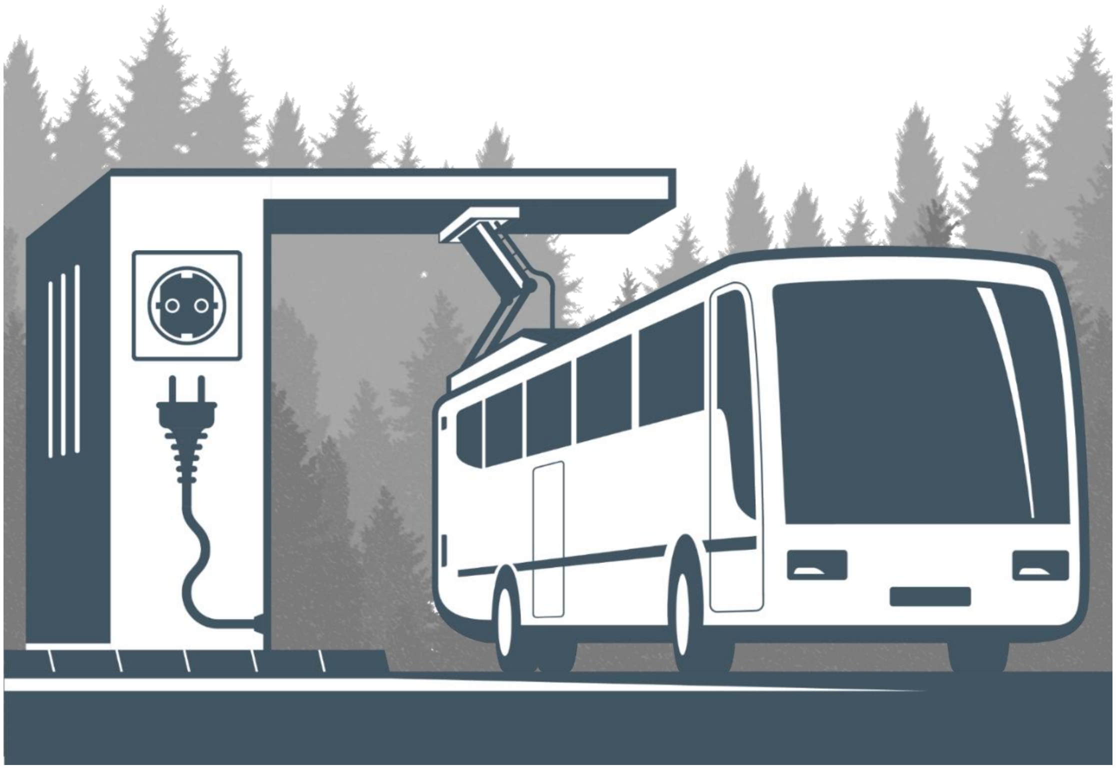

Vehicle Electrification Transition Plan for Regional Transportation Program (RTP)

Prepared by:

HATCH

Version: 1.1

2/10/2023

Table of Contents

1. Executive Summary

Regional Transportation Program (RTP), the paratransit agency serving Cumberland County, Maine, is currently considering transitioning its bus fleet to battery electric and hybrid drivetrain technologies. 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, RTP 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 26 vehicles, replacing four demand-response vehicles with electric vans and the remainder of the fleet with hybrid vehicles. To support the battery electric vans, the agency also plans to procure, install, and commission four level 2 charging stations at the main storage facility in Westbrook, Maine, that will have the capacity to support overnight charging of the electric fleet.

One of the primary motivations behind RTP's transition to hybrid and battery electric drivetrain technologies is to achieve emissions reductions compared to their existing gasoline operations. As part of this analysis, an emissions projection was generated for the proposed future hybrid and battery electric fleet. The results of this emissions projection estimate that the new fleet will provide up to an 29% reduction in emissions compared to RTP's existing gasoline operations.

A life cycle cost estimate was also developed as part of the analysis to assess the financial implications of the transition. The cost estimate includes the capital costs to procure the new vehicles, charging systems, and supporting infrastructure, as well as the operational and maintenance expenditures. The costing analysis indicates that RTP can anticipate 82% increase in capital expenditures due to the transition. It is estimated, however, that there will be a 2% annual reduction in operational and maintenance costs due to the improved reliability and efficiency of battery electric and hybrid drivetrain technologies. In summation, the cost estimate predicts that RTP will see roughly 1% life cycle cost savings by transitioning to hybrids and electric vehicles.

The conclusion of the analysis is that although battery electric vehicles are not yet ready for complete replacement of RTP's fleet, the agency would benefit from beginning the transition with a small pilot, accompanied by a shift to hybrid technology for the remaining vehicles. These vehicles offer the potential for the agency to greatly reduce emissions, slightly reduce operating costs, and gain the required skillsets and operating experience for future electrification once the technology advances further. Therefore, RTP 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 Governor's Roadmap and the FTA requirements, the Regional Transportation Program (RTP), in association with the Maine Department of Transportation (Maine DOT) and its consultant Hatch, have developed this fleet transition plan. In addition to the FTA requirements, this transition plan also addresses details on RTP's future route plans, vehicle technology options, building electrical capacity, emissions impacts, resiliency, and financial implications.

3. Existing Conditions

RTP is a transit agency providing demand-response paratransit service throughout Cumberland County, Maine, in addition to operating one fixed route service. The agency currently owns and operates a fleet of twenty-six passenger vehicles, all of which are gasoline powered. RTP also runs a volunteer-driver program, where drivers use their personal vehicles to fulfill trips and are reimbursed on a per-mile basis; as this is not operated with

Section Summary

- RTP operates one scheduled route and an on-demand paratransit service with a twenty-six-vehicle fleet and volunteer drivers' vehicles
- On-demand vehicles operate for up to eight hours a day on widely varying routes due to unpredictable user demand.

RTP assets it is not considered in this report. There are currently fewer than ten volunteers, but previously there were as many as one hundred volunteer drivers.

Table 1 Current Vehicle Roster

Vehicle Type/Roster Number	Fuel Efficiency (MPG)	Number of Vehicles	Procurement Date/Age	Projected Retirement Date
Non-ADA minivan (90)	19	1	2007	2024
Low floor wheelchair ramp minibus (104, 106)	12.3	2	2010	2023
Wheelchair lift minibus (123)	7.6	1	2013	2023
Wheelchair lift minibus (124)	7.6	1	2014	2023
Wheelchair lift minibus (128)	7.6	1	2011	2025
Wheelchair lift minibus (129, 130, 133)	7.6	3	2010	2024
Wheelchair lift minibus (134-142)	14.5	9	2019	2026
Wheelchair lift bus (143)	9.5	1	2019	2025
Wheelchair lift bus (144)	9.5	1	2019	2027
Wheelchair lift minibus (145-149)	7.6	5	2019	2027
Wheelchair lift minibus (150)	7.6	1	2014	2025

RTP has one scheduled fixed route which typically operates four round trips daily (though it currently only runs three). Each round trip is around three hours long. The route is shown in Figure 1 below. All other RTP services are on-demand paratransit.

Lakes Region Explorer

- Service along Route 302 between Bridgton and Portland.
- Operates every Monday to Friday between 6:00 AM to 7:00 PM, typically four round trips per day.
- Seasonal Saturday service between Memorial Day and Labor Day, 10:00 AM to 6:00 PM.
- Overnight layovers occur at the American Legion in Naples.

On-Demand Paratransit Services

- Based on rider pick-up and drop-off locations, serving all of Cumberland County.
- Service available 5:00 AM to 9:00 PM.
- Trip Master software is used to minimize downtown and optimize route efficiency.
- Volunteer drivers operating their personally owned vehicles are used in remote areas.
- Vehicles are occasionally parked overnight at drivers' homes to decrease deadhead driving.
- Vehicles generally operate for up to eight hours daily, then return to the depot. Vehicles generally operate 80-100 miles per day, though a few operate up to 120 or 150 miles.

