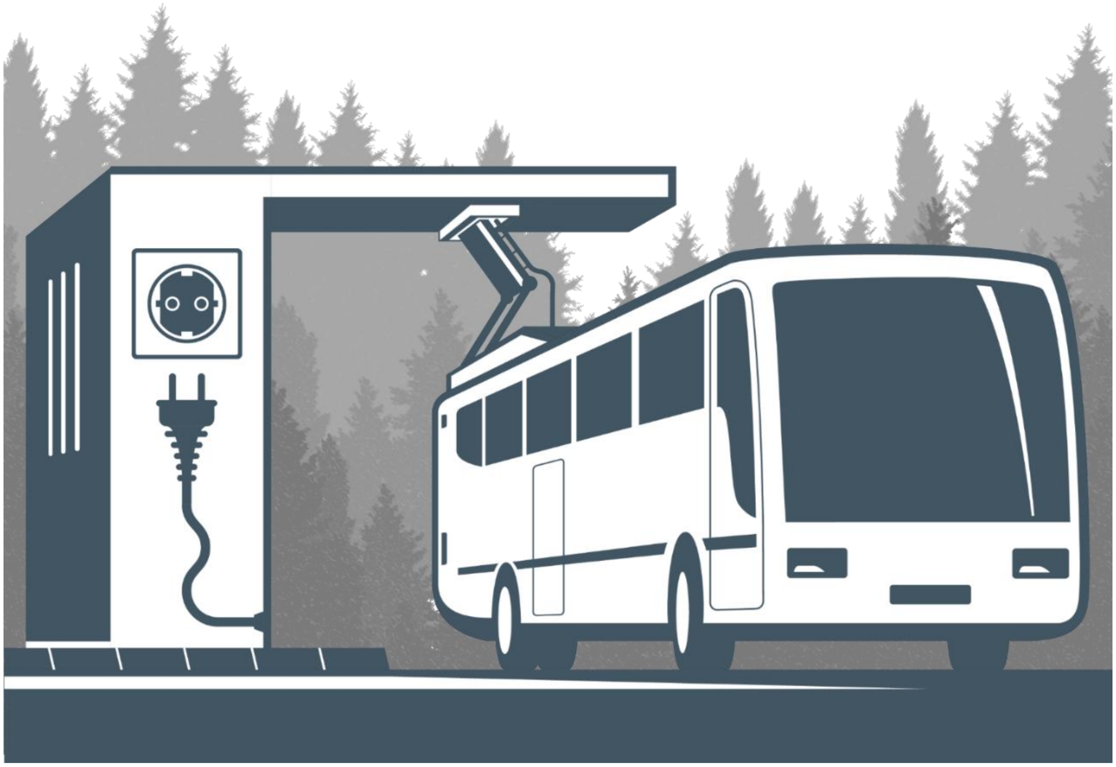

Vehicle Electrification Transition Plan for York County Community Action Corporation (YCCAC)

York County
COMMUNITY
ACTION
Corporation

Prepared by:

HATCH

Version: 1.1
2/10/2023

Table of Contents

1. Executive Summary

York County Community Action Corporation (YCCAC), the bus and paratransit agency serving York County, Maine, is currently considering transitioning its vehicle 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, YCCAC 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 increases the agency's fleet size from 30 to 31 vehicles, with six electric flex-route cutaways, seven electric trolleys, and four electric demand-response vans, with hybrid vehicles comprising the remainder of the demand-response fleet. To support the battery electric vehicles, the agency also plans to procure, install, and commission one centralized and seven level 2 chargers at the main storage facility in Sanford, Maine, one plug-in DCFC-type charger at the Nasson Healthcare site, and two centralized chargers at the Wells Regional Transportation Center.

One of the primary motivations behind YCCAC'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 projection estimate that the new fleet will yield a 63-70% reduction in emissions compared to YCCAC'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 YCCAC can anticipate a 126% increase in capital expenditures due to the transition, primarily due to the acquisition of electric trolley vehicles which are not a widely available product, and as a result are far more expensive than gasoline trolleys. It is estimated, however, that there will be a 6% 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 YCCAC will see a life cycle cost increase of roughly 6% 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 YCCAC's fleet, the agency would benefit from electrifying its flex-route and trolley services and beginning the demand-response 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 pollution and noise, take a leadership role in vehicle electrification in York County, and gain the required skillsets and operating experience for future electrification once the technology advances further. Therefore, YCCAC 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 inspect 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 York County Community Action Corporation (YCCAC), 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 YCCAC's future route plans, vehicle technology options, building electrical capacity, emissions impacts, resiliency, and financial implications.

3. Existing Conditions

YCCAC is a transit agency providing demand-response paratransit services throughout York County, Maine, in addition to operating four flex route services. The agency currently owns and operates a fleet of thirty passenger vehicles, all of which are gasoline powered, though it plans to transition to a demand-response fleet primarily composed of vans.

Section Summary

- YCCAC currently operates four scheduled routes, two seasonal trolley routes, and three on-demand paratransit / curb-to-curb services with a thirty-vehicle fleet.
- On-demand vehicles operate for up to twelve hours a day on widely varying routes due to unpredictable user demand.

Table 1 Current Vehicle Roster

Vehicle Type/Roster Number	Fuel Efficiency (MPG)	# of Vehicles	Procurement Date/Age	Projected Retirement Date
Dodge mini-van (83, 84, 86)	20	3	2014-2015	2023
Chevy Arboc (147-149, 151-153)	8.9	6	2010-2011	2021
Chevy Arboc (201)	8.9	1	2012	2024
Chevy Glaval (154-156)	8.9	3	2017	2022
Ford Champion Defender (157-158)	5.6	2	2019	2026
Ford E-450 / Startrans (159-167)	7.8	9	2019	2024
Ford Molly Trolley (Dory, Driftwood, Lobstah, Osprey, Scallop, Seahorse)	6.5	6	2009	2022

YCCAC operates four year-round flex routes and two seasonal trolley routes. There are also three additional trolley routes which, despite being branded together with YCCAC's routes from a public perspective, are run by private operators. Because these vehicles are not owned or operated by YCCAC, they are not considered in this report. All other YCCAC services are on-demand paratransit. The flex routes and YCCAC service area are shown in Figure 1 below.

Sanford Transit

+ Service from Springvale to South Sanford.
+ Operates approximately every 80 minutes Mondays to Fridays between 8:00 AM to 3:30 PM.

Orange Line

+ Service from Sanford to Wells.
+ Operates every 1.5-2.5 hours, daily except major holidays, between 6:00 AM to 7:00 PM.

Kennebunk In Town Transportation (KITT)

+ Local shuttle service in Kennebunk.
+ Operates approximately every 2.5 hours only on Tuesdays between 10:00 AM to 4:00 PM.

Southern Maine Connector

+ Shuttle service connecting Springvale to Saco.
+ Operates approximately every 3 hours on Mondays to Fridays between 7:30 AM to 3:45 PM.

WAVE

+ On-demand curb to curb service within Sanford as well as to Biddeford and Wells.
+ Operates eight trips every day from Sanford to Biddeford between 6:00 AM and 11:00 PM.
+ Operates eleven trips every day from Sanford to Wells between 6:00 AM and 11:00 PM.

Local Rides

+ On-demand curb to curb service, for local shopping and medical appointments.
+ Service available in various York County towns.
+ Operates every Monday from 7:45 AM to 4:15 PM, with morning service in South Sanford and afternoon service in Alfred/Waterboro/North Sanford.

- Operates every Wednesday from 7:45 AM to 4:15 PM, with morning service in Kennebunk/Biddeford and afternoon service in Saco/Old Orchard Beach.
- Operates every Thursday from 8:00 AM to 12:00 PM with service in Berwicks.
- Operates every Friday from 8:00 AM to 12:00 PM with service in Eliot/York/Kittery.

Connecting Cancer Care Program

- On-demand curb to curb service, serving York County residents traveling for cancer care.

Shoreline Explorer – Blue 4, Blue 4b

- Two lines that service Wells, Kennebunk, Perkins Cove, and York Short Sands.

Figure 1 YCCAC Route Map

YCCAC is currently studying the possibility of providing a micro-transit service that would provide service to Kittery, by the Portsmouth Naval Shipyard. This service is expected to involve a partner such as Via and use vans. Additionally, YCCAC is included in PACTS's *Transit Tomorrow* and *Transit Together* studies. The results and recommendations from these studies will have an impact on YCCAC operations in the future but have not yet been implemented. Although YCCAC will need to adapt its electrification strategy to any future service changes, the recommendations in this report are generally expected to remain relevant even after those changes are made.

