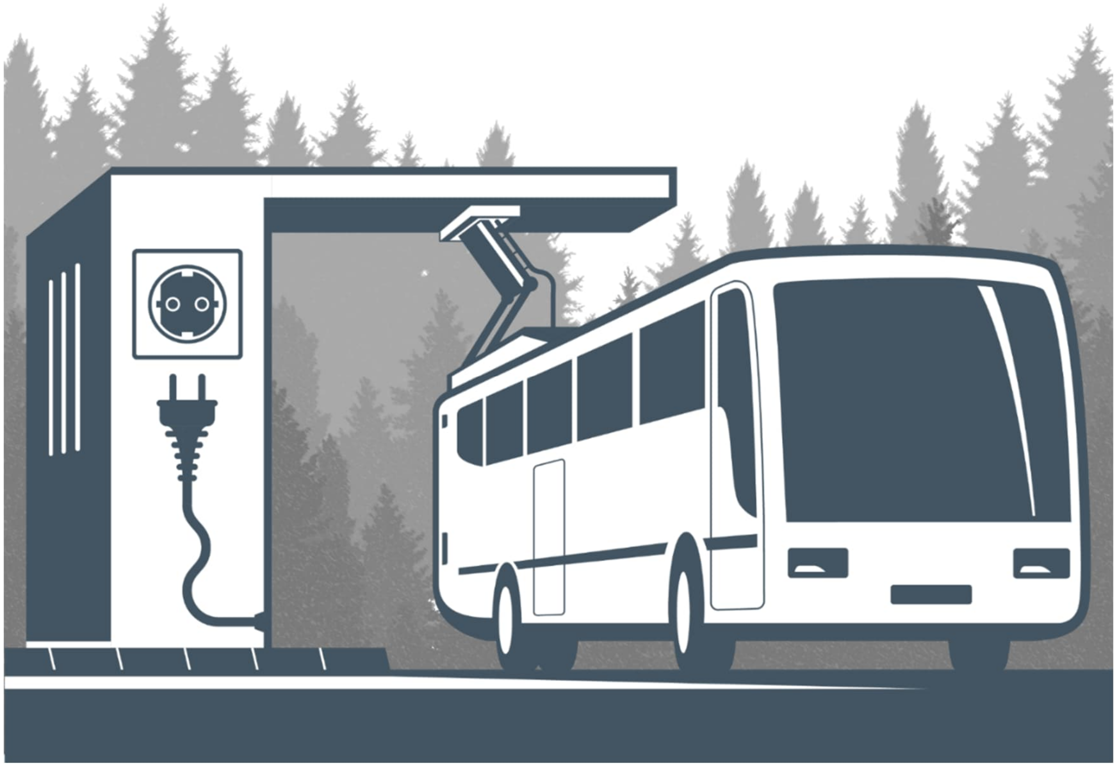

Vehicle Electrification Transition Plan for Waldo Community Action Partners (WCAP)

Waldo Community Action Partners
WCAP
we care about people

Prepared by:
HATCH

Version: 5.0
12/5/2024

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1. Executive Summary

Waldo Community Action Partners (WCAP) is currently considering transitioning its fleet to battery electric vehicles. To effectively plan for this transition a thorough analysis was conducted to develop a feasible strategy for the agency. This report summarizes the results of the analysis for asset configuration, emissions, and the costs associated with the transition.

Through this analytical process, WCAP has expressed a preference for fleet and infrastructure asset configurations that will provide a feasible transition to battery electric vehicles while supporting the agency's operational requirements and financial constraints. The selected configuration maintains the agency's current fleet size of 34 vehicles, replacing 3 flex-route and 2 fixed-route vehicles with electric cutaways, and replacing 3 demand-response vehicles with electric vans. To support these vehicles, three Direct Current Fast Chargers (DCFC) and eight level 2 charging stations will be installed in the main storage facility in Belfast, Maine that is currently under development. In addition, Waldo CAP is recommended to negotiate charger use agreements with KVCAP (in Waterville) and the owner of Rockland Plaza in Rockland. At this stage, no chargers are recommended at the satellite hubs in Rockland and Bath to minimize capital spending and keep most of the electric vehicles consolidated to a single location for ease of maintenance.