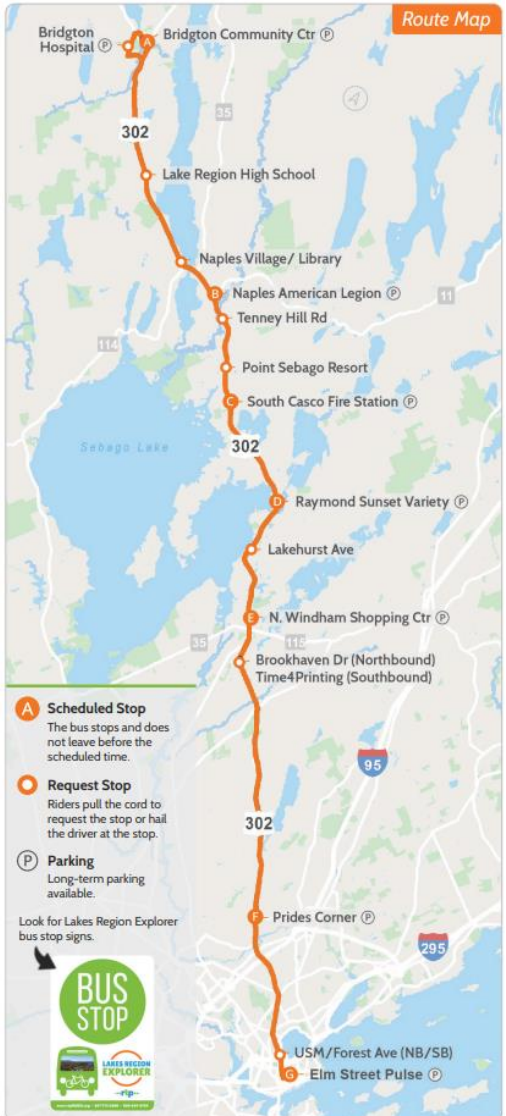

Figure 1 RTP Lakes Region Explorer Route Map

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 RTP lower procurement cost

As discussed in Section 3, RTP's revenue service fleet is composed primarily of wheelchair lift minibuses and vans. For future procurements, RTP is planning to shift its demand-response fleet entirely to vans, which are easier to maneuver in narrow streets and driveways. The Lakes Region Explorer vehicles are expected to remain cutaway shuttles as they are today. Both categories of electric vehicles may have limitations that the gasoline versions do not have. For example, because of the weight of the battery, Lightning eMotors'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 (shown in 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 RTP. In general, though, Hatch recommends that RTP consider a broad range of vehicles in its future procurements, enabling maximum competition and potentially lowering cost.

Figure 2 Lightning eMotors Electric Cutaway Vehicle

A summary of hybrid and battery electric vehicle models that are commercially available (provided in Appendix A) demonstrates that there is a variety of possible vehicles for RTP to utilize. Hybrids are generally equivalent in range to gasoline vehicles, so no detailed modeling is required. 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 128 kWh battery capacity and vans to have a 120 kWh battery capacity, which are representative values for the range of batteries offered by the industry. Two types of safety margins were also 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 (82 kWh for the cutaways and 77 kWh for the vans). Finally, as the industry is advancing quickly and technology continues to improve, a 3% yearly improvement in battery capacity was assumed.

5. Infrastructure Technology Options

There are two primary types of chargers that are applicable to RTP'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.

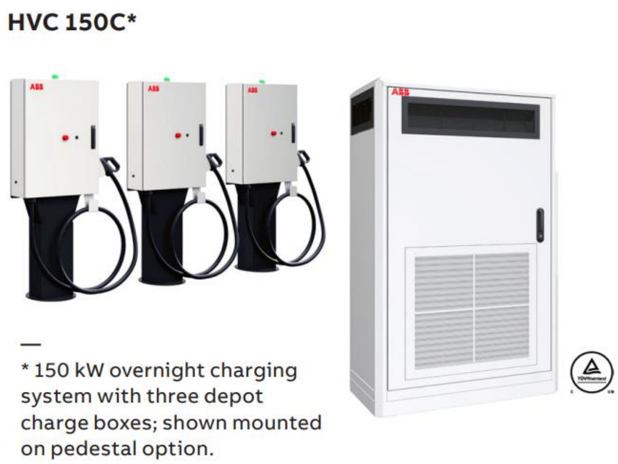

Figure 4 Example Charging Systems (Source: ABB): Charging Cabinet (System) and Three Dispensers (Charge Boxes)

For RTP's operations, Hatch recommends installing 19.2 kW level 2 chargers at the vehicle storage facility. 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.

If RTP decides to convert the Lakes Region Explorer route to electric, RTP will need to install a single de-centralized plug-in style DCFC charger at one end of the route. This will allow charging during both overnight layovers (which could also be accommodated by a 19.2 kW level 2 charger if needed) and midday periods (which are short enough that a DCFC charger's high power would be required). This would likely be most feasible at Bridgton Community Center but could also be installed in downtown Portland (or potentially shared with another agency) if the Lakes Region Explorer schedule is modified accordingly. As with the vehicles, charging infrastructure is available in numerous configurations; Appendix A shows commercially available charging system options and configurations.

6. Route Planning and Operations

RTP's current operating model is similar to that of many transit agencies across the country. Each vehicle leaves the garage at the appropriate time in the morning, operates nearly continuously for as long as necessary, and then returns to the depot / overnight parking location. Although RTP's

Section Summary

- Electric vehicles do not offer comparable operating range to gasoline vehicles – so detailed operations modeling is needed
- Electric cutaways cannot cover RTP's Lakes Region Explorer route without layover charging.
- Shorter on-demand service runs can be electrified with available electric vans

schedulers must account for driver-related constraints such as maximum shift lengths and breaks, the vehicles are assumed to 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, on the Lakes Region Explorer and many of the demand-response vehicle runs, particularly if recommended practices like pre-conditioning the vehicle before leaving the garage are not always followed.

RTP's paratransit service operates between 5:00 AM and 9:00 PM on an on-demand basis, though each individual vehicle operates for only eight hours per day. Trip Master software is used to minimize downtime and optimize route efficiency. 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 top-up charging. Another potential issue is that in some cases, RTP 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 and is best avoided, at least in the short term.

6a. Operational Simulation

To assess how battery electric vehicles' range limitations may affect RTP'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 gradients, road congestion, stop frequency, driver performance, severe weather, and other factors specific to RTP's operations. As mentioned above, it was not necessary to simulate hybrid operations because the vehicles offer comparable range to gasoline vehicles.

Hatch conducted a route-specific electric vehicle analysis by generating a drive cycle for the Lakes Region Explorer route, as well as for a route representative of demand-response operation. 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. These RTP-specific drive cycles were used to calculate the energy consumption per mile and therefore total energy consumed by a Lakes Region Explorer or demand-response vehicle.

As discussed in the previous section, the resultant runs were evaluated against a common electric cutaway with a 128-kWh battery and a van with a 120 kWh battery. As technology advances, Hatch assumed that these battery capacities will increase at a rate of 3% per year, allowing for additional range. Combined with the safety margins discussed in Section 4, this yielded usable battery energy of 95 kWh for electric cutaways by 2027, which is approximately when the existing cutaway fleet is due for replacement. 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 RTP operations. Figures for the Lakes Region Explorer are presented on a per-trip and full-day basis, showing the severe demands the route's length places on the vehicles. Two representative on-demand run lengths are shown, illustrating the operational variability inherent in an on-demand service. Green shading denotes those runs that can be operated by the specified vehicle and red shading denotes those that cannot.

Table 2 Energy Requirements by Run

Block	Mileage	kWh Required	Mileage Shortage/Excess
Lakes Region Explorer (one round trip)	81	87	7
Lakes Region Explorer (full day)	344	372	-256
On-demand (short)	80	77	1
On-demand (long)	120	115	-39

6b. Operational Alternatives

As shown in Table 2, an electric van is expected to have a usable range of approximately 80 miles in the harshest weather conditions. To avoid impact on RTP operations, the most viable service model replaces the vehicles on shorter runs with electric vans, with all other runs being operated by hybrid vehicles. Trip Master's range-conscious routing feature, under development as of this writing, will help RTP 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 RTP's operations are feasible for electrification and the higher a proportion of the fleet Hatch recommends that RTP make electric.