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 YCCAC lower procurement cost

As discussed in Section 3, YCCAC's revenue service fleet is composed of wheelchair lift minibuses, vans, and trolleys. For future procurements, YCCAC is planning to shift its demand-response fleet largely to vans, which are easier to maneuver in narrow streets and driveways. (Because any remaining demand-response services using cutaways would be operated ad-hoc, for consistency they were not considered here). The flex route vehicles are expected to remain cutaway shuttles as they are today, and the trolley vehicles will likewise remain unchanged. Each category of electric vehicles may have limitations that the gasoline versions do not have. For example, because of the weight of the battery, one of the commercially available electric vans on the market can accommodate eight ambulatory passengers and only one wheelchair (as opposed to two on a gasoline van) while staying under GVWR limits. Such a change would have an impact on agency operations. In some cases YCCAC can consider alternate options; for example, shifting from an electric cutaway vehicle (shown in Figure 2) to 30' transit buses would potentially allow greater operating range and passenger capacity, even though such a shift would have cost and maintenance implications. In general, Hatch recommends that YCCAC consider a broad range of vehicles in its future procurements, enabling maximum competition and potentially lowering cost.

Figure 2 Example 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 YCCAC 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 157 kWh battery capacity, vans 120 kWh battery capacity, and trolleys 226 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 (100 kWh for the cutaways, 77 kWh for the vans, and 145 kWh for the trolleys).

5. Infrastructure Technology Options

There are two primary types of chargers that are applicable to YCCAC's fleet – level 2 chargers, which are common in light-duty commercial 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.

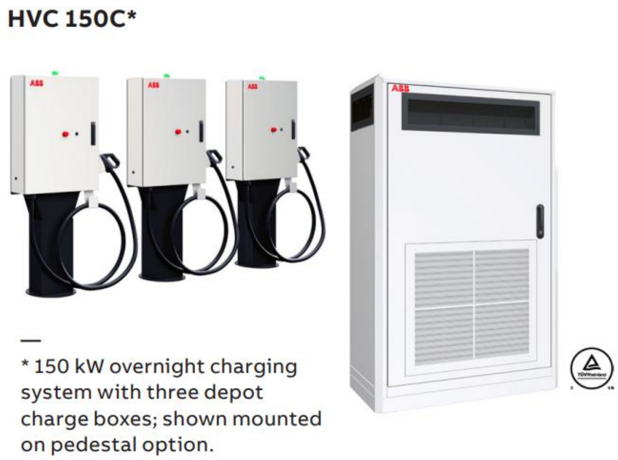

Figure 4 Example Charging Systems (Source: ABB): Charging Cabinet (System) and Three Dispensers (Charge Boxes)

For YCCAC's operations, a mix of 19.2 kW level 2 chargers, decentralized DC fast chargers, and centralized 150 kW fast chargers will be appropriate. Each type of charger has distinct advantages. Level 2 chargers are the easiest and cheapest to install and maintain, as they do not require electrical equipment to convert AC to DC power. They are also the most commonplace on the market, reducing the risk of obsolescence. Decentralized DC fast chargers are best in locations where quick top-up charging (that level 2 chargers could not accommodate) is needed, but with only one vehicle at a time, making a centralized charger uneconomical. Where a large number of vehicles is charging, with at least some vehicles requiring fast charging, centralized chargers are recommended. Although they are the most expensive, their advanced power distribution algorithms allow the agency maximum flexibility. If only one vehicle is plugged in, it will be provided with as much power as it can accommodate (up to 150 kW), and if multiple vehicles are plugged in the power will be distributed between them. As with the vehicles, charging infrastructure is available in numerous configurations; Appendix A shows commercially available charging system options and configurations. The specific recommended installation locations for each type of charger are discussed in Section 8.

6. Route Planning and Operations

Section Summary

- Electric vehicles do not offer comparable operating range to gasoline vehicles – so detailed operations modeling is needed
- Shorter on-demand runs can be electrified with electric vans, or with cutaways if necessary
- Flex-route and trolley vehicles will need charging throughout the day.

YCCAC'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 YCCAC's 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 do; 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 flex routes 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.

YCCAC's paratransit service operates throughout the day on an on-demand basis. The busiest periods are the early morning and late afternoon; though some vehicles operate continuously throughout the day, others return to the storage facility during the midday. Easy Rides 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 to operate without charging until they return to the depot.

YCCAC's trolley services operate in the Wells area, which is a 30 minute drive from the vehicle storage facility in Sanford. This presents an operational hindrance as vehicles must deadhead to and from the depot each day. Previously, the trolleys were stored overnight at the highway department facility near Wells; however, this option is no longer available. YCCAC is interested in identifying an alternate location near the trolley routes to store (and potentially charge) the trolleys. As discussed in Section 9, this study assumed that a storage and charging location is available at the Wells Regional Transportation Center, as planned for storage for the 2023 season.

6a. Operational Simulation

To assess how battery electric vehicles' range limitations may affect YCCAC'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 YCCAC'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 scheduled routes, as well as for routes representative of demand-response operations. 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 vehicle performance was simulated in worst-case weather conditions (hot summer for the trolleys and cold winter for other vehicles) to create a drive cycle. These YCCAC-specific drive cycles were used to calculate the energy consumption per mile and therefore total energy consumed by a flex-route, trolley, or demand-response vehicle.

As discussed in the previous section, the resultant runs were evaluated against common electric cutaways, vans, and trolleys with 157 kWh, 120 kWh, and 226 kWh batteries respectively. As technology advances, these battery capacities are likely to increase by approximately 3% each year, allowing for additional range. As all three of YCCAC's vehicle types are approaching their replacement dates, the agency will not be able to take advantage of these future improvements during the current procurement cycle. However, during subsequent procurement cycles, the combination of market advancements and YCCAC's experience with already-procured EVs will let the agency electrify its fleet further. Clearly, if battery electric technology advances faster than anticipated, if the first-generation electric fleet proves reliable and long-lasting, or if cutaway range improves significantly over that of vans, a greater portion of the demand-response vehicles will be available for electrification. Conversely, if technology develops more slowly or the first-generation fleet requires replacement sooner, a pilot deployment may remain the practical limit on the demand-response services for the foreseeable future.

Table 2 below presents the mileage and energy requirements for YCCAC flex-route and trolley operations. Green shading denotes those runs that can be operated by the specified vehicle and red shading denotes those that cannot. As mileage on the demand-response services varies by day and by vehicle, a representative route was used to estimate vehicle range.

Table 2 Energy Requirements by Run

Block	Mileage	kWh Required	Mileage Shortage/Excess
Kennebunk In-Town Transit (KITT)	64	98	1
Orange Line	213	245	-125
Sanford Transit	107	149	-34
Southern Maine Connector	150	177	-65
Trolley Blue 4	205	270	-94
	184	242	-72
Trolley Blue 4b	181	239	-71
	181	239	-71

6b. Operational Alternatives

For the demand-response services, an electric van is expected to have a usable range of approximately 80 miles in the harshest weather conditions. (Due to the larger vehicle weight, a cutaway's range is roughly comparable). To avoid impact on YCCAC operations, the most viable service model replaces the vehicles on shorter runs with electric vans, with all other runs being operated by hybrid vehicles. Easy Rides's route distance measurement tool, already available to YCCAC, will help YCCAC 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 YCCAC's demand-response vehicles are feasible for electrification.

On the flex-route services, an electric cutaway can operate the KITT (Kennebunk In-Town Transportation) route, but not the other three routes, before recharging. This allows several operating models, which are described below and presented in additional detail in Appendix B.

One possibility is to use hybrid vehicles, which as discussed above have identical range to gasoline vehicles. Operations would be able to remain exactly as they are today. However, this would increase vehicle procurement cost for comparatively small reductions in emissions and would not allow the agency to meet the State's climate goals. Because other operating alternatives are available, unlike for demand-response services, YCCAC chose not to consider hybrid vehicles for flex-route and trolley services.

Another possibility is to operate electric vehicles and swap them at the YCCAC facility in Sanford after one or several round trips, with one vehicle charging while another operates in service. This would simplify YCCAC's infrastructure by consolidating it at the storage facility and would improve on-time performance by extending vehicle layover times. However, this would require a substantial increase in fleet size, to allow service to be operated while some vehicles are charging. In addition, the additional deadheading to and from the depot would increase operations costs, making this configuration impractical for YCCAC.

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. Adopting a transit bus would also let YCCAC increase capacity, 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 YCCAC staff to operate and inspect. Because of these drawbacks, this option is currently not being considered.

