction with on-site energy storage can be a viable option for resiliency, reducing GHG and completely offsetting the electricity used by electric vehicles

Every new vehicle procurement brings about a certain degree of operational risk to the agency. Even when the existing fleet is being replaced 'in-kind' with new gasoline vehicles, there are new technologies to contend with, potential build quality issues that must be uncovered, and maintenance best practices that can only be learned through experience with a particular vehicle. Vehicle electrification makes some failure modes impossible – for example by eliminating the gasoline engine – but introduces others. For example, the ability to provide service becomes dependent on the continuous supply of electricity to the charging location. Understanding these risks and the best ways to mitigate them is key to successful electric vehicle operation.

11a. Technological and Operational Risk

The vehicle and wayside technology required for electric vehicle operation is in its early stages; few operators have operated their electric fleets or charging assets through a complete life cycle of procurement, operation, maintenance, and eventual replacement. As detailed in the earlier Transit Vehicle Electrification Best Practices Report, this exposes electric vehicle purchasers to several areas of uncertainty:

- Technological robustness: By their nature as newer technology, many electric vehicles and chargers have not had the chance to stand the test of time. Although many industry vendors have extensive experience with gasoline vehicles, and new vehicles are required to undergo Altoona testing, some of the new designs will inevitably have shortcomings in reliability.
- Battery performance: The battery duty cycle required for electric vehicles – intensive, cyclical use in all weather conditions – is demanding, and its long-term implications on battery performance are still being studied. Though manufacturers have recommended general principles like battery conditioning, avoiding full depletion, and preferring lower power charging to short bursts of high power, best practices in vehicle charging and battery maintenance will become clearer in coming years.
- Supply availability: Compared with other types of vehicles, electric vans are particularly vulnerable to supply disruptions due to the small number of vendors and worldwide competition for battery raw materials such as lithium. Particularly for smaller vehicle

classes like vans and cutaways, the industry remains tumultuous, with major vendors like Lightning eMotors declaring bankruptcy and exiting the market in 2023.

+ Lack of industry standards: Although the market has begun moving toward standardization in recent years – for example through the adoption of a uniform vehicle charging interface – there are many areas (e.g. battery and depot fire safety) in which best practices have not yet been developed. This may mean that infrastructure installed early may need to be upgraded later to remain compliant.
+ Reliance on wayside infrastructure: Unlike gasoline and diesel vehicles, which can refuel at any public fueling station, electric vehicles require level 2 chargers for overnight charging and specialized DCFC chargers for midday fast charging. Particularly early on, when there is not a widespread network of public chargers, this may pose an operating constraint in case of charger failure, particularly in a comparatively remote service area like ARTS's where backup chargers may be few, occupied, snowed-in, or otherwise inaccessible.
+ Fire risk: The batteries on electric vehicles require special consideration from a fire risk perspective (see Section 12b).

Most of these risks are likely to be resolved as electric vehicle technology develops. ARTS is in a good position in this regard, as the comparatively small size of the recommended pilot fleet and the short lifespan of the vehicles means that any electrification decision does not present a long-term financial commitment. Nevertheless, it will be prudent for the agency to begin its transition to electric vehicles with an eye toward operating robustness in case of unexpected issues. Hatch recommends several strategies to maximize robustness:

+ Require the electric vehicle vendor to have a technician nearby in case of problems, or identify an EV service station that is familiar with the vendor's vehicles. This is most economical when a partnership is reached with other nearby fleet operators deploying EVs, such as Versant.
+ Retain gasoline vehicles for at least two years after they are retired to ensure they can substitute for electric vehicles if any incidents or weather conditions require it.
+ Develop contingency plans in case of charger failure, particularly for high-speed chargers required for midday use. This may include using another charger in the area, swapping vehicles more often than planned, or borrowing a vehicle from a nearby operator.
+ Include fire detection, suppression and mitigation analysis in the facility reconstruction project (see section 12b).

11b. Electrical Resiliency

Electricity supply and energy resilience are important considerations for ARTS when transitioning from fossil fuel to electric vehicle fleets. As the revenue fleet is electrified, the ability to provide service is dependent on access to reliable power. In the event of a power outage, there are three main options for providing resiliency:

+ Battery storage
+ Generators (diesel or CNG generators)

+ Solar Arrays

Table 5 summarizes the advantages and disadvantages of on-site storage and on-site generation systems. The most ideal solution for ARTS will need to be determined based on a cost benefit analysis.

Table 5 Comparison of the resiliency options

Resiliency Option	Pros	Cons
Battery Storage	Can serve as intermittent buffer for renewables. Cut utility cost through peak-shaving.	Short power supply in case of outages. Batteries degrade over time yielding less available storage as the system ages. Can get expensive for high storage capacity.
Generators	Can provide power for prolonged periods. Lower upfront cost.	GHG emitter. Maintenance and upkeep are required and can be costly.
Solar Arrays	Can provide power generation in the event of prolonged outages. Cut utility costs.	Cannot provide instantaneous power sufficient to support all operations. Constrained due to real-estate space and support structures. Requires Battery Storage for resiliency usage.