One of the primary motivations behind WCAP's transition to battery electric vehicles is to achieve emissions reductions compared to its existing gasoline operations to be in line with the State of Maine's Clean Transportation Roadmap. As part of this analysis, an emissions projection was generated for the proposed future hybrid and battery electric fleet. The results of this emissions projection estimate that the new fleet will provide up to a 19% reduction in emissions compared to WCAP's existing gasoline operations. This reduction will be achieved while increasing lifetime cost by only 1%, albeit with an 85% increase in upfront capital spending.

The conclusion of the analysis is that although battery electric vehicles are not yet ready for complete replacement of WCAP's fleet, the agency would benefit from beginning the transition with a small pilot for all three of the service categories it operates (flex-route, fixed-route, and demand-response). These vehicles offer the potential for the agency to greatly reduce emissions, though significant upfront capital spending will be required. Further, WCAP will gain the required skillsets and operating experience for future electrification once the technology advances further. Therefore, WCAP 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" that encourages Maine's transit agencies to transition their bus fleets to hybrid and battery electric vehicle technologies.

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

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

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

3. Existing Fleet Status

Waldo Community Action Partners (WCAP) is a regional transportation program providing transit services in the Mid-Coast Region of Maine. WCAP operates deviated flex-route and demand-response services throughout Waldo, Knox, Lincoln, Cumberland, and Sagadahoc counties, Maine area, and operates two small city bus services in Belfast and Rockland. The agency

Section Summary

- Waldo CAP operates flex-route and demand-response services throughout Waldo County, and two city bus services in Belfast and Rockland, with a fleet of 34 vehicles.
- Mileage of on-demand service vehicles varies between 50 to 275 miles, with the average vehicle traveling 200 miles a day.

currently owns and operates a total fleet of 34 passenger vehicles.

Table 1 Current Vehicle Roster

Vehicle Type/Roster Number	Fuel Efficiency (MPG)	Number of Vehicles	Procurement Date/Age	Projected Retirement Date
Chevrolet Stratton – Cutaway (84)	8	1	2022	2029
Dodge Caravan – Non-ADA Minivan (37)	15	1	2016	2023
Dodge Caravan – Minivan (74)	15	1	2019	2026
Dodge Entervan – Minivan (50)	15	1	2016	2023
Dodge Rear Enter – Minivan (52)	15	1	2017	2024
Ford Champion – Cutaway (9)	8	1	2016	2023
Ford Connect – Van (75, 78, 79)	17	3	2022	2029
Ford Goshen coach – Cutaway (62)	8	1	2015	2022
Ford Senator – Cutaway (64, 65, 66)	12	3	2019	2026
Ford Starcraft – Cutaway (69, 71)	8	2	2018	2025
Ford Transit – Van (57, 58, 60)	12	3	2017	2024
Ford Transit – Van (53, 54, 55, 56)	12	4	2018	2025
Ford Transit – Van (47, 48, 49, 67, 72)	12	5	2019	2026
Ford Transit – Van (63)	12	1	2020	2027
Ford Transit – Van (70)	12	1	2021	2028
Ford Transit – Van (80, 81, 82, 83)	12	4	2022	2029
Toyota Sienna – Non-ADA Minivan (73)	18	1	2018	2025

WCAP currently does not maintain an agency-owned bus depot. Rather, WCAP leases its primary hub at Belfast as well as two satellite facilities in Bath and Rockland. In 2021, WCAP purchased a land parcel that is currently under development, and will house a new primary hub. WCAP plans to consolidate all agency services into this one place in 2025 or 2026, including a modern transit facility. Current leased locations in Belfast, Bath, and Rockland are shown in Figure 1 below.