A fourth choice, and the one YCCAC selected, is to recharge the vehicle during its layovers using a fast charger. Though this would require revising the schedule, a well-designed timetable could combine vehicle charging time and driver meal break time, maximizing efficiency. As most blocks do not have sufficient time to deadhead to and from the YCCAC facility for each charging window, this option would require the installation of an YCCAC-owned fast charger at one terminal for each route. For the Sanford Transit and Southern Maine Connector routes, this is most practical at the Nasson Healthcare site (see Sections 9 and 12). As the Orange Line terminates a half-mile from the vehicle storage facility, it is most practical to deadhead the vehicle to and from the depot when needed, with a fast charger installed at the depot to facilitate prompt charging. As the current schedules do not include allowances for charge time, YCCAC would need to tweak the schedules slightly, but the general span of service and number of trips is expected to remain unchanged. A comparison of the current schedule, and a conceptual schedule that would allow a full day of electric operation on all flex-route services, is presented in Figure 5. This schedule assumes fast charging at the depot (for the Orange Line) and at the Nasson Healthcare site (for the other two flex-route services).

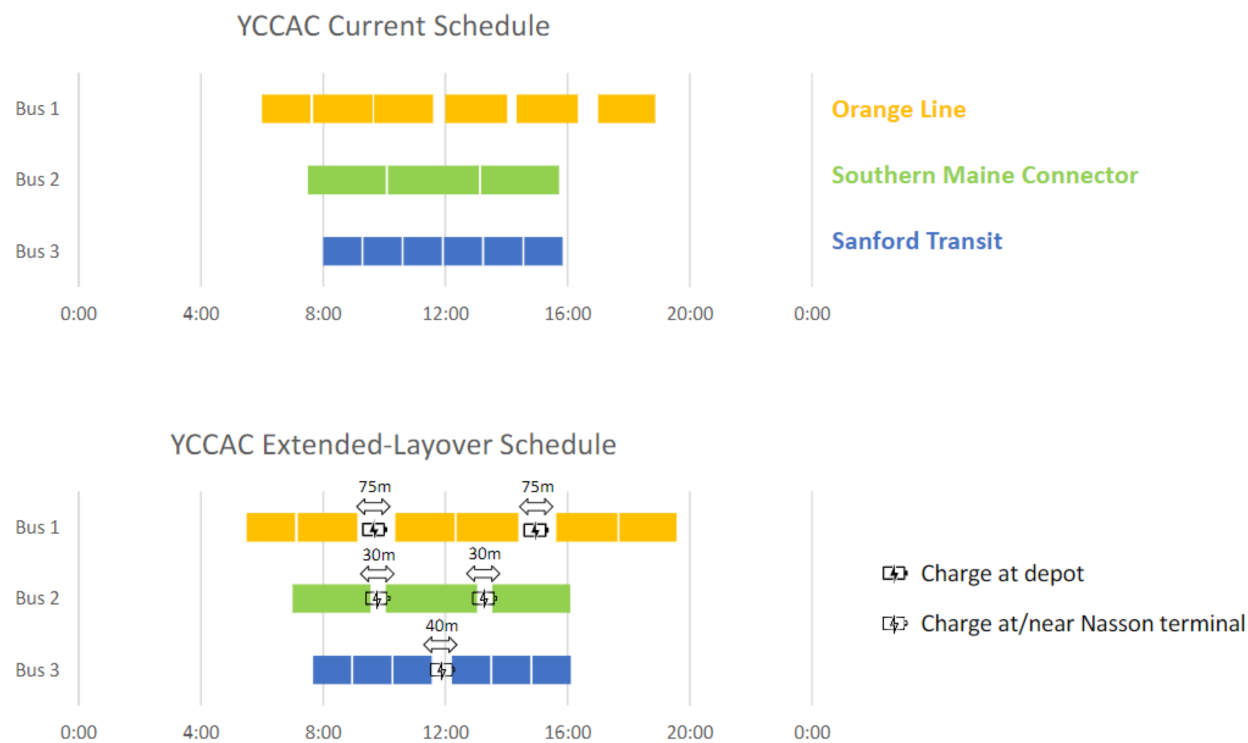

Figure 5 Comparison of Current and Conceptual Electric-Vehicle Schedules

For the trolley services, a similar operating model is assumed. As mentioned above, charging is assumed to occur at Wells Regional Transportation Center. Because the Blue 4 trolley route does not serve Wells RTC directly, deadheading between the eastern terminal and Wells RTC was assumed. Alternatively, YCCAC could choose an operating schedule that would swap buses between the Blue 4 and Blue 4b routes at the Bypass Road eastern terminal, allowing all trolleys to access the charger without deadheading.

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 YCCAC 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 YCCAC, and described in the previous section of this report, assumes that vehicles will be charged both overnight and throughout the day, at both the main facility and other locations.

YCCAC's current electricity rates are determined by Central Maine Power's 'MGS-S' rate table, as shown in Table 3. Under this rate table YCCAC pays a flat "customer charge" monthly, regardless of usage. YCCAC 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 YCCAC's usage. Finally, YCCAC 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 YCCAC 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 YCCAC 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 YCCAC 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 YCCAC 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, for each of the three proposed charging sites, around the operational plan developed in the previous section of the report and the above listed utility schedules. The results of this optimization for proposed charging locations at YCCAC office, Nasson Healthcare and Wells RTC are shown in Figure 6, Figure 7 and Figure 8 respectively. It can be seen in the figures that the optimized charging schedule assumes that vehicles will be charged primarily overnight (between 9 PM and 5 AM), with on-route/mid-day charging as needed during the daytime. This will avoid charging during the Central Maine Power grid's 'coincidental peak' (between 3 PM and 7 PM) as much as possible and allow YCCAC 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.

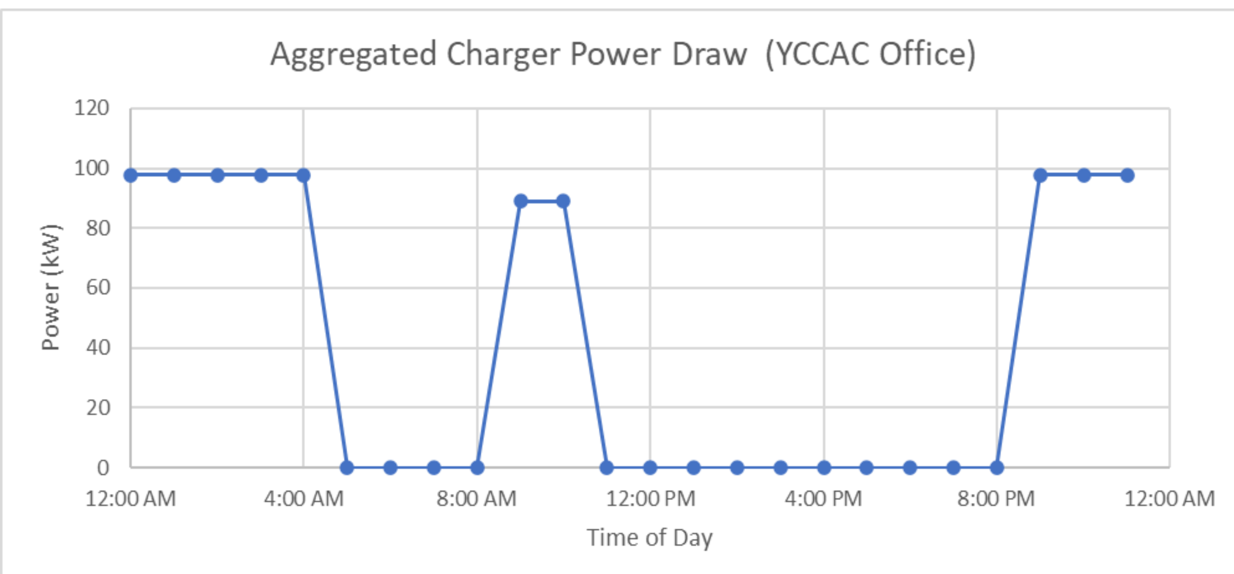

Figure 6 Proposed Overnight Charging Schedule for YCCAC's Flex-Route and Demand Response Vehicles