12. Conceptual Infrastructure Design

12a. Conceptual Layouts

For the first step of ARTS's transition to electric vehicles, Hatch recommends installing two 19.2 kW level 2 chargers at the Houlton fire station. This is advantageous given the initial small pilot fleet – which would make the heavy capital investment for DC chargers less economical – and preference for vans, which require comparatively low power levels. In addition, lower charging levels are generally preferred, as fast charging can shorten the lifespan of the battery pack.

Section Summary

- Hatch recommends designing the 24 Houlton Road facility reconstruction for ten post-mounted chargers

If ARTS decides to convert other routes to electric operation, including the Fort Kent and Presque Isle on-demand services, ARTS will need to install de-centralized plug-in style DCFC chargers to allow charging midday. This is necessary both to lengthen vehicle range and because the vehicles are parked overnight at the driver's houses. DCFC chargers will also be required for conversion of longer-range routes, like the school bus service.

To assist ARTS with visualizing the required infrastructure transition, conceptual plans were next developed based on the previous information established in this report. As outlined previously, the 24 Houlton Road facility will undergo major reconstruction in the near future; however, as this redevelopment has not yet started, these layouts are based on the existing building design.

There are two primary methods for installing vehicle chargers:

+ Mounted on the wall (or on posts if outdoors)
+ Suspended from the ceiling (or from a canopy if outdoors)

Of these options, the ceiling suspension would allow the most layout flexibility, but would also be the most expensive and maintenance-intensive. The wall-mounted alternative would offer comparable utility for the small fleet size of the recommended pilot; vehicles would be able to park adjacent to the dispensers to charge overnight. Hatch recommends that ARTS select the wall-mounted alternative to minimize the capital and operational impacts of charger installation. Figure 12 illustrates a potential suggested layout for the chargers with the existing facility layout.