On the Lakes Region Explorer route, an electric cutaway can reliably operate one round-trip before requiring charging. This allows several operating models, which are described below and presented in additional detail in Appendix B.

One possibility is to recharge the vehicle after each round trip using a fast charger. This would require approximately one hour of charging time to gain sufficient energy to operate another trip. Though this would require revising the schedule, a well-designed timetable could combine vehicle charging time and driver meal break time, maximizing efficiency. As there would not be sufficient time to deadhead to and from the RTP facility for each charging window, this option would require the installation of an RTP-owned fast charger at one of the two terminals, or alternatively an agreement with another party for access to a fast charger during the required times of day and night.

Another possible service pattern is to swap the vehicles at the RTP facility in Westbrook after each round trip, with one vehicle charging while another operates in service. Although this would minimize RTP's dependence on external infrastructure, the resulting increase in fleet size and operator hours make this configuration impractical for RTP.

A third option involves using a transit bus rather than a cutaway vehicle. Because transit buses have more room for batteries on the roof and under the floor, they typically have longer range than cutaway vehicles. In this case, a transit-style bus would likely be able to operate two roundtrips before needing to recharge, allowing charging windows or vehicle swaps to be coordinated with driver shift changes. Adopting a transit bus would also allow RTP to increase capacity on the route, accommodating ridership gains from any service changes the Transit Together project may recommend. However, transit buses are significantly more expensive than cutaways, are less maneuverable on narrow streets, and would require additional training for RTP staff to operate and maintain. Because of these drawbacks, this option is currently not being considered.

A hybrid cutaway vehicle, however, would provide a good balance between the advantages of lower-emission vehicles and the range required for this route. Operations would be able to remain exactly as they are today, since hybrid vehicles have comparable range to gasoline-powered ones. Hatch recommends that RTP tentatively choose this option for the fixed-route vehicles but review this decision at least once before procurement. The state of the electric vehicle market, the performance of RTP's pilot demand-response vehicles, and the feasibility of installing or sharing an enroute fast charger will determine whether electric vehicles are viable for this route or if hybrids are the most practical alternative.

7. Charging Schedule and Utility Rates

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 RTP charge its vehicles economically

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. The operational configuration and fleet composition selected by RTP, and described in the previous section of this report, assumes that vehicles (excluding the Lakes Region Explorer) will be charged only overnight at the main facility and that all the electric vehicles will be brought back to the facility each night.

RTP's current electricity rates are determined by Central Maine Power's 'MGS-S' rate table, as shown in Table 3. Under this rate table RTP pays a flat "customer charge" monthly, regardless of usage. RTP also pays a single distribution charge of $16.64 per kW for their single highest power draw (kW) that occurs during each month. This peak charge is not related to Central Maine Power's grid peak and is local to RTP's usage. Finally, RTP is charged an 'energy delivery charge' of $0.001745 per kWh, and an 'energy cost' of $0.12954 per kWh. These costs are recurring and are dependent on the amount of energy used by RTP throughout the month.

To encourage the adoption of electric vehicles (EV), Maine's Public Utilities Commission (PUC) requested that utilities, including Central Maine Power, propose new rate structures for vehicle charging. In response to this request, Central Maine Power proposed a 'B-DCFC' utility schedule filed under Docket No. 2021-00325. The new proposed rate structure was approved effective July 1st, 2022 and is available as an optional rate for customers with electric vehicle DCFCs or level 2 charger arrays. To qualify for this rate, Central Maine Power requires that the customers like RTP install a new meter and dedicated service for their charging equipment to accurately account for the power draw associated with charging.

Table 3 below outlines the other differences between the existing 'MGS-S' and the new 'B-DCFC' rate structures. The new rate structure would provide RTP with a lower monthly 'distribution charge' but introduces a transmission charge that is calculated based on Central Maine Power's grid peak, termed the 'coincidental peak'. The agency can avoid this transmission service charge, that is calculated on a monthly basis, by not charging vehicles during periods when Central Maine Power's grid load is peaking. The historic data indicates that the daily system peak for Central Maine Power happens between 3 PM and 7 PM. Therefore, it is advisable for RTP to develop a charging plan which avoids charging vehicles during these hours.

Table 3 Utility Rates Structure Comparison

	Current MGS-S Rates	B-DCFC Rates
Customer Charge	$50.01 per month	$50.01 per month
Distribution Charge	$16.64 per non-coincidental peak kW (calculated monthly)	$4.39 per non-coincidental peak kW (calculated monthly)
Transmission Charge	$0.00 per non-coincidental peak kW (calculated monthly)	$19.35 per coincidental peak kW (calculated monthly)
Energy Delivery Charge	$0.001745 per kWh	$0.001745 per kWh
Energy Cost	$0.12954 per kWh	$0.12954 per kWh

Accordingly, a charging schedule was optimized around the operational plan developed in the previous section of the report and the above listed utility schedules. The results of this optimization are shown in Figure 5. It can be seen in the figure that the optimized charging schedule assumes that vans will be charged overnight (between 9 PM and 5 AM), outside of the times when RTP's vans are in-service, using the plug-in chargers. This will avoid charging during the Central Maine Power grid's 'coincidental peak' (between 3 PM and 7 PM), and allow RTP to avoid a monthly 'transmission charge', should the agency decide to adopt the Central Maine Power's special optional 'B-DCFC' rate schedule for its charging operation.

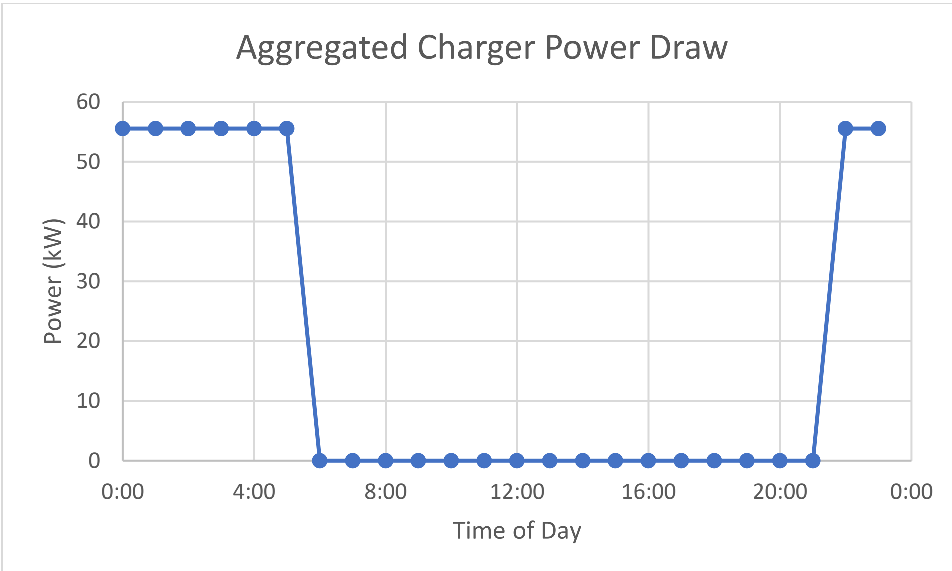

Figure 5 Proposed Charging Schedule for RTP's Future Fleet

Below is an estimate of expected operational costs associated with the proposed charging schedule, based on both the existing 'MGS-S" and the new optional 'B-DCFC' rates.

Daily kWh consumption = 444 kWh
Monthly Non-coincidental peak = 56 kW
Monthly coincidental peak = 0 kW

Under Current MGS-S Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 444\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$58.29$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non - coincidental\ Peak\ \times Transmission\ Charge)$$
$$= 56\ kW\ \times \$16.64$$
$$= \$931.84$$

Under New B-DCFC Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 444\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$58.29$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (56\ kW\ \times \$4.39) + (0\ kW \times \$19.35)$$
$$= \$245.84$$

As this estimate shows, the optional ‘B-DCFC’ rate structure would save RTP $686 per month. These savings are, again, achieved by avoiding charging during the coincidental peak between 3 PM and 7 PM, and the reduced monthly ‘distribution’ charges under the “B-DCFC” rate structure. If the charging schedule were adjusted to charge during the coincidental peak, it could lead to an increase of up to $1,083.60 per month from a ‘transmission charge’. As the number of electric vehicles increases in RTP’s fleet, the saving from the B-DCFC rate structure will also increase proportionally. Therefore, it is critical that RTP only charges the vehicles outside the coincidental peak window between 3 PM and 7 PM or procures a smart charging management system which is programmed to avoid charging during the coincidental peak. Furthermore, it is also important that RTP monitors changes in Central Maine Power’s coincidental peak window and adjusts its charging schedule accordingly.