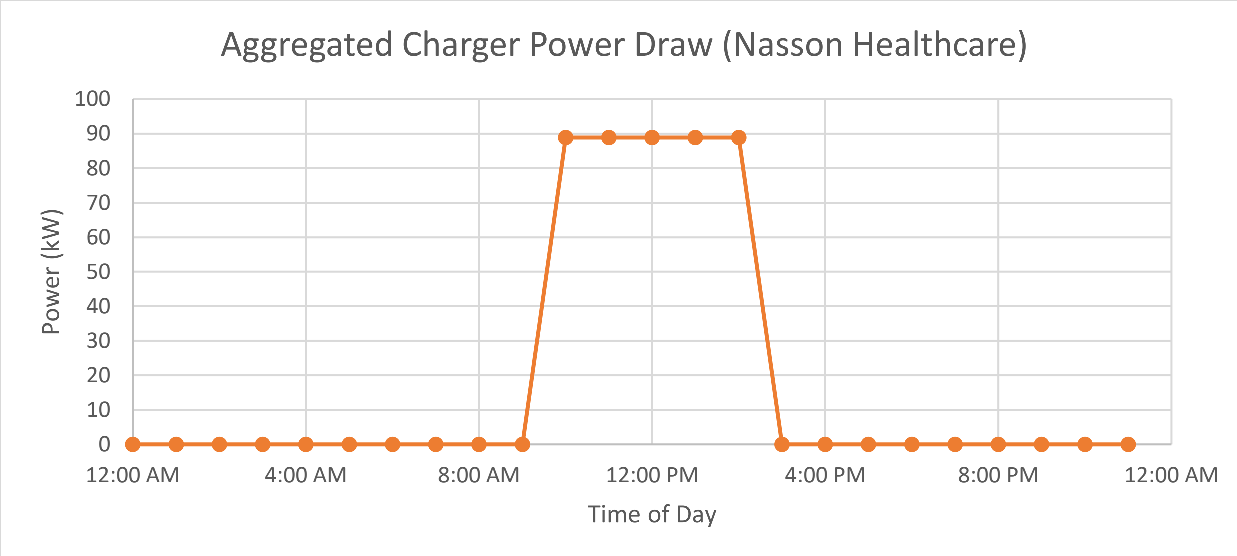

Figure 7 Proposed On-Route Charging Schedule for YCCAC's Flex Route Vehicles

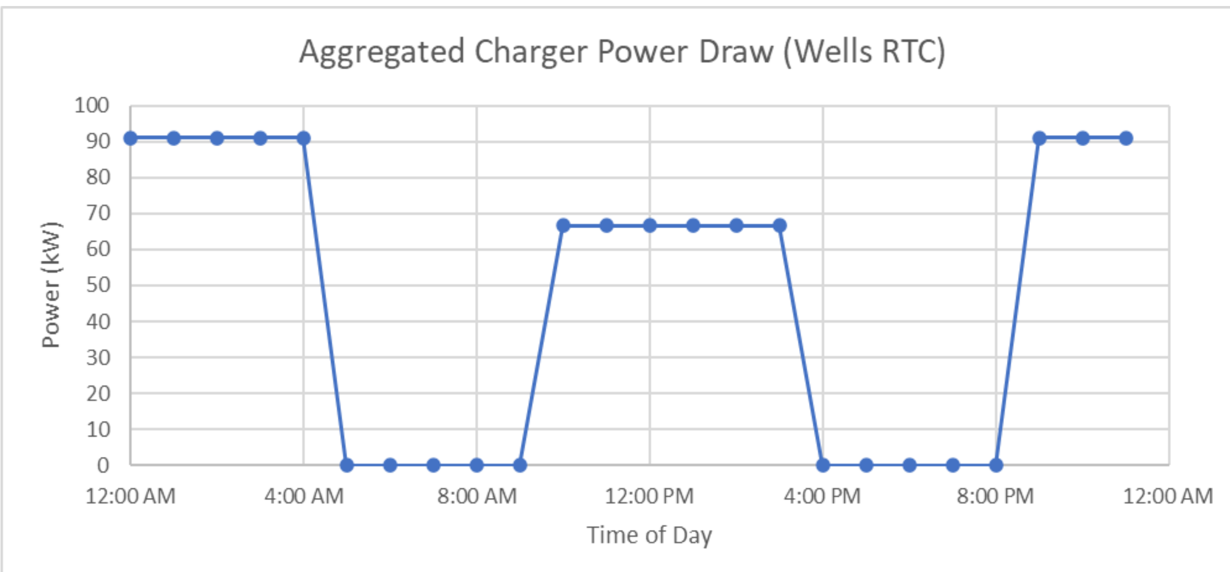

Figure 8 Proposed Overnight and Mid-day Charging Schedule for YCCAC's Trolley Buses

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.

Depot – YCCAC office (6 Spruce St.)

Daily kWh consumption = 878 kWh
Monthly Non-coincidental peak = 98 kW
Monthly coincidental peak = 0 kW

Under Current MGS-S Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 878\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$115.27$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non - coincidental\ Peak\ \times Transmission\ Charge)$$
$$= 98\ kW\ \times \$16.64$$
$$= \$1{,}630.72$$

Under New B-DCFC Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 878\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$115.27$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (98\ kW\ \times \$4.39) + (0\ kW \times \$19.35)$$
$$= \$430.22$$

On-Route – Nasson Healthcare (15 Oak St)

Daily kWh consumption = 246 kWh
Monthly Non-coincidental peak = 89 kW
Monthly coincidental peak = 0 kW

Under Current MGS-S Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 246\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$32.29$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non - coincidental\ Peak\ \times Transmission\ Charge)$$
$$= 89\ kW\ \times \$16.64$$
$$= \$1{,}480.96$$

<u>Under New B-DCFC Rate Structure:</u>

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 246\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$32.29$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (89\ kW\ \times \$4.39) + (0\ kW \times \$19.35)$$
$$= \$390.71$$

Depot – Wells RTC

Daily kWh consumption = 999 kWh
Monthly Non-coincidental peak = 91 kW
Monthly coincidental peak = 0 kW

<u>Under Current MGS-S Rate Structure:</u>

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 999\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$131.15$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non - coincidental\ Peak\ \times Transmission\ Charge)$$
$$= 91\ kW\ \times \$16.64$$
$$= \$1{,}514.24$$

<u>Under New B-DCFC Rate Structure:</u>

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 999\ kWh\ \times (\$0.001745 + \$0.12954)$$
$$= \$131.15$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (91\ kW\ \times \$4.39) + (0\ kW \times \$19.35)$$
$$= \$399.49$$

As this estimate shows, the optional 'B-DCFC' rate structure would save YCCAC $3,405.50 per month combined for all sites. 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 $5,379.30 per month from a 'transmission charge'. As the number of electric vehicles increases in YCCAC's fleet, the saving from the B-DCFC rate structure will also increase proportionally. Therefore, it is important YCCAC charges the vehicles outside the coincidental peak window between 3 PM and 7 PM as much as possible or procures a smart charging management system which is programmed to avoid charging during the coincidental peak. (Although the charging schedule in Figure 8 requires some charging for a brief period after 3 PM, the variability in grid peak times means that this limited charging is unlikely to trigger demand charges). Furthermore, it is also important that YCCAC 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 summer load. Weekend, holiday, and off-season calculations 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 YCCAC's operation.

8. Asset Selection, Fleet Management and Transition Timeline

Section Summary

- Hatch recommends procuring four electric vans, 7 electric trolleys, and 6 electric cutaways, with the remainder of the fleet being hybrid
- Hatch recommends installing eight chargers at the YCCAC office, two at Wells RTC, and one at the Nasson Healthcare site

With operational and charging plans established, it was then possible to develop procurement timelines for infrastructure and vehicles to support those plans. YCCAC, 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. YCCAC 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, YCCAC operates a mix of cutaways, vans, and trolleys. As commercial electric vehicles remain a comparatively niche market, this means that YCCAC will likely have a small pool of potential suppliers to choose from. To increase procurement competition, YCCAC is encouraged to keep its vehicle specifications flexible, for example by allowing small-size buses to be proposed instead of cutaways for the flex-route services. A vehicle like the Hometown Urban, if selected, would allow parts and diagnostics commonality with the most likely electric trolley fleet, as well as allowing for growth in passenger demand. In addition, the EV market is changing rapidly, with new entrants annually; YCCAC is similarly encouraged to monitor the market and adjust specifications as needed. To maintain a fair comparison, however, this analysis assumes that the existing fleet will be replaced as planned by YCCAC, with vans for demand-response service, cutaways for flex-route operation, and trolley-style vehicles for seasonal routes.

With respect to infrastructure procurements, the choice of charger type at each will be important for future operations. At 6 Spruce St., the primary use case is slow overnight charging of demand-response vans and cutaways, which have comparatively small batteries. This need is best fulfilled by level 2 chargers. However, the Orange Line’s midday layovers will be too short for the low level of power provided by a level 2 charger; therefore, fast-charging capability is required as well. Although this could be accommodated by a single DC fast charger, for redundancy and future expansion possibility Hatch recommends installing one centralized 150 kW charger with three dispensers. As mentioned above, this can accommodate both fast charging of a single vehicle and lower-power charging of up to three vehicles at a time. A 1:1 dispenser to vehicle ratio is recommended to allow all vehicles to be charged overnight without requiring staff intervention. To accommodate the remainder of the 10-vehicle electric fleet charging at 6 Spruce St., seven level 2 chargers are also recommended. If configured accordingly, all eight chargers can be used during the daytime hours by the personal vehicles of YCCAC staff.