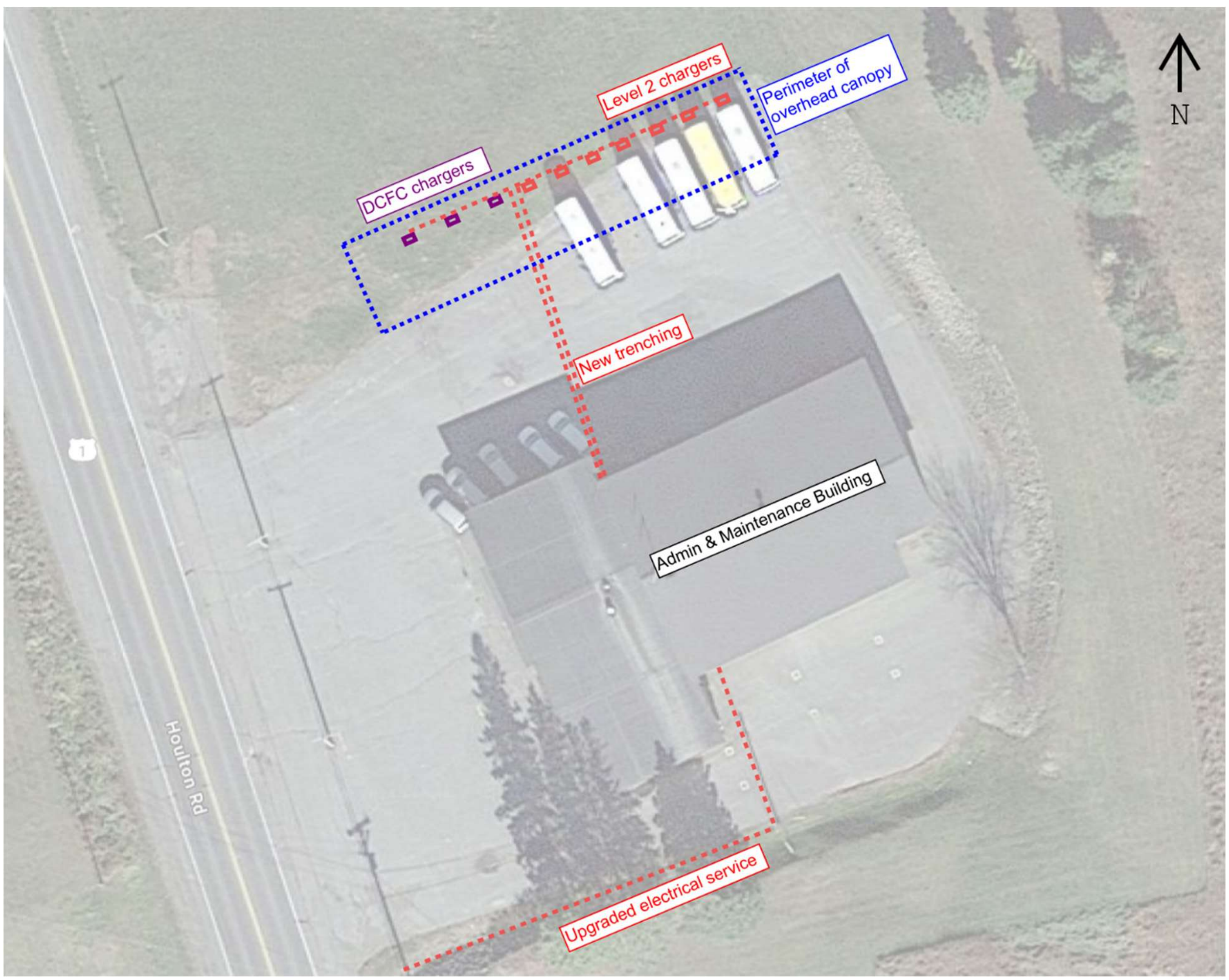

Figure 12 Conceptual Layout

12b. Fire Mitigation

An electric vehicle's battery is a dense assembly of chemical energy. If this large supply of energy begins reacting outside of its intended circuitry, for example due to faulty wiring or defective or damaged components, the battery can start rapidly expelling heat and flammable gas, causing a "thermal runaway" fire. Given their abundant fuel supply, battery fires are notoriously difficult to put out and can even reignite after they are extinguished. Furthermore, without prompt fire mitigation the dispersed heat and gas will likely spread to whatever is located near the vehicles. If this is another electric vehicle then a chain reaction can occur, with the heat emanating from one vehicle overheating (and likely igniting) the batteries of another vehicle. This can endanger all the vehicles in the storage facility, and anyone nearby.

For the aforementioned risks that battery electric vehicle operations introduce, mitigations are recommended. On the vehicles themselves, increasingly sophisticated battery management systems are being developed, ensuring that warning signs of battery fires – such as high temperature, swelling, and impact and vibration damage – are quickly caught and addressed. Though research is ongoing, most battery producers believe that with proper manufacturing quality assurance and operational monitoring the risk of a battery fire can be minimized.

The infrastructure best practices for preventing fire spread with electric vehicles are still being developed. Although ARTS's risk is relatively low because of the smaller initial size of the electric fleet, the agency should nevertheless monitor any development of standards for fire suppression and mitigation of facilities housing battery electric vehicles (which currently do not exist). There are partially relevant standards for the storage of high-capacity batteries indoors for backup power systems, such as UL9540, NFPA 70, and NFPA 230, and the primary components of any fire mitigation strategy are well understood. These include detectors for immediate discovery of a fire, sprinklers to extinguish it as much as possible, and barriers to prevent it from spreading to other vehicles or the building structure. To aid emergency response, the fire detectors should also be designed to automatically notify the fire department to ensure response even if no ARTS staff are able to respond. Further, ARTS should commission a fire safety study as part of detailed design work for the new facility to consider other mitigation measures.

13. Policy Considerations and Resource Analysis

ARTS's current operating budget is roughly $1.8 million per year. The agency's funding sources are summarized in Figure 13. As can be seen in the figure, ARTS's largest source of funding comes from federal assistance. For vehicle, facility, and infrastructure costs the agency's primary federal funding comes from the Formula Grants for Rural Areas program (49

Section Summary

- A wide range of funding sources is available to ARTS to help fund electrification
- State and local support will be required as well

U.S.C. 5311), and the Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b)) through the FTA.

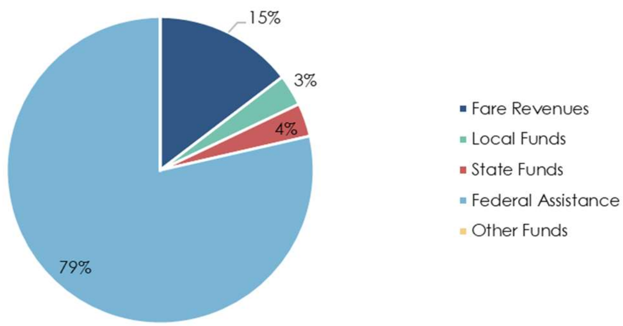

Figure 13 Current Agency Funding Summary (Source: Maine DOT)

As the agency transitions to battery electric technology, additional policies and resources will become applicable to ARTS. Table 6 provides a summary of current policies, resources, and legislation that are relevant to the fleet electrification transition.

Despite the large number of potential funding opportunities available to transit agencies seeking to transition to battery electric technologies, these programs are competitive and do not provide ARTS with guaranteed funding sources. Therefore, this analysis assumes that the agency will only receive funding through the largest grant programs that provide the highest likelihood of issuance to the agency. Specifically, this analysis assumed that ARTS will receive 80% of the capital required to complete the vehicle, charging system, and supporting infrastructure procurements outlined in this transition plan through the following major grant programs:

- Formula Grants for Rural Areas (49 U.S.C. 5311),
- Low or No Emission Grant Program (FTA 5339 (c)
- Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b))
- EPA Clean Heavy Duty Vehicles Grants for school buses (EPA-R-OAR-CHDV-24-06)

It is assumed that all other funding required to complete this transition will need to be provided through state or local funds.