It should also be noted that the above charges are calculated based on a typical weekday load. Weekend and holiday calculation would follow a similar calculation for daily charges. The typical weekday and weekend/holiday charges are combined with monthly charges to calculate the annual utility cost for RTP’s operation.

8. Asset Selection, Fleet Management and Transition Timeline

Section Summary

- Hatch recommends procuring four electric vans to enter service in 2024, with the remainder of the fleet being hybrid
- Hatch recommends installing level 2 chargers at the 1 Ledgeview Drive vehicle storage building

With operational and charging plans established, it was then possible to develop procurement timelines for infrastructure and vehicles to support those plans. RTP, 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. RTP 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, RTP currently operates a mix of cutaways and vans. The larger cutaways serve the Lakes Region Explorer route, while the vans and smaller cutaways are used to service on-demand paratransit operations. For the Lakes Region Explorer route, the demanding duty cycle means that – in the context of electric vehicles – continuing cutaway operation may pose a constraint on operations and vehicle purchasing flexibility. Most manufacturers of cutaway vehicles do not offer electric versions, and the vendors that do often have range, passenger capacity, or vehicle availability limitations. For example, Lightning eMotors offers a Class 4 (Ford E-450) vehicle but has paused development on its Class 5 (Ford F-550) vehicle. Although alternatives like 30' transit buses are more expensive and require bespoke maintenance skills, keeping a wide range of options open will help RTP procure vehicles as efficiently as possible. For the demand-response service, RTP has plans to shift to an all-van fleet. This is a rapidly changing market, with new entrants annually; RTP is similarly encouraged to monitor the market and keep procurement specifications performance-based to ensure maximum competition during procurement. To maintain a fair comparison, however, this analysis assumes that the existing fleet will be replaced approximately as expected by RTP, with new cutaway vehicles for the Lakes Region Explorer entering service in 2027 and the demand-response vehicles being replaced with vans as their lifetimes expire.

With respect to infrastructure procurements, the vehicle storage building at 1 Ledgeview Drive will eventually need to have enough chargers to accommodate all of RTP's electric vehicles. 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. Some of the infrastructure like spare duct banks from the maintenance building to the vehicle storage facility is already in place in anticipation of future electrification, which should help reduce the infrastructure capital costs for the selected scenario in this study. However, additional investment might be required in the future when more of RTP's fleet is electrified. A detailed engineering design will be required to develop an accurate estimate of the costs.

As discussed earlier, Hatch recommends installing level 2 chargers at the vehicle storage facility to charge the pilot electric vehicles. This will allow RTP to charge the entire electric fleet at the same time while minimizing the required infrastructure investment. 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. If the pilot is successful and RTP pursues further vehicle electrification, a more detailed planning study would be needed to determine the correct number of chargers, ensuring that some spares are available for resiliency while avoiding over-investment in infrastructure. 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
2023	Four (four Hybrid Transit Vans)		104, 106, 123, 124
2024	Four (four Electric Transit Vans)	Four level 2 chargers + electrical upgrades (transformers, switchgears, etc.)	90, 129, 130, 133
2025	Two (two Hybrid Transit Vans)		128, 150
2026	Nine (nine Hybrid Transit Vans)		134, 135, 136, 137, 138, 139, 140, 141, 142
2027	Seven (two Hybrid Cutaways, five Hybrid Transit Vans)		143, 144, 145, 146, 147, 148, 149

Hatch recommends a robust testing program for the pilot order of electric vans on operating cycles across Cumberland County year-round. This experience will help RTP understand electric van operation across different geography (hilly vs flat), environments (urban vs rural), and weather conditions (winter vs summer) to inform future decisions on fleet electrification. If some downtime in vehicle operation is available, RTP can also consider using local public charging infrastructure; the knowledge gained about charger location and reliability/availability will let RTP 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 RTP operations.

9. Building Spatial Capacity

RTP's main storage and maintenance facility is located at 1 Ledgeview Drive in Westbrook. One building is used for administration, vehicle maintenance, and vehicle wash, while the second building is used for indoor vehicle storage, with space for 35 vehicles. The facility does not have a gas station but does have a generator for back-up power and space for chargers. In addition to the Westbrook facility, RTP has a dedicated space in the American Legion parking lot at 26 Casco Road in

Section Summary

- The existing 1 Ledgeview Drive facility is suitable for installation of level 2 chargers
- If RTP chooses to electrify the Lakes Region Explorer, RTP should consider installing an overnight charger at Bridgton Community Center, or partnering with an organization with public charger infrastructure interests

Naples, which is used as an overnight layover area for the Lakes Region Explorer vehicle. This site is not owned by RTP, and no inspections or maintenance are performed there.

Based on RTP's current facilities and on-demand paratransit operations, the most suitable location for the required chargers is the Westbrook facility. As shown in Figure 6, the facility should have sufficient space to accommodate these needs.

Figure 6 Existing Indoor Vehicle Storage Building Suitable for Chargers

Assuming the initial pilot is successful and RTP considers continued electrification, an additional overnight charger would also be needed to accommodate the Lakes Region Explorer vehicle's operations given that the vehicle does not have an overnight layover in the Westbrook facility. The following two locations were identified as possible options for overnight charging locations:

+ American Legion, 26 Casco Road, Naples
+ Bridgton Community Center, 15 Depot Street, Bridgton

Although installing an overnight charger at RTP's existing parking spot at American Legion is a suitable option, this would require organizational coordination as there is no existing infrastructure there. On the other hand, the Bridgton Community Center has an existing charger. Although it is public and would not meet sufficient power requirements, given that a charger is already available it may be more feasible to coordinate with the Community Center to install the required DC fast charger for overnight and midday charging. If this proves infeasible, RTP can also explore a partnership with a local organization interested in creating public charging infrastructure. These options should be reevaluated in the event of future electrification based on updated assumptions, plans, and conditions.

10. Electrical, Infrastructure, and Utility Capacity

Section Summary

- The existing service at the garage might be sufficient to support the charging infrastructure
- Separately metered service would be necessary to take advantage of optional B-DCFC rate structure, unless submetering is permitted.

Central Maine Power is the utility provider for RTP's primary proposed charging location at 1 Ledgeview Drive. As part of the development of this transition plan, RTP has been partnering with Central Maine Power to communicate its projected future utility requirements at this location.

The 1 Ledgeview Drive facility has a 12.47 kV 3-phase service that is stepped down to 120/208V through a 300 kVA step-down transformer located outdoors, as shown in Figure 7. The facility was built with solar provision and as a result likely has additional capacity to support the 56kW load for overnight charging of the initial four electric vans. Hence, RTP might be able to install the initial four level 2 chargers without requiring substantial upgrades to the facility. 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 the 56kW of spare capacity. If submetering is not permitted, Central Maine Power may require the installation of a separate service to take advantage of the B-DCFC rate.

Figure 7 1 Ledgeview Drive Electrical Distribution Transformer

If RTP decides to electrify further vehicles, it may consider installing DCFC chargers at the 1 Ledgeview Drive facility rather than continuing to add level 2 chargers. The DCFCs typically require 480V 3-phase input voltage which is currently not available at the site (12.7kV is directly stepped down to 208V). Hence, a new 480 V utility service will be required. Hatch has confirmed with Central Maine Power that it can accommodate a new service at the 1 Ledgeview Drive facility if required. Central Maine Power has provided an initial estimate for the new transformers and service feed to be approximately $50,000. In addition, a similar new 480V service and DCFC charger will be required at the Lakes Region Explorer's overnight layover location, as described in Section 9.