At the Nasson Healthcare site, YCCAC’s only charging need is during short midday layovers. As there is only one vehicle expected to charge there at a time, a single 80 kW DC fast charger is recommended. When not in use by YCCAC vehicles the charger could be made available for public use, generating additional revenue for the agency.

At Wells TC, the charging infrastructure must accommodate both midday fast charging and overnight lower-powered charging. Although the midday fast charging need could be served by a single DC fast charger, with level 2 chargers used for overnight charging, for redundancy and design simplicity Hatch recommends installing two centralized 150 kW chargers, with six dispensers total, at this site. As at Nasson, when not in use by trolleys the chargers can be opened for use by the public as a revenue-generating measure.

The main depot of Biddeford Saco Old Orchard Beach Transit (BSOOB) is used for maintenance of some YCCAC vehicles. Charger use during maintenance is generally small in scale and short in duration, with vehicles only needing to be connected to a charger for fault diagnosis. Although YCCAC will need to reach a payment agreement with BSOOB regarding electricity use by YCCAC vehicles during maintenance, BSOOB’s existing and already-planned chargers are expected to be sufficient for maintaining YCCAC vehicles.

As fleet electrification continues in future vehicle procurements beyond the horizon of this report, the vehicle storage area at 6 Spruce St. will eventually need to have enough chargers to accommodate all of YCCAC'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. Hatch recommends that spare capacity in ductbanks, transformer pads, etc. be included in the initial design for charging infrastructure at 6 Spruce St. to offset some of these future costs.

Providing sufficient resiliency and redundancy to continue operation after failure of a single charger is an important concern. The suggested infrastructure strikes a reasonable balance between mitigating the impact of a charger outage and avoiding excess capital and maintenance cost. At 6 Spruce St., the proposed number of dispensers exactly matches the proposed number of electric vehicles charging there. This allows some room for charger outages, as some vehicles will be in reserve or undergoing minor maintenance on a given day and will therefore not need charging. At the Nasson site, it is uneconomical to provide more than one charger for YCCAC use, unless as part of a larger public charging station. In case of charger failure or maintenance YCCAC will be required to deadhead vehicles to and from the depot. At Wells, the recommended six dispensers will provide allowance for a standby trolley or for dispenser maintenance.

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	7 (7 Hybrid Transit Vans)		147-9, 151-3, 201
2024	13 (7 Electric Trolleys, 4 Electric Transit Vans, 2 Hybrid Transit Vans)	Spruce St.: 7 level 2 chargers, 1 centralized 150 kW charger Wells TC: 2 centralized 150 kW chargers Nasson HC: 1 80 kW DCFC	83-4, 86, 154-6, all trolleys
2025			
2026	11 (6 Electric Cutaways, 5 Hybrid Transit Vans)		157-67

For the demand-response services, Hatch recommends a robust testing program for the pilot order of electric vans on operating cycles across York County year-round. This experience will help YCCAC 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. YCCAC can also consider using local public charging infrastructure for occasional charging during driver breaks; the knowledge gained about charger location and reliability/availability will let YCCAC 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 YCCAC operations.

9. Building Spatial Capacity

YCCAC's headquarters, and main storage facility is located at 6 Spruce St. in Sanford. There is a vehicle wash located inside the facility, but no depot or covered storage building. The facility does not have a gas station. All vehicles are usually stored onsite, though in the winter the seasonal trolleys are sometimes stored in rented indoor spaces such as shipyards. As shown in Figure 11 and Figure 10, most of the vehicles are stored on an unpaved area adjacent to YCCAC's main building; financing improvements to this area is likely infeasible because it is

Section Summary

- The existing 6 Spruce St. facility is suitable for installation of level 2 and centralized DC fast chargers
- The Nasson Healthcare site has space for a charger, assuming landowner agreement
- Wells TC has space for vehicle charging as well; the bus parking area is recommended

Figure 10 Unpaved Storage Lot

Figure 9 Paved Storage Lot

Figure 11 Aerial View of YCCAC Property and Adjacent Unpaved Storage Lot (Source: AxisGIS)

included in the nearby Stenton Trust building parcel, rather than the parcel owned by YCCAC. However, there are several paved parking lots on YCCAC land, shown in Figure 9, that are used for storage of some vehicles.

In addition to the Sanford facility, YCCAC owns eleven other properties that are used for non-transportation YCCAC services. As these sites are generally small and used for non-transportation uses (e.g. daycare) they are not expected to provide charging location opportunities.

The Nasson Healthcare site is located at 15 Oak St., in Springvale, on the former campus of Nasson College, which closed in the 1980s. The property is currently divided between a variety of public and private landowners, as shown in Figure 12. This complex arrangement may make attempts at infrastructure development (e.g. installation of a bus shelter) politically challenging. However, there are no spatial obstacles to installation of a charger. In addition, because multiple government entities are present on the site, it is likely that YCCAC will be able to form a partnership with one of these organizations to advance vehicle electrification, which is a State priority.

Figure 12 Nasson Healthcare Site and Property Lines (Source: AxisGIS)

The Wells Regional Transportation Center, shown in Figure 13, is an Amtrak train station located at 696 Sanford Rd. in Wells, Maine. This site is owned by the Maine Turnpike Authority and has several acres of parking lots and unused land that could be used for charging infrastructure. Although it is not near YCCAC's primary operations in the Sanford area, it is located in close proximity to the seasonal trolley services and is the terminal of the Blue 4b service. Therefore, it is an ideal candidate for a trolley charging and overnight storage location. Although there are several possibilities for the specific location of chargers within the WRTC, this study assumed that they are placed in the existing bus parking area. This area could be expanded if significant use by non-YCCAC buses during summer overnight periods is expected.

Figure 13 Wells Regional Transportation Center (Source: Google Earth)

The Sanford Seacoast Regional Airport, located at 199 Airport Rd. in Sanford is closer to YCCAC's headquarters and has ample space for future charging infrastructure. The airport is also the site of the largest solar array in New England, shown in Figure 14, ensuring that any electricity used for charging will be as renewably-sourced as possible. However, it is not located near a terminal for any flex-route services, so charging any cutaway or trolley vehicles would require significant deadheading each day. Therefore, it was not selected as a charging location for further study.

Figure 14 Sanford Airport Solar Farm

As mentioned above, the BSOOB facility at 13 Pomerleau St in Biddeford is used to maintain a portion of the YCCAC fleet. Because maintenance typically occurs during the daytime (when revenue vehicles are not charging), and since BSOOB plans to install additional chargers to continue its fleet electrification, Hatch expects that BSOOB will be able to continue maintaining YCCAC vehicles after electrification without needing to install chargers especially for that purpose.

10. Electrical, Infrastructure, and Utility Capacity

Section Summary

- The existing service at 6 Spruce St. is likely at capacity.
- 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 YCCAC's proposed charging locations at the YCCAC office, Nasson site, and Wells RTC. As part of the development of this transition plan, YCCAC has been partnering with Central Maine Power to communicate its projected future utility requirements at these locations.

The 6 Spruce St. facility has a 12.47 kV 3-phase service that is stepped down to 480/277V through a step-down transformer located outdoors, as shown in Figure 15. The transformer feeds a 480V panel located inside the electrical room. This main 480V panel appears to be at capacity with no spare breakers for the centralized charger that is recommended earlier in this report. Additionally, because the panel schedule and utility drawing were not available at the time of this analysis, space availability on 120/208V panels could not be determined. However, given that a new 480V panel will likely be required for the centralized charger and a new service with separate meter is required to qualify for the special B-DCFC rate structure, Hatch recommends installing a brand new 480V service under a separate meter, with a new 480V panel and a 120/208V panel dedicated for the charging operation. As mentioned previously, the centralized charger requires a 480V 3-phase input while the level 2 chargers, that are also recommended for this site, require either 1-phase 208V or 240V input.

Figure 15 6 Spruce St. Electrical Distribution Transformer

Hatch has confirmed with Central Maine Power that, as of this writing, it can accommodate a new service and required power at the 6 Spruce St. facility. However, the local feeder is approaching its rated capacity and availability of the power is not guaranteed in the future. Hatch highly recommends engaging with Central Maine Power very early in the design stage for its chargers to ensure that the utility has time to upgrade their assets in the area if required. Central Maine Power has provided an initial estimate for the new transformers and service feed to be approximately $50,000. This cost estimate is based on the current available capacity, and it could increase if additional capital investments are required by Central Maine Power to upgrade local distribution assets.

In addition, a similar new 480V service will be required at the Nasson site and Wells RTC for the DCFC chargers, 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. As YCCAC plans to adopt electric vehicles comparatively quickly and is looking to purchase relatively non-standard types of vehicles, it will be critical for YCCAC to develop its operating strategy 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 RTP.
+ Reach a "mutual aid" agreement with another transit agency in Maine that would let YCCAC borrow spare buses/vehicles in case of difficulties with its fleet. For example, YCCAC may arrange to borrow a 35' bus from BSOOB if the Southern Maine Connector vehicle is unavailable on a given day, or to borrow a van from RTP to cover for shortfalls in the demand-response fleet.
+ 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 Southern Maine Connector, Sanford Transit, and seasonal trolleys, 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 locations where chargers and electric vehicles will be housed (see section 12b).