Table 6 Policy and Resources Available to ARTS

Policy	Details	Relevance to Agency Transition
The U.S. Environmental Protection Agency's Clean Heavy Duty Vehicles Grants	To address harmful emissions from non-zero-emission heavy-duty vehicles, Section 60101 of the Inflation Reduction Act of 2022 (or IRA) created Section 132 of the Clean Air Act (CAA) (42 U.S.C. 7431) and provided $1 billion to fund the replacement of non-zero-emission (non-ZE) Class 6 or Class 7 heavy-duty vehicles (as defined in 40 CFR 1037.801) with zero-emission (ZE) vehicles.	Can be used to fund procurements for electric school buses.
The U.S. Department of Transportation's Public Transportation Innovation Program	Financial assistance is available to local, state, and federal government entities; public transportation providers; private and non-profit organizations; and higher education institutions for research, demonstration, and deployment projects involving low or zero emission public transportation vehicles. Eligible vehicles must be designated for public transportation use and significantly reduce energy consumption or harmful emissions compared to a comparable standard or low emission vehicle.	Can be used to fund electric vehicle deployments and research projects. (*Competitive funding)
The U.S. Department of Transportation's Low or No Emission Grant Program	Financial assistance is available to local and state government entities for the purchase or lease of low-emission or zero-emission transit buses, in addition to the acquisition, construction, or lease of supporting facilities. Eligible vehicles must be designated for public transportation use and significantly reduce energy consumption or harmful emissions compared to a comparable standard or low emission vehicle.	Can be used for the procurement of electric vehicles and infrastructure (*Competitive funding)
The U.S. Department of Transportation's Formula Grants for Rural Areas - 5311	This program provides capital, planning, and operating assistance to states and federally recognized Indian tribes to support public transportation in rural areas with populations less than 50,000, where many residents often rely on public transit to reach their destinations. It also provides funding for state and national training and technical assistance through the Rural Transportation Assistance Program.	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities.
The U.S. Department of Transportation's Grants for Buses	This grant makes federal resources available to states and direct recipients to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities, including technological	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities. (*Competitive funding)

Policy	Details	Relevance to Agency Transition
and Bus Facilities Competitive Program (49 U.S.C. 5339(b))	changes or innovations to modify low or no emission vehicles or facilities. Funding is provided through formula allocations and competitive grants.	
The U.S. Department of Energy (DOE) Title Battery Recycling and Second-Life Applications Grant Program	DOE will issue grants for research, development, and demonstration of electric vehicle (EV) battery recycling and second use application projects in the United States. Eligible activities will include second-life applications for EV batteries, and technologies and processes for final recycling and disposal of EV batteries.	Could be used to fund the conversion of electric vehicle batteries at end of life as on-site energy storage. (*Competitive funding)
Maine Renewable Energy Development Program	The Renewable Energy Development Program must remove obstacles to and promote development of renewable energy resources, including the development of battery energy storage systems. Programs also available to provide kWh credits for solar and storage systems.	Can be used to offset costs of solar and battery storage systems at the main facility. (*Non-Competitive funding)
Energy Storage System Research, Development, and Deployment Program	The U.S. Department of Energy (DOE) must establish an Energy Storage System Research, Development, and Deployment Program. The initial program focus is to further the research, development, and deployment of short- and long-duration large-scale energy storage systems, including, but not limited to, distributed energy storage technologies and transportation energy storage technologies.	Can be used to fund energy storage systems for the agency. (*Competitive funding)
The U.S. Economic Development Administration's Innovative Workforce Development Grant	The U.S. Economic Development Administration's (EDA) STEM Talent Challenge aims to build science, technology, engineering and mathematics (STEM) talent training systems to strengthen regional innovation economies through projects that use work-based learning models to expand regional STEM-capable workforce capacity and build the workforce of tomorrow. This program offers competitive grants to organizations that create and implement STEM talent development strategies to support opportunities in high-growth potential sectors in the United States.	Can be used to fund EV training programs. (*Competitive funding)
Congestion Mitigation and Air	The U.S. Department of Transportation Federal Highway Administration's CMAQ Program provides funding to state departments	Can be used to fund capital requirements for the transition.

Policy	Details	Relevance to Agency Transition
Quality Improvement (CMAQ) Program	of transportation, local governments, and transit agencies for projects and programs that help meet the requirements of the Clean Air Act by reducing mobile source emissions and regional congestion on transportation networks. Eligible activities for alternative fuel infrastructure and research include battery technologies for vehicles.	(*Competitive funding)
Hazardous Materials Regulations	The U.S. Department of Transportation (DOT) regulates safe handling, transportation, and packaging of hazardous materials, including lithium batteries and cells. DOT may impose fines for violations, including air or ground transportation of lithium batteries that have not been tested or protected against short circuit; offering lithium or lead-acid batteries in unauthorized or misclassified packages; or failing to prepare batteries to prevent damage in transit. Lithium-metal cells and batteries are forbidden for transport aboard passenger-carrying aircraft.	Should be cited as a requirement in procurement specifications.
Maine Clean Energy and Sustainability Accelerator	Efficiency Maine administers the Maine Clean Energy and Sustainability Accelerator to provide loans for qualified alternative fuel vehicle (AFV) projects, including the purchase of plug-in electric vehicles, fuel cell electric vehicles, zero emission vehicles (ZEVs), and associated vehicle charging and fueling infrastructure.	Can be used to fund vehicle and infrastructure procurements. (*Competitive funding)
Maine DOT VW Environmental Mitigation Trust	The Maine Department of Transportation (Maine DOT) is accepting applications for funding of heavy-duty on-road new diesel or alternative fuel repowers and replacements, as well as off-road all-electric repowers and replacements. Both government and non-government entities are eligible for funding.	Can be used to fund vehicle procurements (*Competitive funding)
Efficiency Maine Electric Vehicle Initiatives	Efficiency Maine offers a rebate of $350 to government and non-profit entities for the purchase of Level 2 EVSE. Applicants are awarded one rebate per port and may receive a maximum of two rebates. EVSE along specific roads and at locations that will likely experience frequent use will be prioritized.	Can be used to subsidize charger purchases. (*Formula funding)
Efficiency Maine Electric Vehicle Accelerator	Efficiency Maine's Electric Vehicle Accelerator provides rebates to Maine residents, businesses, government entities, and tribal governments for the purchase or lease of a new PEV or plug-in hybrid electric vehicle (PHEV) at participating Maine dealerships.	Can be used to subsidize vehicle procurements. (*Formula funding)