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. As society increasingly shifts to electricity for an ever-broader range of needs, from heating to transportation, both the demand and the supply will need to expand and adapt.
+ 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 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.
+ 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. RTP 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 RTP 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. This is most economical when the technician is shared with nearby agencies such as YCCAC.
+ Reach a “mutual aid” agreement with another transit agency in Maine that would let RTP borrow spare buses/vehicles in case of difficulties with its fleet. For example, RTP may arrange to borrow a 35’ bus from Portland Metro if the Lakes Region Explorer vehicles are unavailable on a given day.
+ 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.
+ For the Lakes Region Explorer, if RTP chooses to electrify it, develop contingency plans in case of on-route charger failure. This may include using another charger in the area, swapping vehicles after each round trip, or borrowing a vehicle from another agency.
+ Conduct a fire detection, suppression and mitigation study of RTP locations where chargers and electric vehicles will be housed (see section 12b).

11b. Electrical Resiliency

Electricity supply and energy resilience are important considerations for RTP when transitioning from gasoline 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 RTP 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.

11.b.1. Existing Conditions

The 1 Ledgeview Drive facility currently has a 128 kW generator that might be able to support battery electric vehicle operations should there be an electrical service interruption. However, the existing load of the building needs to be studied to determine the available spare capacity of the generator, which could be done once utility information is available. If additional demand-response vehicles are converted to electric vehicles in the future, the available generator capacity will not be sufficient to support the extra charging load. Additional generation capacity will be required for resiliency in that case.

RTP has at least 5 acres of available land that could be used to install solar panels. This would allow on-site generation of clean energy, which can be used for resiliency as well as to offset the operations cost of charging electric vehicles.

11.b.2. Outage Data and Resiliency Options

Hatch assessed potential resiliency options should the on-site generator not have sufficient capacity to support vehicle charging needs during power outages. Typically, the past five-year power outage data for the utility feed at the facility is analyzed to determine the backup power requirement. Since the 1 Ledgeview Drive facility is very new, the outage data is only available for the last two years. There were only two recorded outages at this location in the last two years

(2021 and 2022). Both the outages were insignificant and only lasted for two minutes and one minute, respectively. Appendix C shows the outage data provided by Central Maine Power for reference.

Resiliency system requirements are typically determined based on the worst outage instance outlined above and the charging needs for the full fleet during this type of outage scenario. Since the outage history is not extensive for this site, Hatch assumed the outage requirement to be the charging requirements for one overnight charging session for the electric vehicles. The on-site energy storage requirement to charge the fleet during that outage period would be 444 kWh. Assuming a 20% safety factor on top of the required energy, the size of the on-site energy storage system would need to be approximately 555 kWh. The power requirement for generator capacity was assumed to be the aggregated power draw required during overnight charging for the fleet for four vehicles, which is 50 kW. Assuming an efficiency of 90%, and a 20% spare capacity, the resulting on-site generation capacity required would be approximately 70 kVA.

Hatch next generated cost estimates associated with the two resiliency system options for the 1 Ledgeview Drive facility. Table 6 summarizes the approximate project cost for implementing each option. Note that as these are conceptual proposals on which no decision has been made, these costs are not included in the life cycle costs in Section 14.

Table 6 Resiliency Options for Overnight Outage Scenario

	Size	Capital Cost
Option 1 On-site Battery Storage	555 kWh	$350,000
Option 2 On-site Diesel Generation	70 kVA	$45,000

The above analysis and corresponding options are based on an assumption. Since outages like this might occur very rarely, the above resiliency options may be oversized for most use cases resulting in a poor return on the capital investment. As the utility industry evolves over the course of RTP's electrification transition, the agency will have to choose an appropriate level of resiliency investment based on historical and anticipated needs.

11.b.3. Solar Power

In addition to the above two options for backup power, on-site solar generation should also be considered to add resiliency, offset energy costs, and further reduce RTP's GHG impact by utilizing clean energy produced on-site. As mentioned previously, however, solar does not reliably provide enough instantaneous power to provide full operational resilience. On-site solar production can provide backup power in some specific scenarios, but a battery storage system is necessary for solar to be considered part of a resiliency system. The function of a solar array would primarily be to offset energy from the grid and reduce utility costs.

An on-site solar system was evaluated for the 1 Ledgeview Drive facility because the additional agency-owned vacant land at the site provides a large surface area that could be utilized for a solar array. Though a more detailed study would be needed to determine the optimal location for the solar array, one possible layout is illustrated in Figure 8 below.

Table 7 outlines parameters for the solar power system that would be required to offset total annual electricity usage by the electric vehicle charging infrastructure, the surface area that is required for the solar panels, and the resulting cost savings from offsetting energy consumed from the grid.

Table 7 1 Ledgeview Drive Solar Field Design Parameters

Solar System Design Parameters	
Solar System Sizing Method:	Full Annual Energy Match
Solar Array Area Width	60 ft
Solar Array Area Length	100 ft
Solar Array Area	5,700 ft^2
Maximum Number of Panels	256 panels
Maximum System Power	109 kW
Annual Production Coefficient	1,291 hours
Sunny Days Per Year	203 days
Annual Solar Energy Production	140,730 kWh
Annual Electric Usage	136,889 kWh
Maximum Percent of Electrical Usage Offset	103%
Electricity Rate	$0.12954 / kwh
System Cost	**$300,000**
Utility Bill Savings Per Year	**$18,230**
Simple Payback Period Without Grants	**16.5 years**
Payback Period with 80% Federal Grants	**3.3 years**

Based on the above parameters, the maximum daily production for sunny days is estimated to be approximately 693 kWh. Since the energy requirement for charging the vehicles overnight during an outage is estimated to be 444 kWh, solar has the potential to provide enough energy to support the operation in the event of an outages on a sunny day.

However, solar power generation is not recommended as a primary resiliency system as power outages are likely to occur due to winter storms during the time of the year when the least amount of solar energy is available due to cloud cover.

An on-site battery storage system could complement solar as it would allow for storing of energy produced during the daytime for use during overnight charging. This would not only result in cost savings from the grid energy offset, but it would also result in savings due to a smaller utility feed requirement and lower non-coincidental peak energy use for the site. In addition, having on-site solar energy production can help further reduce RTP’s GHG contribution by reducing energy consumed from the grid, which is partially produced using GHG emitting conventional energy sources.

If solar is considered for the site, the on-site storage system should be sized according to the full solar production rather than to only support outage scenarios, and potentially for future expansion of the electric fleet. A more detailed study should be conducted to determine the battery energy requirements, which are likely to be more than 555 kWh based on the above solar estimates.

12. Conceptual Infrastructure Design

12a. Conceptual Layouts

Section Summary

- Hatch recommends installing four wall-mounted chargers in vehicle storage building at the 1 Ledgeview Drive facility

To assist RTP with visualizing the required infrastructure transition, conceptual plans were next developed based on the previous information established in this report. As outlined previously, Hatch recommends that the charging infrastructure be placed inside the vehicle storage building.

At the 1 Ledgeview Drive location, the utility service enters the admin building where the electrical room, housing the service panel, is located. The electrical service is carried to the vehicle storage building via a set of conduits installed between the two buildings. There are space conduits installed between the buildings that could be utilized to carry cables for the charging equipment from the admin building electrical room. The availability of these spare conducts needs to be evaluated as part of a detailed engineering study.

There are two primary methods for installing the overnight chargers:

+ Mounted on the wall
+ Suspended from the ceiling

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 RTP selects the wall-mounted alternative to minimize the capital and operational impacts of charger installation. It is recommended that the chargers are installed on the southeast wall of the vehicle storage building as that is where the spare conduits are terminated. Installing the chargers closer to the existing conduit will reduce the civil work required, resulting in reduced capital cost and operations disruption. (If RTP chooses to install additional chargers in the future, placing these along the northwest wall is recommended as this would allow wall-mounting rather than requiring ceiling-hung chargers.) Figure 8 illustrates the suggested layout for the chargers, as well as the suggested solar array discussed previously.