11b. Electrical Resiliency

Electricity supply and energy resilience are important considerations for YCCAC 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 YCCAC 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 6 Spruce St. facility currently does not have any generator for backup power during electrical service interruption. Because of the limited real estate and orientation of the building roofs, the site does not have enough space available for a meaningful solar array installation. Resiliency options in the form of an on-site storage system or on-site generator should be considered for this location for service reliability.

The Nasson Health Center also does not have any backup power. Like the 6 Spruce St. facility, due to the space constraints, solar is not feasible at this location and backup power in form of on-site storage system or on-site generator should be considered.

The Wells Regional Transportation Center has 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

After noting no viable resiliency systems in place currently, Hatch assessed potential resiliency options. The first step in that assessment was to analyze the power outage data for the utility feeds that supply power to the three locations to determine the requirements for backup power. Following is a summary of the outages at each of the locations in the last five years. Appendix C shows the outage data provided by Central Maine Power for reference.

+ 6 Spruce St. facility – There were only five outages at this location in the last five years. Out of the five outages, the one in 2019 lasted for approximately 2.5 hours. This outage was caused by a squirrel contact and was the longest one in the last five years. The rest of the outages were very insignificant and only lasted for less than 2 mins.
+ Nasson Health Center – There were only seven outages at this location in the last five years. Most of the outages were minor and lasted between 0.5 and 2 hours.
+ Wells Regional Transportation Center – There were total 18 outages at this location in the past five year. Out of these 18 outages, one was the most significant one that lasted for 28 hours. There were two other outages that were long and lasted 13 and 15 hours each. The remaining outages lasted anywhere between 1 and 5 hours.

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.

At the 6 Spruce St. location, the on-site energy storage requirement to charge the fleet during the 2.5 hour outage period would be 245 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 306 kWh. The power requirement for generator capacity was assumed to be the aggregated power draw required during overnight charging for the fleet, which is 98 kW. Assuming an efficiency of 90%, and a 20% spare capacity, the resulting on-site generation capacity required would be approximately 140 kVA.

At the Nasson Health Center, the on-site energy storage requirement to charge the fleet during the 2-hour outage period would be 176 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 220 kWH. The power requirement for generator capacity was assumed to be the aggregated power draw required during overnight charging for the fleet, which is 89 kW. Assuming an efficiency of 90%, and a 20% spare capacity, the resulting on-site generation capacity required would be approximately 125 kVA.

At the Wells Regional Transportation Center, the on-site energy storage requirement to charge the fleet during the 28-hour outage period would be 1363 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 1704 kWh. The power requirement for generator capacity was assumed to be the aggregated power draw required during mid-day charging for the fleet, which is 91 kW. Assuming an efficiency of 90%, and a 20% spare capacity, the resulting on-site generation capacity required would be approximately 130 kVA.

Hatch next generated cost estimates associated with the two resiliency system options for all three facilities. 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 Worst Case Outage Scenarios

		Size	Capital Cost
Option 1 On-site Battery Storage	6 Spruce St. facility	245 kWh	$160,000
	Nasson Health Center	176 kWh	$115,000
	Wells RTC	1704 kWh	$1,082,000
Option 2 On-site Diesel Generation	6 Spruce St. facility	140 kVA	$65,000
	Nasson Health Center	125 kVA	$58,000
	Wells RTC	130 kVA	$60,000

The above analysis and corresponding options are based on an assumption of full service operated and maximum-duration outages. 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 YCCAC'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 can also be considered to add resiliency, offset energy costs, and further reduce YCCAC'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.

As discussed previously, 6 Spruce St. and Nasson Health Center are too space constrained for a meaningful solar installation. However, on-site solar system was evaluated for the Wells Transportation Center because the 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 16 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 at this site, the surface area that is required for the solar panels, and the resulting cost savings from offsetting energy consumed from the grid.

Table 7 Wells Transportation Center Solar Field Design Parameters

Solar System Design Parameters	
Solar System Sizing Method:	Full Annual Energy Match
Solar Array Area Width	49 ft
Solar Array Area Length	65 ft
Solar Array Area	3,325 ft^2
Maximum Number of Panels	150 panels
Maximum System Power	64 kW
Annual Production Coefficient	1,318 hours
Sunny Days Per Year	200 days
Annual Solar Energy Production	83,833 kWh
Annual Electric Usage	79,911 kWh
Maximum Percent of Electrical Usage Offset	105%
Electricity Rate	$0.12954 / kwh
System Cost	**$175,137**
Utility Bill Savings Per Year	**$10,860**
Simple Payback Period Without Grants	**16.1 years**
Payback Period with 80% Federal Grants	**3.2 years**

Based on the above parameters, YCCAC would need to install approximately 3,325 ft^2 of solar panels by surface area to offset the energy used for charging trolley buses over the year. This, however, does not mean that the charging operation can be performed completely off grid. YCCAC still needs the utility connection for charging during the days when there is not enough sunlight, as well as for charging during the summer months. In the winter, when no charging will occur, the solar array will produce excess energy; this energy can either be sold back to the grid or stored in the on-site energy storage system for later use.

An on-site battery storage system would not only allow 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 YCCAC's GHG contribution by reducing energy consumed from the grid, which is partially produced using GHG emitting conventional energy sources.

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.

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. A more detailed study should be conducted to determine the battery energy requirements.

12. Conceptual Infrastructure Design

12a. Conceptual Layouts

Section Summary

- Hatch recommends installing chargers at:
  - The southwestern parking lot at 6 Spruce St.
  - The Springvale public library at the Nasson site
  - The existing bus parking area at Wells RTC
- At the Nasson site and Wells RTC, public-sector landowners may be more ready to cooperate on vehicle electrification, which is a State initiative

To assist YCCAC with visualizing the required infrastructure transition, conceptual plans were next developed based on the previous information established in this report. Due to spatial constraints, Hatch recommends that the charging infrastructure be placed outdoors at each charging location.

At the 6 Spruce St. location, multiple parking lots are available for potential charger installation. Chargers could potentially be constructed at any of them. Key considerations for selecting optimal charger location include vehicle maneuverability into the parking space, proximity to charging cabinets, nearby underground utilities, sight lines and vehicle circulation around parked vehicles, ease of snow clearance, and security. In light of these factors, and in keeping with YCCAC's existing vehicle storage practices, Hatch recommends installing the chargers at the southwestern parking lot, closest to downtown Sanford. The most optimal location for dispenser installation is along the western property line, allowing the berths with easiest access to and from the main driveway to be used by the (larger) electric vehicles. Figure 16 shows a conceptual layout for the proposed chargers. In addition to the chargers, YCCAC should install fencing and cameras to deter any potential vandalism to the vehicles or chargers.

Figure 16 Conceptual Layout of Chargers at the 6 Spruce St. Facility (Source: Google Earth)

At the Nasson Healthcare site, any decision on charger location will be highly dependent on agreement with local stakeholders. In addition to the considerations outlined above for 6 Spruce St., the ideal charger location at the Nasson site will allow YCCAC vehicles to pull out of the flow of traffic while charging, as well as being in a location easily accessible by the public during off-hours. Figure 17 shows one possible location for the charger; this location offers the advantage of being located on a single property owner's land, potentially easing implementation.