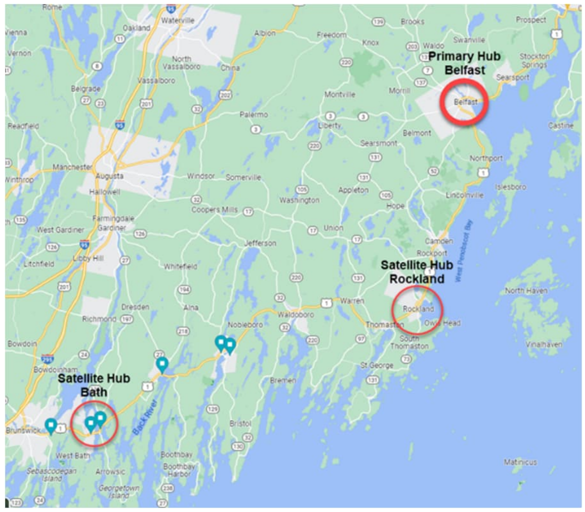

Figure 1. Primary and Satellite Hub locations in Belfast, Rockland, and Bath.

WCAP operates the following passenger services:

City Bus Services

- Belfast Dash: Fixed-route service around the Belfast area, operated with 1 cutaway.
- Rockland Dash: Fixed-route service around the Rockland area, operated with 1 cutaway.
- Services operate from Monday through Friday, from 8:00 AM to 4:00 PM.

Flex-Route Ride Services

- Flex-route service to different destinations through 10 different routes, operated with 4 cutaways:
  - To Waterville – through Belfast, Waldo, Brooks, Knox, Thorndike, Unity, Burnham. Operates 1st and 3rd Monday of the month.
  - To Augusta – through Belfast, Belmont, Morrill, Searsmont, Montville, Liberty, Palermo. Operates 2nd and 4th Monday of the month.
  - To Rockland – through Belfast, Northport, Lincolnville. Operates 2nd and 4th Tuesday of the month.
  - To Belfast – through Searsport. Operates Monday through Friday.
  - To Belfast – through Troy, Unity, Thorndike, Freedom, Knox, Jackson, Brooks, Waldo. Operates every Tuesday.
  - To Belfast – through Winterport, Frankport, Stockton Springs, Searsport. Operates every Wednesday.
  - To Bangor – through Belfast, Searsport, Stockton Springs, Prospect, Frankfort, Winterport. Operates every Friday.
  - To Belfast – through Swanville, Monroe, Jackson, Brooks, Waldo. Operates every Wednesday.
  - To Belfast – through Lincolnville Ctr., Lincolnville Beach, Northport. Operates every Wednesday and Friday.
  - To Belfast – through Palermo, Freedom, Montville, Liberty, Searsmont, Morrill, Belmont. Operates every Thursday.

+ Service operates from 7:30 AM to 4:50 PM.

Demand-Response Services

+ Demand-response services are scheduled in coordination with Medicaid Non-Emergency Medical Transportation (NEMT) and other contractual demand-response services.
+ Demand-response fleet is comprised of 28 vehicles including cutaways, vans, and minivans, distributed between the primary and secondary hubs at Belfast, Rockland, and Bath.
+ Vehicles covering this service generally travel between 50 to 275 miles daily.
+ Approximately 20% of vehicles return to depot at some point on an average day.
+ About 80% of trips are not local – trips to rural areas across several counties.

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 WCAP lower procurement cost.

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

Figure 2. Electric Cutaway Vehicle

There are a variety of possible battery-electric vehicles for WCAP to utilize. Battery capacity can be varied on many commercially available vehicle platforms to provide varying driving range. For this study, battery electric cutaways were assumed to have 125 kWh battery capacity, and battery electric vans were assumed to have 118 kWh, which is a representative value for the range of batteries offered by the industry. Two types of safety margins were also subtracted from the nominal battery capacity of the vehicle. First, the battery was assumed to be six years old (i.e. shortly before its expected replacement). As batteries degrade over time, their capacity decreases. To account for this, the battery capacity was reduced by 20%. Second, the vehicle was assumed to need to return to the garage before its level of charge falls below 20%. This is both a manufacturer's recommendation – batteries have a longer life if they are not discharged to 0% – and an operational safety buffer to prevent dead vehicles from becoming stranded on the road. Combining these two reduction factors yields a usable battery capacity of 64% of the nominal value (80 kWh and 75.5 kWh respectively). Finally, as the industry is advancing quickly and technology continues to improve, a 3% yearly improvement in battery capacity was assumed.