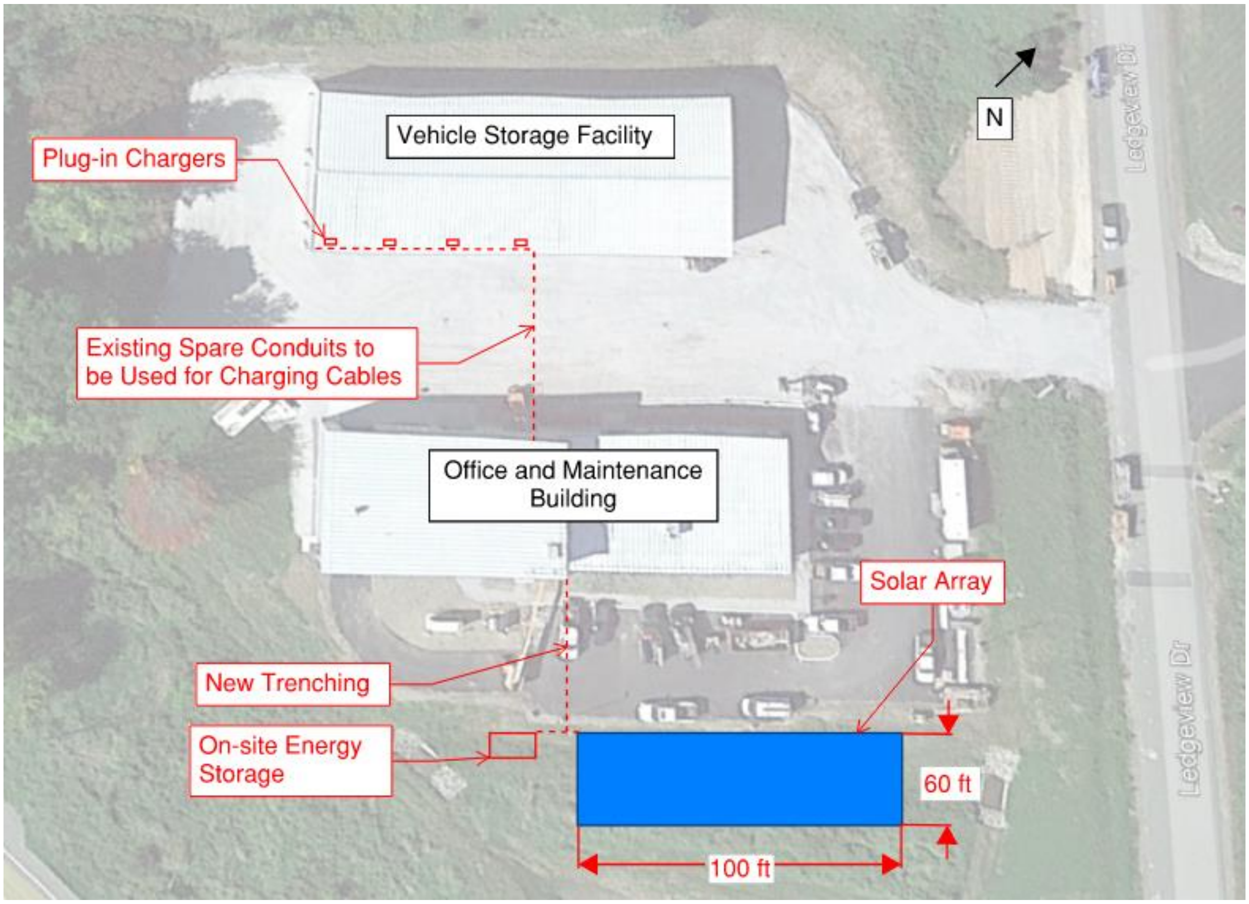

Figure 8 Conceptual Layout

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.

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 RTP's risk is relatively low because of the smaller initial size of the electric fleet size, Hatch still recommends that RTP 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. In terms of staffing, it is recommended that staff be located nearby to respond in case of a fire and move unaffected vehicles out of harm's way. If RTP does not maintain staff at the depot overnight, staff at the nearby Scarborough Engine 5 firehouse may be able to fulfill this function during their response to an incident. Each of the factors mentioned above requires specific consideration with respect to RTP's facility and operations. Hatch recommends that RTP commission a fire safety study as part of detailed design work for the charger installation to consider these factors.

13. Policy Considerations and Resource Analysis

Section Summary

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

RTP's current operating budget is roughly $2.5 million per year. The agency's funding sources are summarized in Figure 9. As can be seen in the figure, RTP's largest source of funding comes from federal assistance. For vehicle, facility, and infrastructure costs the agency's primary federal funding comes from the Urbanized Area Formula Funding program (49 U.S.C. 5307), and the Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b)) through the FTA.

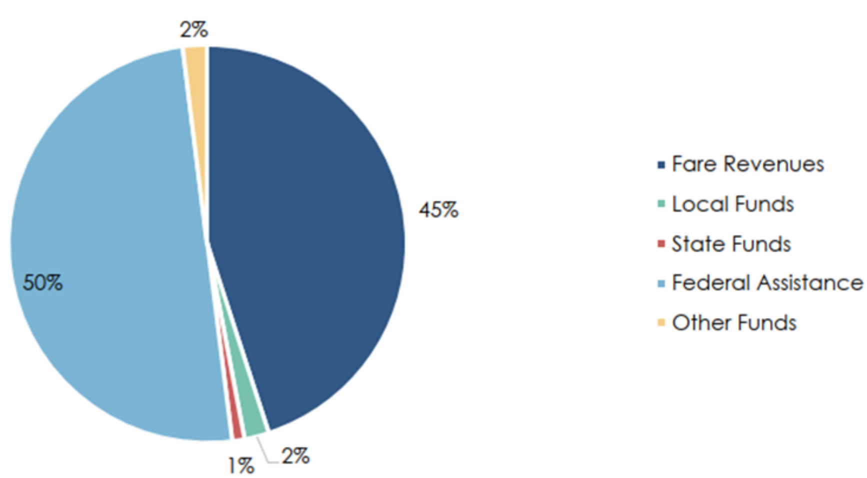

Figure 9 Current Agency Funding Summary (Source: Maine DOT)

As the agency transitions to hybrid and battery electric technology, additional policies and resources will become applicable to RTP. Table 8 provides a summary of current policies, resources and legislation that are relevant to RTP's fleet electrification transition.

Despite the large number of potential funding opportunities available to transit agencies seeking to transition to hybrid and battery electric technologies, these programs are competitive and do not provide RTP with guaranteed funding sources. Therefore, this analysis assumes that RTP will only receive funding through the largest grant programs that provide the highest likelihood of issuance to the agency. Specifically, this analysis assumed that RTP 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:

- Urbanized Area Formula Funding (49 U.S.C. 5307),
- Low or No Emission Grant Program (FTA 5339 (c)
- Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b))

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

Table 8 Policy and Resources Available to RTP

Policy	Details	Relevance to Agency Transition
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 Urbanized Area Formula Grants - 5307	The Urbanized Area Formula Funding program (49 U.S.C. 5307) makes federal resources available to urbanized areas and to governors for transit capital and operating assistance in urbanized areas and for transportation-related planning. An urbanized area is an incorporated area with a population of 50,000 or more that is designated as such by the U.S. Department of Commerce, Bureau of the Census.	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities. (*Competitive funding)
The U.S. Department of Transportation's Grants for Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b))	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 changes or innovations to modify low or no emission vehicles or facilities. Funding is provided through formula allocations and competitive grants.	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
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 Quality Improvement (CMAQ) Program	The U.S. Department of Transportation Federal Highway Administration's CMAQ Program provides funding to state departments 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.	Can be used to fund capital requirements for the transition. (*Competitive funding)

Policy	Details	Relevance to Agency Transition
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 Analysis

Section Summary

- Vehicle electrification will save RTP money over the long term, as electric vehicles cost less to maintain and fuel
- Upfront capital costs increase by approximately 82% and annual operating cost will decrease by approximately 2%, yielding a net 1% savings in total cost of ownership

Hatch calculated the life cycle cost (LCC) of the proposed transition strategy and compared it to maintaining RTP's current gasoline operations as a baseline, using a net present value (NPV) model. This allows all costs incurred throughout the fleet transition to be considered in terms of today's dollars. The costs, which are based on the weekday service levels analyzed above and scaled to account for weekends and holidays, include initial capital as well as operations and maintenance costs of the vehicles and supporting infrastructure for gasoline, hybrid, and battery electric vehicles. Table 9 outlines the LCC model components, organized by basic cost elements, for gasoline and battery electric vehicle technologies.