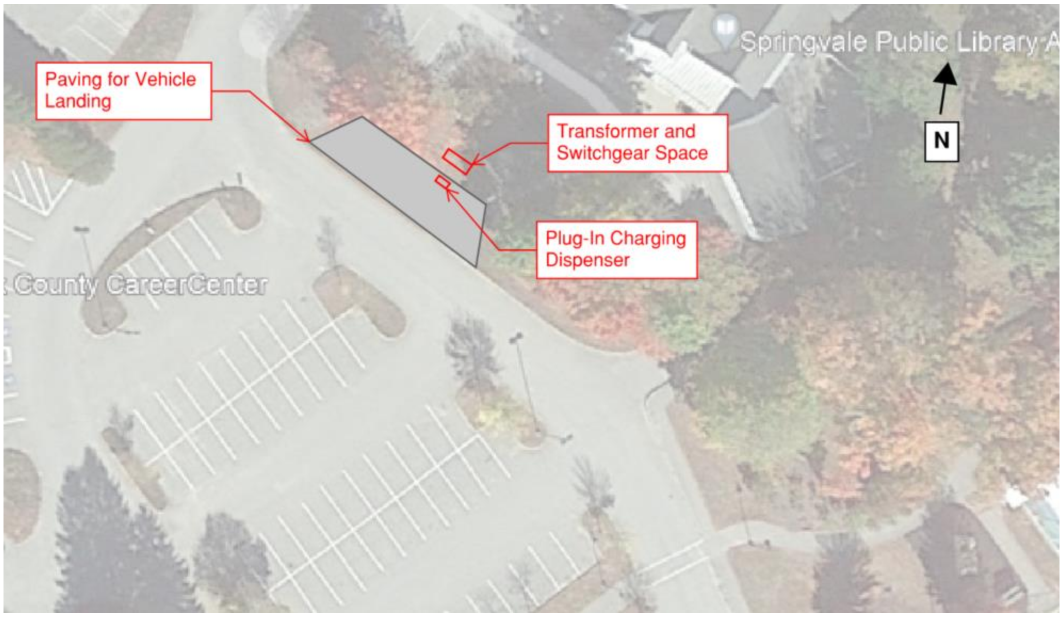

Figure 17 Conceptual Layout of Charger at the Nasson Healthcare Site (Source: Google Earth)

At the Wells Regional Transportation Center, the preferred location for the chargers – and the decision on whether to use existing parking spots for the chargers or create additional paved area – will require consultation with the Maine Turnpike Authority and local leadership. This study assumed that the existing bus parking area is used as a charging station. If significant usage by non-YCCAC buses is expected during summer overnight periods (which is when the maximum number of trolleys would be parked there), the lot could potentially be expanded. Assuming this is not necessary, the space and chargers could be made available for public use during midday hours as well as throughout the off-season, with signage or a charge management system enforcing priority for YCCAC vehicles during trolley charging times. Figure 18 shows a potential layout for the chargers at WRTC.

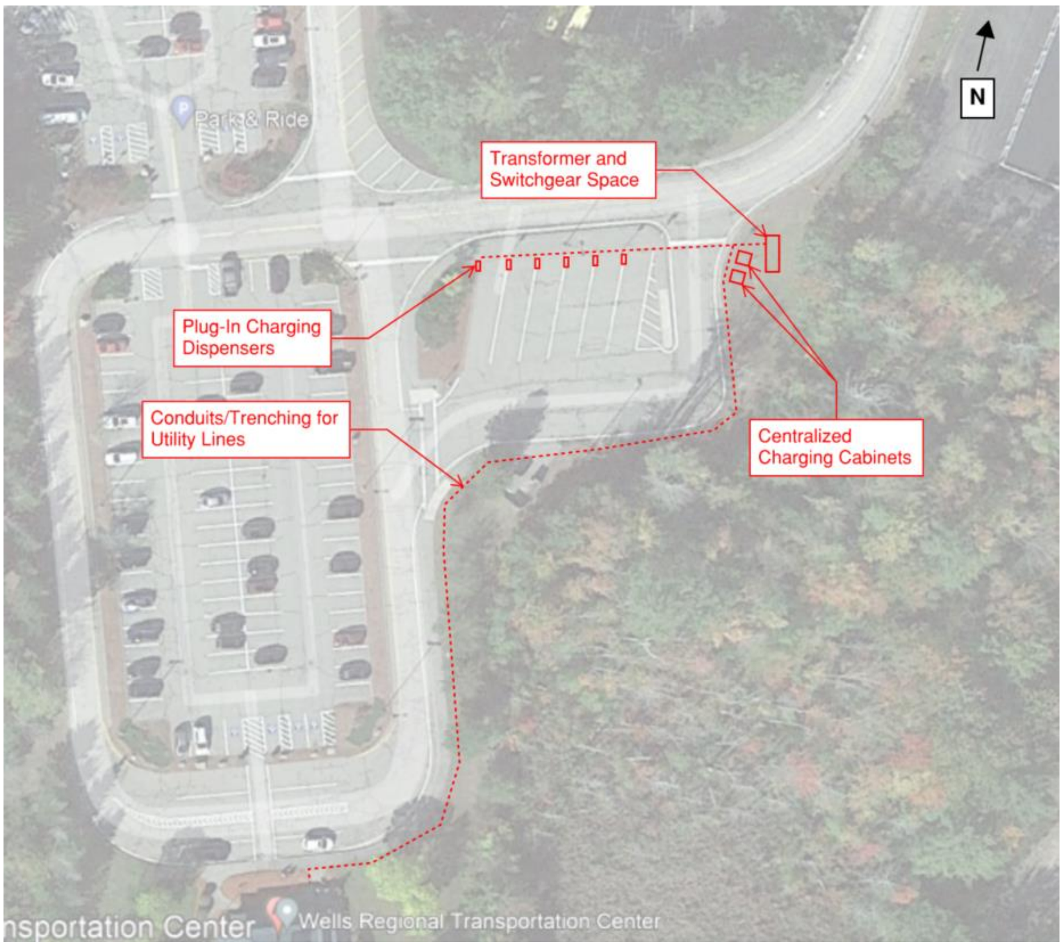

Figure 18 Conceptual Layout of Chargers at the Wells Regional Transportation Center (Source: Google Earth)

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 area.

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 YCCAC's risk is comparatively low because all vehicles will be charged outdoors, Hatch still recommends that YCCAC 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 YCCAC does not maintain staff at the depot overnight, responding firefighters could potentially be trained to fulfill this function during their response to an incident. Each of the factors mentioned above requires specific consideration with respect to YCCAC's facility and operations. Hatch recommends that YCCAC 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 YCCAC to help fund electrification
- State and local support will be required as well

YCCAC's current operating budget is roughly $2.8 million per year. The agency's funding sources are summarized in Figure 19. As can be seen in the figure, YCCAC'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.

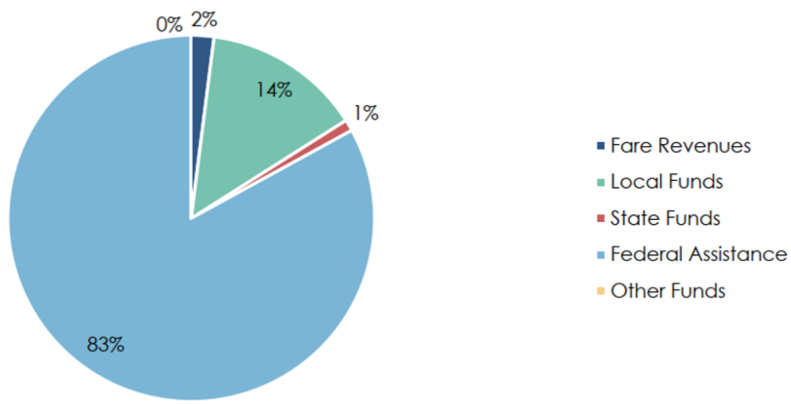

Figure 19 Current Agency Funding Summary (Source: Maine DOT)

As the agency transitions to hybrid and battery electric technology, additional policies and resources will become applicable to YCCAC. Table 8 provides a summary of current policies, resources and legislation that are relevant to YCCAC'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 YCCAC with guaranteed funding sources. Therefore, this analysis assumes that YCCAC will only receive funding through the largest grant programs that provide the highest likelihood of issuance to the agency. Specifically, this analysis assumed that YCCAC 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 YCCAC

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. (*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

Hatch calculated the life cycle cost (LCC) of the proposed transition strategy and compared it to maintaining YCCAC'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 summer weekday service levels analyzed above and scaled to account for weekends, holidays, and the off-season, 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.

Section Summary

- Vehicle electrification will save YCCAC money over the long term, as electric vehicles cost less to maintain and fuel
- Upfront capital costs increase by approximately 126% and annual operating cost will decrease by approximately 6%, yielding a net 6% increase in total cost of ownership

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, YCCAC 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 trolleys is 14 years and of other vehicles is 7 years, in accordance with YCCAC practice.

- All demand response vehicles are replaced with vans at their expected retirement year.
- YCCAC will make capital investment on the installation of charging infrastructure at all locations described previously; partnerships with other entities are not considered.

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 YCCAC's figures and general industry trends and have been escalated to 2022 dollars where necessary, with capital costs estimated based on industry references as specified in Appendix D.