14. Cost Considerations

Fleet electrification has significant financial impacts for the transit agency. Substantial capital cost increases are expected for both vehicles and infrastructure, compared to what is required for the agency's existing operations with fossil fuel vehicles. On the other hand, some savings on recurring expenses are likely, because electric vehicles require less maintenance and have cheaper energy costs.

Section Summary

- Bus electrification is expected to significantly increase capital cost
- However, reduced ARTS recurring expenses are expected, as electric vehicles cost less to maintain and fuel

The upfront purchase cost of battery electric vehicles is much higher than for fossil fuel ones. For battery-electrics, this is largely due to the high cost of the propulsion batteries. Although the cost of batteries is declining each year it is still very high, particularly for heavy-duty transit vehicles. Because transit agencies prefer high-capacity batteries to extend vehicle range, the additional price of the batteries overshadows the cost savings from eliminating the engine and associated components on a diesel or gasoline vehicle.

Electrifying a transit fleet often requires major infrastructure investment as well, to ensure that three separate items – the chargers themselves, the facility, and the utility connection – are suited for electric vehicles. Chargers are, of course, a prerequisite to EV operation; they must be purchased, installed, and commissioned. Particularly for heavy-duty applications like transit service, the required chargers are often high-powered and expensive. The facility itself must also be adapted for EV charging, as ARTS is planning to do. In some cases, for modern facilities designed with spare electrical capacity, this will only require installation of additional conduit to connect to the electrical panel. For other, older facilities with outdated electrical and fire detection systems this could involve a multimillion-dollar upgrade before the first charger can be installed. Finally, the facility's utility connection often requires upgrades as well, as detailed in Section 10. Although bus depots are industrial facilities, their existing electrical systems are usually unsuited for the heavy power demands of EV charging. Although the cost of utility and facility upgrades varies on a case-by-case basis, the price of chargers themselves is relatively consistent and is presented below.

These upfront capital costs are expected to be balanced out by recurring savings on operations and maintenance cost. For operations, EVs are cheaper to recharge than fossil fuel vehicles are to refuel. This is especially true if a charge management system is used to avoid electricity demand charges. In addition to operations spending, maintenance costs are expected to decline as well. EVs have many fewer drivetrain parts, especially moving parts, than fossil fuel vehicles. Therefore, components will wear out less often, meaning that less time has to be spent maintaining them and spare parts can be bought less frequently.

Table 7 lists the operating and capital costs assumed for this study. These are based on general industry trends and have been escalated to 2024 dollars where necessary.

Table 7 Cost Assumptions

Asset	Estimated Cost Per Unit (2024 $'s)
Gasoline Transit van	$50,000
Electric Transit van	$180,000
Gasoline Cutaway	$80,000
Electric Cutaway	$280,000
Diesel School Bus	$150,000
Electric School Bus	$350,000

Expense	Estimated Cost (2024 $'s)
Gasoline/Diesel Vehicle maintenance	$0.97 / mile
Electric Vehicle maintenance	$0.73 / mile

The financial analysis outlined below makes the following assumptions:

Capital Investment

+ The lifespan of a vehicle is 7 years, in accordance with the average active lifetime of ARTS vehicles
+ All demand-response vehicles are replaced with vans at their expected retirement year
+ ARTS will fund a capital reconstruction of its maintenance facility using separate funding. This estimate does not account for that cost, as this project has several goals unrelated to electrification

Funding

+ Federal grants cover 80% of the procurement cost for vehicles (of all types) as well as charging infrastructure

Costs

+ The proposed DCFC utility rate is implemented
+ Discount rate (hurdle rate) of 7%
+ Inflation rate of 3%

Because the electrification transition process will be gradual, life cycle cost calculations would necessarily overlap multiple vehicle procurement periods. Hatch addressed this issue by setting the start of the analysis period to be the year when the full recommended electric fleet size is reached (2030), with the analysis period stretching for a full 7-year vehicle lifespan. For vehicles at midlife at the end of the analysis period, a remaining value was calculated and applied at the end of the time window.

The LCC analysis determines the relative cost difference between the baseline (fossil fuel) case and the proposed case. Therefore, it only includes costs which are expected to be different between the two options. Costs common to both alternatives, such as building maintenance, are not included as they do not have a net effect on the LCC comparison. Thus, the model indicates the most economical option but does not represent the full or true cost for either technology.

Table 8 and Figure 14 Total Cost of Ownership for Gasoline Baseline and Partially Electrified Future Fleet ScenariosFigure 14 summarize the NPV for both technologies by cost category.