Table 9 Life Cycle Cost Model Components

Category	Gasoline (Base case)	Hybrid	Battery-Electric Vehicles
Capital	Purchase of the vehicles	Purchase of the vehicles	Purchase of the vehicles
			EV charging Infrastructure
			Electrical infrastructure upgrades
			Utility feed upgrades
Operations	Gasoline Fuel	Gasoline fuel	Electricity
	Operator's Cost	Operator's cost	Operator's Cost
			Demand charges for electricity
Maintenance	Vehicle maintenance costs	Vehicle maintenance costs	Vehicle maintenance costs
			Charging infrastructure maintenance costs
Financial Incentives	Grants	Grants	Grants

Like any complex system, RTP has a range of ways it can fund, procure, operate, maintain, and dispose of its assets. In coordination with agency stakeholders, Hatch developed the following assumptions to ensure that the cost model reflected real-world practices:

Capital Investment

- The lifespan of a vehicle is 7 years, in accordance with RTP practice.
- All demand response vehicles are replaced with vans at their expected retirement year.

+ RTP will make capital investment on the installation of charging infrastructure at the vehicle storage building.

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%

Table 10 lists the operating and capital costs that Hatch assumed for this study. These are based on RTP's figures and general industry trends and have been escalated to 2022 dollars where necessary.

Table 10 Cost Assumptions

Asset	Estimated Cost Per Unit (2022 $'s)
Gasoline Transit van	$40,000
Hybrid Transit van	$55,000
Electric Transit van	$180,000
Gasoline Cutaway	$70,000
Hybrid Cutaway	$125,000
Electric Cutaway	$280,000

Expense	Estimated Cost (2022 $'s)
Gasoline Vehicle maintenance	$0.97 / mile
Hybrid Vehicle maintenance	$0.97 / mile
Electric Vehicle maintenance	$0.73 / mile
Operator salary, benefits, overhead	$26.38 / hour
Gasoline fuel	$3.25 / gallon

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 last non-hybrid gasoline vehicle is proposed to be retired (2027), 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 (gasoline) 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 11 and Figure 10 summarize the NPV for both technologies by cost category.

Table 11 Net Present Value Summary

Category	Gasoline Baseline	Future Fleet	Cost Differential (Future Fleet vs. Baseline)
Vehicle Capital Costs	$212,315	$378,156	+82%
Infrastructure Capital Costs	$0	$7,701	
Vehicle Maintenance Costs	$3,624,285	$3,500,589	-2%
Infrastructure Maintenance Costs	$0	$29,855	
Operational Cost	$8,192,027	$8,031,379	
Total Life Cycle Cost	**$12,028,627**	**$11,947,679**	-1%

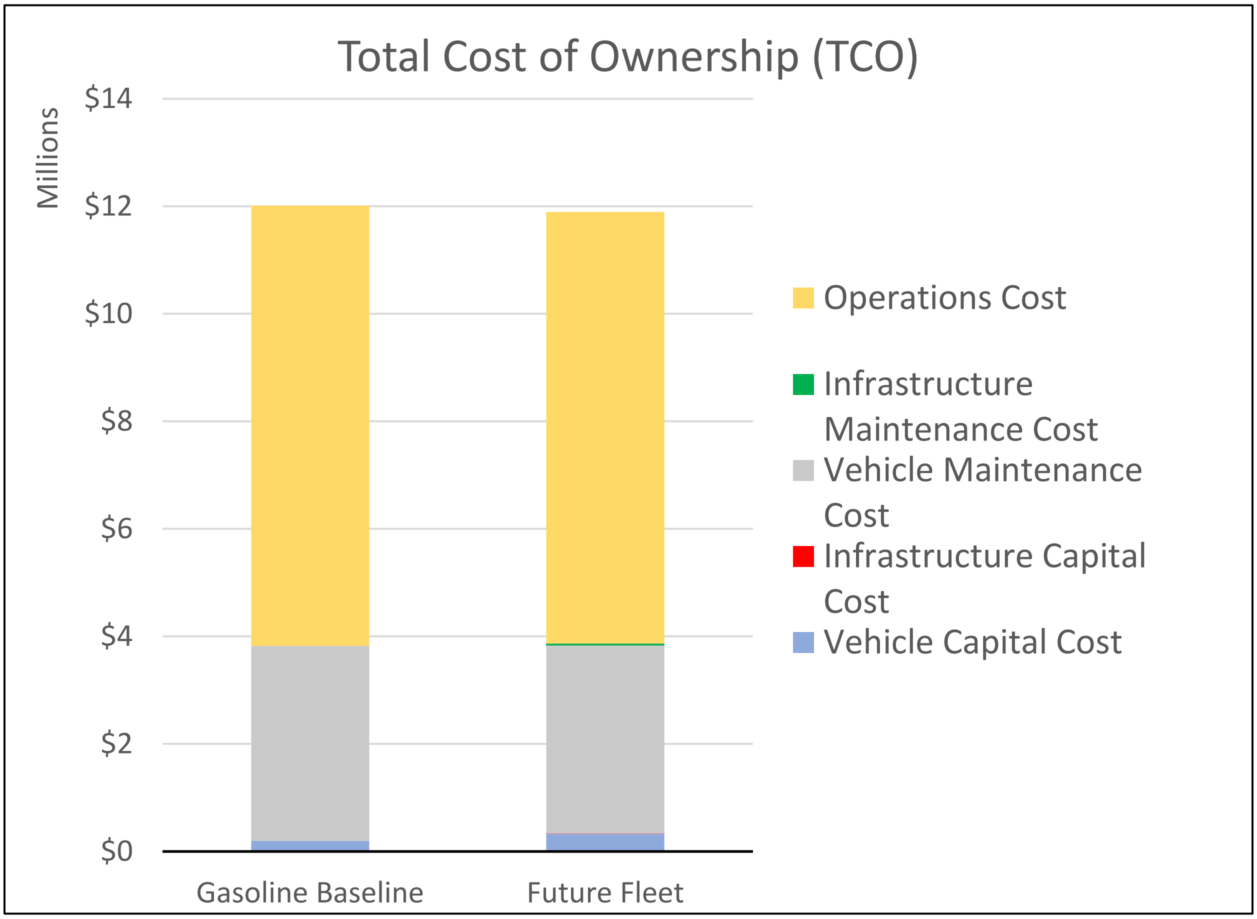

Figure 10 Life Cycle Cost Comparison

As shown in Figure 10, 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 1 Ledgeview Drive facility, the bulk of the extra capital spending is on the vehicles themselves. Hybrid vehicles are more complex than gasoline vehicles, and while electric vehicles are much simpler mechanically they command a cost premium due to their large battery systems. These factors yield a 82% increase in capital costs over the gasoline 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, and even hybrid vehicles experience less wear on certain components, the maintenance and operating costs of the proposed fleet are 2% 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 1%.

The proposed fleet transition requires initial capital spending to reduce life cycle cost and achieve other strategic goals. This finding 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 up front 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 82% increase in upfront capital cost.

The electric vehicle market is a fairly new and developing space, with rapid advancements in technology. Although Hatch has 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 RTP 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 RTP to tweak operating schedules, or otherwise revise this report's assumed end state.

Full details on the LCC model are provided as Appendix D.

14a. Joint Procurements

The cost figures presented above assume that RTP independently procures its vehicles and infrastructure, instead of coordinating with other agencies and the state DOT to form a joint procurement. Shifting to a joint procurement strategy, in particular through the adoption of a state purchasing contract, has the potential to save money for RTP.