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
Gasoline Trolley	$325,000
Hybrid Trolley	$375,000
Electric Trolley	$800,000

Expense	Estimated Cost (2022 $'s)
Gasoline Vehicle maintenance	$0.84 / mile
Hybrid Vehicle maintenance	$0.84 / mile
Electric Vehicle maintenance	$0.63 / 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 14-year vehicle lifespan for trolleys and 7-year lifespan for other vehicles. 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 20 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	$1,020,889	$2,115,545	+126%
Infrastructure Capital Costs	$0	$197,743	
Vehicle Maintenance Costs	$2,667,706	$2,220,570	-6%
Infrastructure Maintenance Costs	$0	$101,227	
Operational Cost	$7,652,358	$7,397,596	
Total Life Cycle Cost	**$11,340,953**	**$12,032,681**	+6%

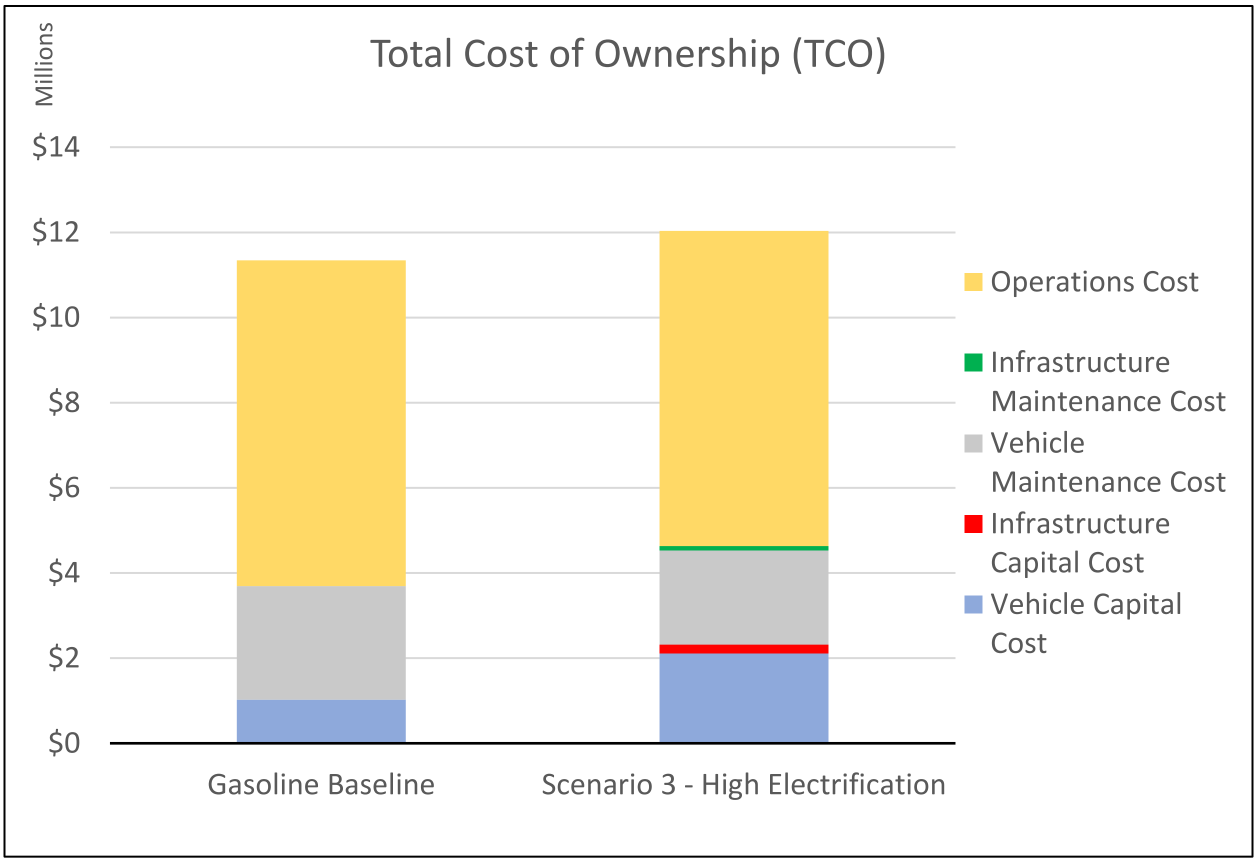

Figure 20 Life Cycle Cost Comparison

As shown in Figure 20, 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 three charging locations, 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. This is particularly true for uncommon vehicle types, such as electric trolleys, which do not benefit from manufacturer economies of scale. These factors yield a 126% increase in capital costs over the gasoline baseline. This initial, non-recurring cost is mostly 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 6% 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 offset much of the initial extra capital spending, yielding a net-present-value increase of approximately 6%.

The proposed fleet transition requires initial capital spending to reduce operating 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 126% 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 YCCAC 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 YCCAC 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 YCCAC 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 YCCAC.

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. These two factors are estimated to reduce YCCAC'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.

YCCAC plans to order 80 vehicles over the next 17 years and their orders can easily be allocated to purchasing contracts. The 2023, 2024, and 2026 order for vans can be part of a 42-vehicle order purchased together with RTP; the 2030, 2031 and 2033 order for vans can be part of a 46-vehicle order purchased together with RTP and Downeast; the 2037, 2038, and 2040 order for vans can be part of a 42-vehicle order purchased together with RTP; the 2026 order for cutaways can be part of a 16-vehicle order purchased together with RTP and Downeast; the 2033 order for cutaways can be part of a 16-vehicle order purchased together with RTP and Downeast; and the 2036 order for trolleys can be part of a 15-vehicle order purchased together with BSOOB. The 2024 order for trolleys will have to be purchased solely by YCCAC.

In summary, although this analysis assumed that YCCAC 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 10% cost saving for the agency.

15. Emissions Impacts

One of the motivations behind YCCAC'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 YCCAC.

Hatch calculated the anticipated emissions reductions from YCCAC's transition plan to quantify the plan's contribution toward meeting the state's emissions reduction goals.

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 63-70%

To provide a complete view of the reduction in emissions offered by the transition plan, the effects were analyzed based on three criteria:

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

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 YCCAC's existing gasoline fleet were calculated. These calculations used industry emissions averages for gasoline vehicles and YCCAC'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 YCCAC 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 21 summarize the results of the emissions calculations. These results demonstrate that the transition plan will achieve 63% emissions reduction assuming the grid mix that existed in 2020, or 70% 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, YCCAC's transition plan will let the agency exceed 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	264,540	447,314	-----	711,854	-----
Future Fleet (2020 grid mix)	68,828	116,382	80,292	265,501	63%
Future Fleet (2030 grid mix)	68,828	116,382	26,496	211,706	70%

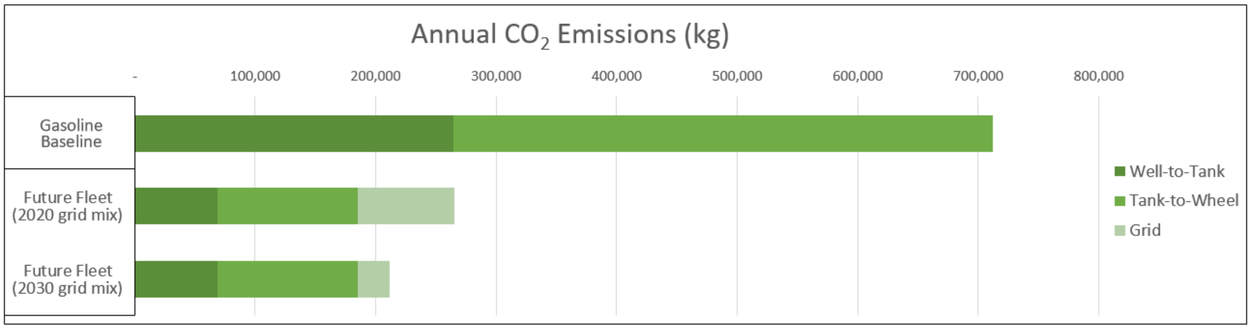

Figure 21 Graph of CO_2 Emissions Estimate Results

Should YCCAC 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 for the remainder of the demand-response fleet

16. Workforce Assessment

YCCAC 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 YCCAC'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 YCCAC 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
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

Although BSOOB maintenance staff (who maintain some YCCAC vehicles) have gained many of these skills as part of that agency's recent acquisition of two electric buses, for long-term successful electrification YCCAC will need to train its own workforce as well. To address these training requirements Hatch recommends that YCCAC consider the following training strategies:

- Add requirements to the operations contract for the system operator to train its staff on the safe operation and inspection 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

Section Summary

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

As part of this study, YCCAC 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, YCCAC currently favors the transition plan presented in this report. Details on the alternative plans are presented in Appendix B and D. Should YCCAC'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 YCCAC review this transition plan on an annual basis to reevaluate the assumptions and decisions made at the time this report was authored.

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 YCCAC 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, YCCAC 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 YCCAC 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 and hybrid 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.
  - Reach an agreement with BSOOB regarding electricity use during vehicle maintenance.
- For the infrastructure at 6 Spruce St., the Nasson site, and Wells RTC:
  - Negotiate with landowners at the two non-YCCAC sites to coordinate charger installation.
  - Upgrade the electrical utilities to support charging infrastructure as 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 126% 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. Alternative Transition Strategy Presentation
C. Utility Outage Data
D. Life Cycle Costing Models