5. Infrastructure Technology Options

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

Power distributed by electrical utilities, both at high voltages in long-distance transmission lines and low voltages in conventional wall outlets, is alternating current (AC), while batteries on vehicles use direct current (DC). Smaller vehicles that require lower power levels generally accept both types of power and have onboard rectifiers to convert AC input to DC. Accepting AC power reduces the cost of charging equipment. For larger vehicles the required rectifier would be too heavy, so the conversion to DC is conducted within the charger. This limitation 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. De-centralized
2. 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, as is typically found in chargers for automobiles. An example of a de-centralized charging system is shown in Figure 4. 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.

Figure 4. Example Charging System (Source: Heliox): Charging Cabinet with Built-in Dispenser

6. Route Planning and Operations

Section Summary

- Electric vehicles do not offer comparable operating range to gasoline vehicles – so detailed operations modeling is needed.
- Electric cutaways cannot cover WCAP's Belfast and Rockland City Bus route without midday charging.
- Six of the ten flex-routes can be electrified with charging at Belfast only.

WCAP'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 WCAP'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. Electric vehicles, on the other hand, will need further scheduling considerations due to reduced range, particularly in winter months. Vans and cutaway shuttles typically do not have auxiliary heaters to reduce the power required for heating, like transit buses; in addition, icy road conditions and cold temperatures reduce 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 Rockland and Belfast City Bus services, as well as many of the longer demand-response vehicle runs. This shortcoming will be particularly limiting if recommended practices like pre-conditioning the vehicle before leaving the garage are not always followed.

WCAP's demand-response service operates between 6:30 AM and 4:30 PM, although service extension (using split driver shifts) to operate up to 14 hours a day has been considered. HBSS QRyde software is used to minimize downtime and optimize route efficiency. The vehicles typically do not have long down-times between pick-ups. Therefore, to avoid significant impacts to operations, the electric demand-response vehicles will need to have enough range for a full day of service with minimal top-up charging. Although most demand-response vehicles park at depot, around 10% of WCAP's demand-response fleet is parked overnight at the drivers' home to avoid lengthy deadheads to the depot. Doing so with electric vehicles would pose challenges with charging compatibility and driver reimbursement and is best avoided, at least in the short term.

6a. Operational Simulation

To assess how battery electric vehicles' range limitations may affect WCAP'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 WCAP's operations.

Hatch conducted a route-specific electric vehicle analysis by generating a drive cycle for the Rockland and Belfast City Bus routes, as well as for a route representative of demand-response operation. The full geography (horizontal and vertical alignment), transit infrastructure (location of key stops), road conditions (vehicle congestion, as well as traffic lights, stop signs, crosswalks, etc.), and use of the wheelchair lift were modeled, and the performance of the vehicle was simulated in worst-case weather conditions (cold winter) to create a drive cycle. These WCAP-specific drive cycles were used to calculate the energy consumption per mile and therefore total energy consumed by the vehicle.

As discussed in the previous section, the resultant runs were evaluated against a common electric cutaway with a 125-kWh battery and a van with a 118 kWh battery. The electric vehicles expected to be procured for the initial pilot were based on vehicles available on the market as of this writing; further procurements will be governed by the performance of the initial vehicles. If battery electric technology advances faster than anticipated, or if the existing fleet proves reliable and can outlast its 7-year lifespan, more flex-route and demand-response service will be available for electrification. Conversely, if technology develops more slowly or the existing fleet requires replacement sooner, a pilot deployment may remain the practical limit for the foreseeable future.

Table 2 below presents the mileage and energy requirements for WCAP operations. Green shading denotes those runs that can be operated by the specified vehicle and red shading denotes those that cannot.