Table 8 Net Present Values for Gasoline Baseline and Partially Electrified Future Fleet Scenarios

Category	Gasoline Baseline	Future Fleet	Cost Differential (Future Fleet vs. Baseline)
Vehicle Capital Costs	$385,436	$797,055	+119%
Infrastructure Capital Costs	$0	$46,206	
Vehicle Maintenance Costs	$2,753,530	$2,455,851	-7%
Infrastructure Maintenance Costs	$0	$86,216	
Operational Cost	$6,276,791	$5,819,889	
Total Life Cycle Cost	$9,415,757	$9,205,216	-2%

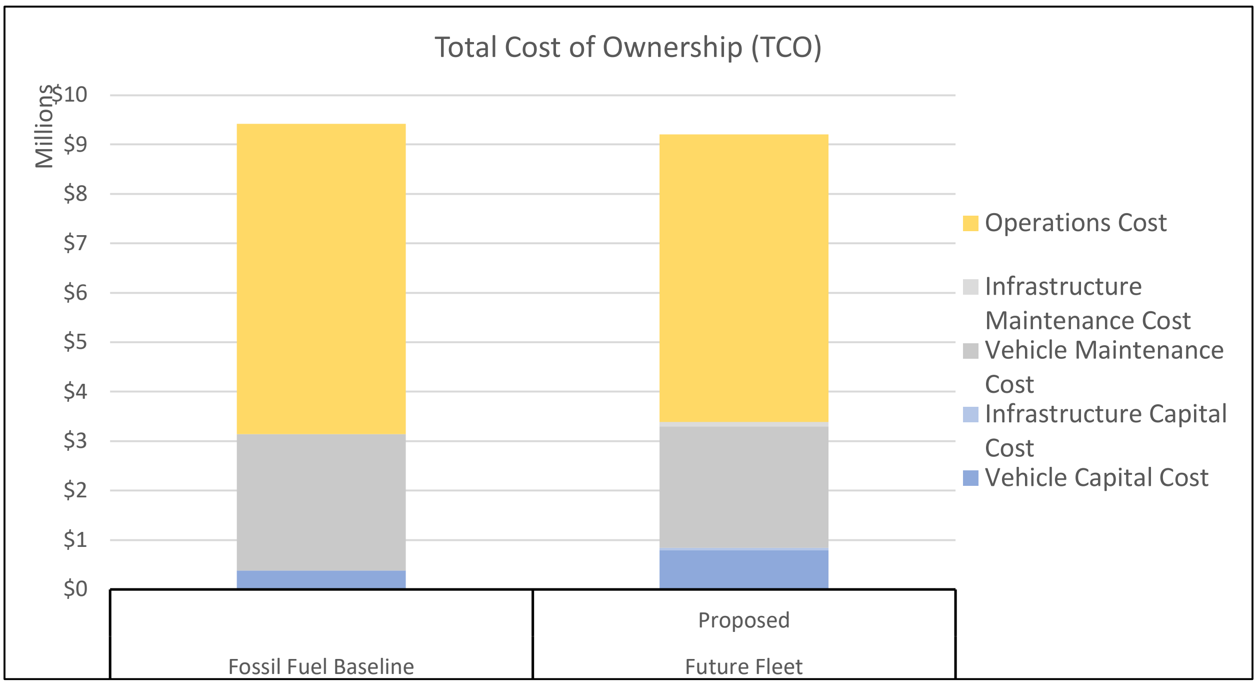

Figure 14 Total Cost of Ownership for Gasoline Baseline and Partially Electrified Future Fleet Scenarios

As shown in Figure 14, vehicle electrification reduces total system cost at the expense of increasing initial capital cost. Although there is some expense related to the charging equipment at the 24 Houlton Road and Houlton Fire Department facilities, the bulk of the extra capital spending is on the vehicles themselves. While electric vehicles are much simpler mechanically they command a cost premium due to their large battery systems. These factors yield a 119% increase in capital costs over the fossil fuel baseline. This initial, non-recurring cost is balanced out by the maintenance and operating savings over the lifetime of the vehicles. Because electric vehicles have fewer components to maintain and are cheaper to refuel than gasoline, the maintenance and operating costs of the proposed fleet are 7% lower than of the gasoline baseline. However, these costs recur daily – worn parts must be replaced and empty fuel tanks must be refilled throughout the lifetime of the vehicle. This means that over the long term the operations and maintenance savings outweigh the initial extra capital spending, yielding a net-present-value savings of approximately 2%.

The proposed fleet transition requires initial capital spending to reduce recurring cost and achieve other strategic goals. This need is common to many transit projects and is representative of the transit industry as a whole, with nearly all bus and rail systems requiring capital investments upfront to save money in other areas (traffic congestion, air pollution, etc.) and achieve broader societal benefits over the long term. By extension, just as with the transit industry at large, policy and financial commitment will be required from government leaders to achieve the desired benefits. The federal government's contribution to these goals via FTA and Low-No grants is already accounted for, leaving state and local leaders to cover the remaining increase in upfront capital cost.

The electric vehicle market is a fairly new and developing space, with rapid advancements in technology. Although this report used the best information available to date to analyze the alternatives and recommend a path forward, it will be important in the coming years for ARTS to review the assumptions underlying this report to ensure that they have not changed significantly. Major changes in capital costs, fuel costs, labor costs, routes, schedules, or other operating practices may make it prudent for ARTS to change the speed of its electrification transition or change the desired end-state altogether.