State purchasing contracts offer financial savings for several reasons. First, the overhead expenses associated with an order – specification development, vendor negotiation, training, and post-acceptance technical support – can be divided across several agencies. Second, the number of orders required by each agency can also be reduced. State purchasing contracts typically have a duration of five years, allowing a large portion of the agency's fleet to be replaced in one lifecycle. For example, in accordance with the procurement schedule in Table 6, RTP expects to place six vehicle orders over the next 4 years. With five-year purchasing contracts, this number can be reduced to two, saving on many of the same per-order expenses outlined previously. These two factors are estimated to reduce RTP's cost per vehicle by approximately 4%. Third, the increase in total order size is likely to reduce cost per vehicle as well. Like agencies, EV vendors incur some of their costs (business development, contract negotiation, customization setup) on a per-order basis; therefore, they typically decrease the price of each vehicle as order size grows. Furthermore, a larger order is likely to attract additional vendors (who would be unwilling to participate in a small procurement); this is expected to drive down cost as well. In addition, technical support for the new vehicles will be more economical if it can be divided among several vehicles, or even several nearby agencies, as the expense of having an on-site vendor technician is roughly constant regardless of the size of the EV fleet. Recent BEB orders across the US show that, on average, for each additional bus in an order the per-vehicle cost decreases by 0.63%. In other words, combining five two-bus orders into one ten-bus order would reduce purchase cost by 5% due to order size alone.

RTP plans to order 76 vehicles over the next 18 years, and these orders can easily be allocated to purchasing contracts. The 2023, 2024, 2025, 2026, and 2027 orders for vans can be part of a 42-vehicle order purchased together with YCCAC; the 2030, 2031, 2032, 2033, and 2034 orders for vans can be part of 46-vehicle order purchased together with YCCAC and Downeast; the 2037, 2038, 2039, 2040, and 2041 orders for vans can be part of 42-vehicle order purchased together with YCCAC; the 2026 order for electric cutaways can be part of a 16-vehicle order purchased together with Downeast and YCCAC; and the 2034 order for cutaways can be part of a 16-vehicle order purchased together with Downeast and YCCAC.

In summary, although this analysis assumed that RTP acts independently in placing its orders, the agency is encouraged to explore opportunities for joint procurements with other agencies. This will potentially save the agency money through reduced administrative expenses, increased vendor competition, and efficiencies with post-procurement technical support. Overall, this strategy will produce a 27% cost saving for the agency.

15. Emissions Impacts

One of the motivations behind RTP'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 RTP.

Hatch calculated the anticipated emissions reductions from RTP'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:

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 27-29%

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

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 RTP's existing gasoline fleet were calculated. These calculations used industry emissions averages for gasoline vehicles and RTP's fuel economy data.

Hybrid vehicles were assumed to have an average fuel economy 25% better than that of gasoline vehicles. Battery electric vehicle propulsion systems do not create emissions, and therefore there are no 'tailpipe' emissions.

Well-to-tank emissions are those associated with energy production. For gasoline (and hybrid) vehicles well-to-tank emissions are due to gasoline production, processing, and delivery. This emissions estimate used industry averages for the well-to-wheel emissions associated with the delivery of gasoline fuel to the gas stations RTP uses.

Battery electric vehicles have a third emissions source: grid electricity generation. The local utility, Central Maine Power, 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 12 and Figure 11 summarize the results of the emissions calculations. These results demonstrate that the transition plan will achieve 27% emissions reduction assuming the grid mix that existed in 2020, or 29% emissions reduction assuming that Central Maine Power is able to meet the state's goals to reduce grid emissions by the year 2030. In either case, RTP's transition plan will help reduce emissions but will not meet the 45% goal established by the State of Maine.

Table 12 CO_2 Emissions Estimate Results

Scenario	Well-to-Tank (kg)	Tank-to-Wheel (kg)	Grid (kg)	Total (kg)	Reduction over Baseline
Gasoline Baseline	281,990	476,820	-----	758,811	----------
Future Fleet (2020 grid mix)	197,003	333,114	24,899	555,016	27%
Future Fleet (2030 grid mix)	197,003	333,114	8,217	538,334	29%

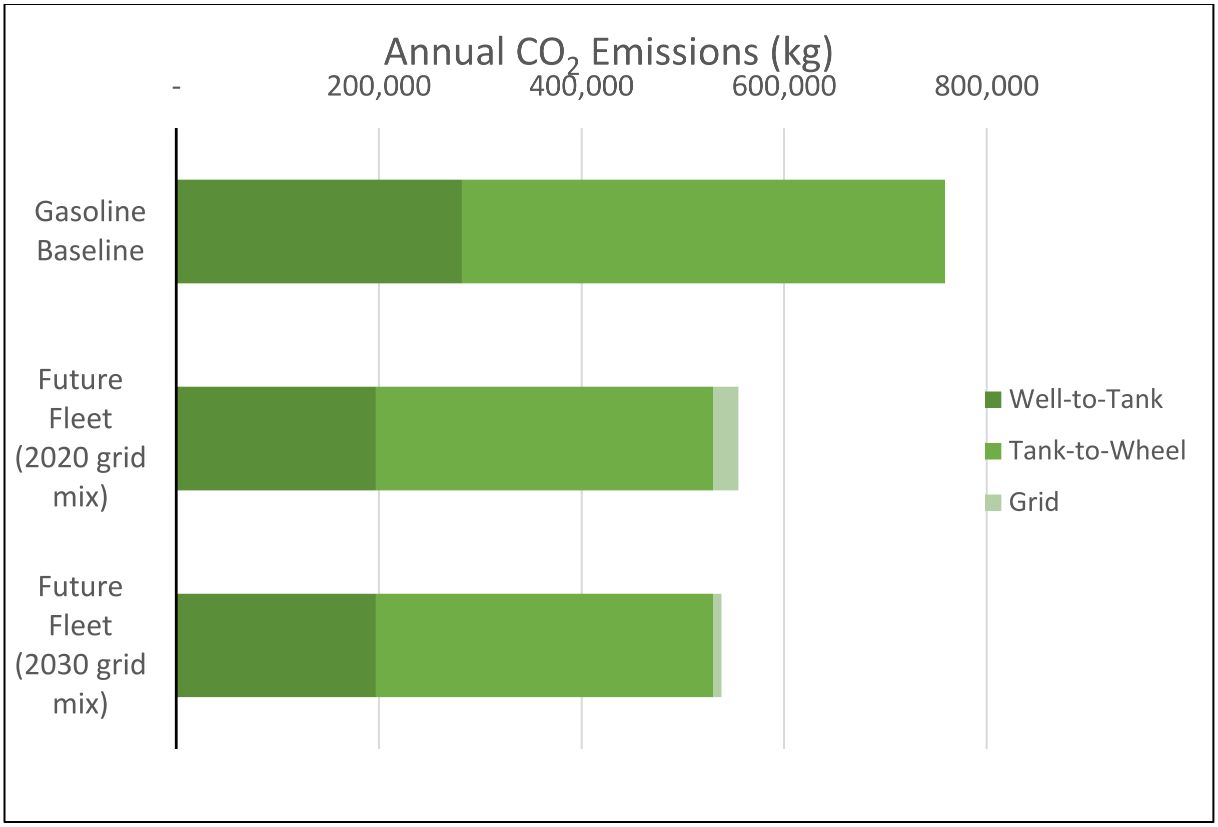

Figure 11 Graph of CO_2 Emissions Estimate Results

Should RTP 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, potentially including the Lakes Region Explorer fleet

16. Workforce Assessment

RTP 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 RTP's future system a workforce assessment was conducted. Table 13 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 RTP success
- Hatch recommends partnering with local colleges and other transit agencies to share skills

Table 13 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 RTP consider the following training strategies:

+ Add requirements to the operations contract for the system operator to train its staff on the safe operation and maintenance of electric vehicles.
+ 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, RTP 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, RTP currently favors the transition plan presented in this report. Details on the alternative plans are presented in Appendix B, D, and E. Should RTP's plans or circumstances change in the future, it is possible that one of the alternative transition plans presented may become more advantageous. Hatch recommends that RTP 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 RTP 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 RTP 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, RTP 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 RTP 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 or the DOT 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 1 Ledgeview Drive:
  - 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, CMP, and Maine DOT.
  - Continually monitor utility structures and peak charge rates and adjust charging schedules accordingly.
  - Develop a funding strategy to account for the 82% increase in capital spending.
  - Review this transition plan annually to update based on current assumptions, plans, and conditions.

Appendices

A. Vehicle and Infrastructure Technology Options
B. Operations Simulations Presentation
C. Utility Outage Data
D. Life Cycle Costing Models
E. Alternative Transition Strategy Presentation