Table 2 Energy Requirements by Run

Block	Mileage	kWh Required	kWh Required Considering Midday Charging	Mileage Shortage/Excess
Flex 1	133	129	64*	15
Flex 2	140	137	137	-58
Flex 3	59	57	57	23
Flex 4	65	64	64	17
Flex 5	20	19	19	62
Flex 6	170	165	82	-2
Flex 7	82	80	80	0
Flex 8	78	76	76	4
Flex 9	69	67	67	13
Flex 10	171	167	83	-3
Belfast DASH	62	91	52	19
Rockland DASH	85	125	71**	6

*Charging at Waterville **Charging at Rockland Plaza

For demand-response service, the high-level available information on vehicle utilization (50-mile minimum daily mileage, 200-mile average, 267-mile maximum) was extrapolated into a cumulative mileage distribution by vehicle across the fleet, assuming a normal distribution of mileage. This was compared to the ranges of an electric van and cutaway. Although WCAP prefers to keep these vehicles running for the entire day, if possible, 30- or 60-minute charge windows were assumed in the middle of the day to maximize achievable range. The results of this comparison are presented below.

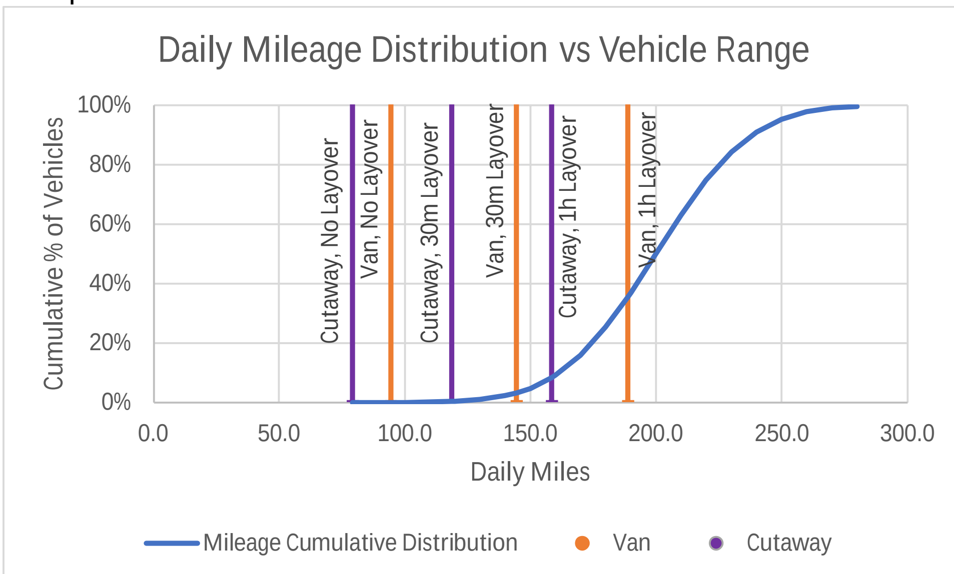

Figure 5 Daily Mileage Distribution vs Vehicle Range, Demand-response

6b. Operational Alternatives

As shown in Table 2, half of all flex and fixed-routes are feasible for operation with an electric vehicle without midday charging, and 75% of all routes are feasible if midday charging is used.

For the routes that do not require midday charging (Flex 3, 4, 5, 7, 8, and 9), no change from existing operations is needed. The vehicles will be able to leave the depot in the morning, deadhead to their starting location, operate their scheduled trips, and return to the depot.