15. Emissions Impacts

One of the motivations behind ARTS's transition towards battery electric vehicles is the State of Maine's goals to reduce emissions. While specific targets for public transportation have not been established, the state goal to achieve a 45% overall emissions reduction by 2030 was considered as a target by ARTS.

The analysis below calculated the anticipated emissions reductions from ARTS's transition plan to quantify the plan's contribution toward meeting the state's emissions reduction goals. To provide a complete view of the reduction in emissions offered by the transition plan, the effects were analyzed based on three criteria:

- Tank-to-wheel
- Well-to-tank
- Grid

Section Summary

- Vehicle electrification will be critical to helping meet State emission goals
- Forecasted grid conversion to clean energy will maximize the benefit of vehicle electrification
- The transition is expected to reduce emissions by 32-39%

The tank-to-wheel emissions impact considers the emissions reduction in the communities where the vehicles are operated. As a tank-to-wheel baseline, the 'tailpipe' emissions associated with ARTS's existing fossil fuel fleet were calculated using available agency and industry data for fuel economy.

Well-to-tank emissions are those associated with energy production. For fossil fuel vehicles, well-to-tank emissions are due to fuel production, processing, and delivery. This emissions estimate used industry averages for the well-to-wheel emissions associated with the delivery of gasoline or diesel fuel to the gas stations that ARTS uses.

Battery electric vehicles have a third emissions source: grid electricity generation. The local utility, Versant, was not able to provide specific details on the emissions associated with its electricity production as part of this project. Therefore, the emissions calculations assumed an EPA and EIA average grid mix for Maine. Similar to the state's overall goals to reduce emissions, the state has also set the goal of reducing grid emissions by roughly 67% by 2030 by transitioning to more renewable energy production. To account for these future grid emissions reduction goals, calculations were completed based on the most recent actual data available (2020), as well as projections that assume that the 2030 targets are met. Table 9 and Figure 15 summarize the results of the emissions calculations. These results demonstrate that the transition plan will achieve 32% emissions reduction assuming the grid mix that existed in 2020, or 39% emissions reduction assuming that Versant is able to meet the state's goals to reduce grid emissions by the year 2030. In either case, ARTS's transition plan will help reduce emissions but will not meet the 45% goal established by the State of Maine.

Table 9 CO_2 Emissions Estimate Results

Scenario	Well-to-Tank (kg)	Tank-to-Wheel (kg)	Grid (kg)	Total (kg)	Reduction over Baseline
Gasoline Baseline	355,431	650,668	-----	1,006,100	----------
Future Fleet (2020 grid mix)	206,088	378,276	97,006	681,369	32%
Future Fleet (2030 grid mix)	206,088	378,276	32,012	616,376	39%

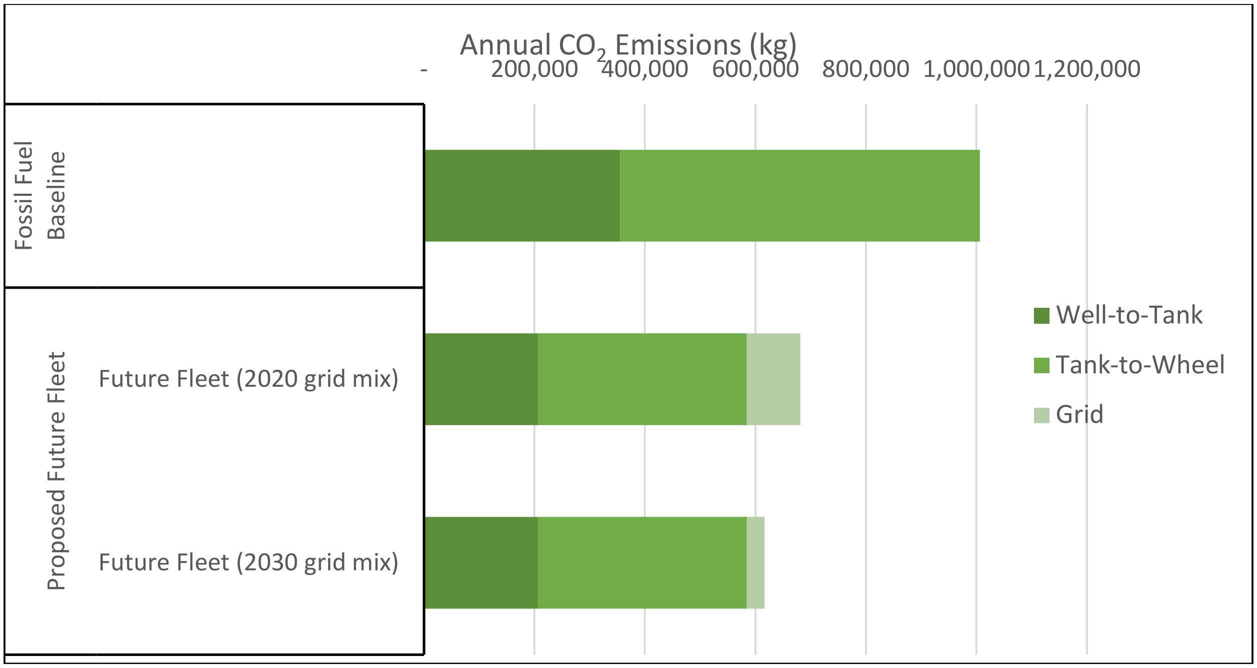

Figure 15 Graph of CO_2 Emissions Estimate Results

Should ARTS seek to achieve greater emissions reductions than those calculated here, the agency may consider the following options:

- Purchase green energy agreements through energy retailers to reduce or eliminate the emissions associated with grid production
- Assuming the initial pilot is successful, purchase additional electric vehicles
- Explore installation of additional chargers, or partnerships to use existing public chargers, at locations like Fort Kent that are currently served by difficult-to-electrify routes

16. Workforce Assessment

ARTS staff currently operate a revenue fleet composed entirely of gasoline vehicles. As a result, the staff have skill gaps related to battery electric vehicle and charging infrastructure technologies that will be operated in the future. To ensure that both existing and future staff members can operate ARTS's future system a workforce assessment was conducted. Table 10 details skills gaps for the workforce groups within the agency and outlines training requirements to properly prepare the staff for future operations.

Section Summary

- Staff and stakeholder training will be critical to ARTS success
- Hatch recommends partnering with local colleges and other transit agencies to share skills

Table 10 Workforce Skill Gaps and Required Training

Workforce Group	Skill Gaps and Required Training
Maintenance Staff	High voltage systems, vehicle diagnostics, electric propulsion, charging systems, and battery systems
Electricians	Charging system functionality and maintenance
Agency Safety/Training Officer/First Responders	High Voltage operations and safety, fire safety
Operators	Electric vehicle operating procedures, charging system usage
General Agency Staff and Management	Understanding of vehicle and charging system technology, electric vehicle operating practices

To address these training requirements Hatch recommends that ARTS consider the following training strategies:

- Add requirements to vehicle and infrastructure specifications to require contractors to deliver training programs to meet identified skill gaps as part of capital projects.
- Coordinate with other peer transit agencies, especially within the state of Maine, to transfer 'lessons learned'. Send staff to transit agency properties that have already deployed battery electric vehicles to learn about the technology.
- Coordinate with local vocational and community colleges to learn about education programs applicable to battery electric technologies, similar to the one Southern Maine Community College recently introduced.

17. Alternative Transition Scenarios

As part of this study, ARTS was presented with alternative fleet and infrastructure transition scenarios that would also satisfy the agency's operational requirements. These alternatives considered different scales of electrification, vehicle choices, and charging locations. Through discussions, however, the agency currently favors the transition plan presented in this report. Should ARTS's plans or circumstances change in the future, it is possible that one of the alternative transition plans discussed in earlier stakeholder meetings may become more advantageous. Hatch recommends that the agency review this transition plan on an annual basis to reevaluate the assumptions and decisions made at the time this report was authored.

Section Summary

- Hatch recommends reviewing this report annually for comparison with technology development and ARTS operations

18. Recommendations and Next Steps

The transit industry is currently at the beginning stages of a wholesale transition. As electric vehicle technology matures, climate concerns become more pressing, and fossil fuels increase in cost, many transit agencies will transition their fleets away from gasoline- and diesel-powered vehicles in favor of battery-electric. By facilitating this study ARTS has taken the first step toward fleet electrification, and the agency stands well-positioned to continue this process in the coming years. In partnership with Maine DOT, other transit agencies in Maine, as well as other key stakeholders, ARTS will be able to reduce emissions, noise, operating cost, and other negative factors associated with gasoline operations, while helping the state comply with the Clean Transportation Roadmap and operating sustainably for years to come.

For ARTS to achieve sustainable and economical fleet electrification, Hatch recommends the following steps:

- Proceed with transitioning the agency's vehicles and infrastructure in the manner described in this report.
- For the vehicles:
    - Consider ordering vehicles as part of larger orders or partnering with other agencies, school transportation providers, or MaineDOT to form large joint procurements.
    - Develop specifications for battery electric vehicles.
    - Consider a broad range of vehicles during procurements, ensuring maximum competitiveness in procurements.
    - Operate the demand-response vehicles on as wide a variety of cycles as possible to gain maximum knowledge of their advantages and limitations.
    - Retain gasoline vehicles for at least two years after they are retired to ensure they can substitute for electric vehicles if incidents or weather require it.
- For the infrastructure at 24 Houlton Road and at the Houlton Fire Department:
    - Upgrade the electrical utilities to support charging infrastructure if necessary.
    - Conduct a fire safety analysis in accordance with Section 12b and standards UL9540, NFPA 70 and 230.
    - Develop specifications for chargers and other required infrastructure.
    - Develop contingency plans for alternate charging locations to use in case of a charger malfunction.
    - Consider energy storage and solar panel installation.
- For other components of the transition:
    - Plan for staff training programs, as described in Section 16.
    - Coordinate transition efforts with peer transit agencies, Versant, and Maine DOT.
    - Continually monitor utility structures and peak charge rates and adjust charging schedules accordingly.
    - Review this transition plan annually to update based on current assumptions, plans, and conditions.