For the vehicles that require midday charging, sufficient charger provision and schedule coordination will be required to ensure that each vehicle can use a charger when it is scheduled to. It is best practice to schedule vehicles to always allow at least one spare charger; this will minimize peak power demand and improve operational resiliency in case of vehicle delay, charger failure, or other issues. For vehicles spending the midday period in Belfast, this will be comparatively simple, as they will charge at a WCAP-owned facility. For vehicles charging elsewhere this will require additional coordination. For the Flex 1 vehicle (which is expected to charge at KVCAP's facility in Waterville, assuming that chargers are installed there), WCAP and KVCAP will have to coordinate their schedules to make sure that the fast charger there is not intended for use by two vehicles at the same time. Meanwhile, for the Rockland DASH route – which is proposed to charge at the Rockland Plaza fast charging station to avoid requiring the expense of a standalone charger – WCAP may need to adjust the DASH operating schedule to avoid midday peak usage times for the public charging station. Before and after the service day, the vehicle will need to charge as well, as there will be no WCAP-owned charger in Rockland. This could occur at the Rockland Plaza charging station before its first trip or after its last trip, at another charging station in Rockland (e.g. the MaineDOT charging station at 517 Main Street), or by deadheading back to the main hub in Belfast.

For demand-response services, the cycles with the shortest mileage will have to be chosen each day to enable electric vehicle operation. If these vehicles will have driver lunch breaks near Belfast, or near another public fast-charging station, their range could be replenished during the lunch break. However, this will be difficult to rely on for daily operation, as the locations of passenger pickups and drop-offs vary. Although HBSS QRyde and dispatcher expertise will help WCAP choose the best runs on which to assign electric vehicles, a small demand-response pilot fleet is recommended as WCAP will gain experience with range-constrained demand-response operations. 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 WCAP's operations are feasible for electrification and the higher a proportion of the fleet Hatch recommends that WCAP make electric.

7. Charging Schedule and Utility Rates

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

Section Summary

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

WCAP's current electricity rates are determined by Central Maine Power's (CMP) 'MGS-S' rate table, as shown Table 3. Under this rate table WCAP pays a flat "service charge" monthly, regardless of usage. WCAP also pays a single demand charge per kW for the single highest power draw (kW) that occurs during each month. Finally, WCAP is charged a recurring 'kWh charge' dependent on the amount of energy used throughout the month.

To discourage demand during times when the utility experiences highest demand, CMP also offers an 'MGS-S-TOU' (time-of-use) rate. As shown in Table 3, demand charges are adjusted depending on the time of day, with peak periods (7am-12pm and 4pm-8pm, weekdays) incurring the highest charges, shoulder periods (12pm-4pm, weekdays, as well as 7am-12pm and 4pm-8pm on winter weekends) incurring lesser charges, and off peak periods (other times) incurring no charges. Accordingly, if using the TOU rate, it is in WCAP's best interest to minimize the amount of electricity used during peak times.

Table 3 Utility Rates Structure Comparison

	Current MGS-S Rates, per Month	MGS-S-TOU Rates, per Month
Service Charge (three-phase)	$297.90	$271.62
Demand Charge (July-August)	$15.79/kW	$12.49/kW (peak) $4.15/kW (shoulder) $0.00/kW (off-peak)
Demand Charge (September-June)	$14.55/kW	$11.80/kW (peak) $3.46/kW (shoulder) $0.00/kW (off-peak)
kWh Charge	$0.011418/kWh	$0.011418/kWh

Accordingly, a charging schedule was optimized around the operational plan developed in the previous section of the report. The results of this optimization for a Friday schedule, which assume that three demand-response vehicles, flex-routes 4, 5, and 9, and the Belfast DASH vehicle charge at the main Belfast facility, are shown in Figure 6. All vehicles charge during the overnight period when power is least expensive. A charge management system will be critical to ensure that chargers only supply the level of energy required to ensure a full charge by the morning rather than supplying the maximum power they are capable of, which will increase power demand and degrade vehicle batteries more quickly. For midday fast charging, WCAP will need to schedule its demand-response and DASH vehicles to avoid using the DCFCs at the same time. Otherwise, the agency will incur substantial demand charges, particularly during summer months. Assuming that the base MGS-S rate is used, ensuring that only one DCFC is used at a time will incur a demand charge of $1,263.20 per month; allowing the DASH and three demand-response vehicles to all use DCFC charging at the same time will increase this to $5,052.80 per month (in addition to the cost for additional chargers).

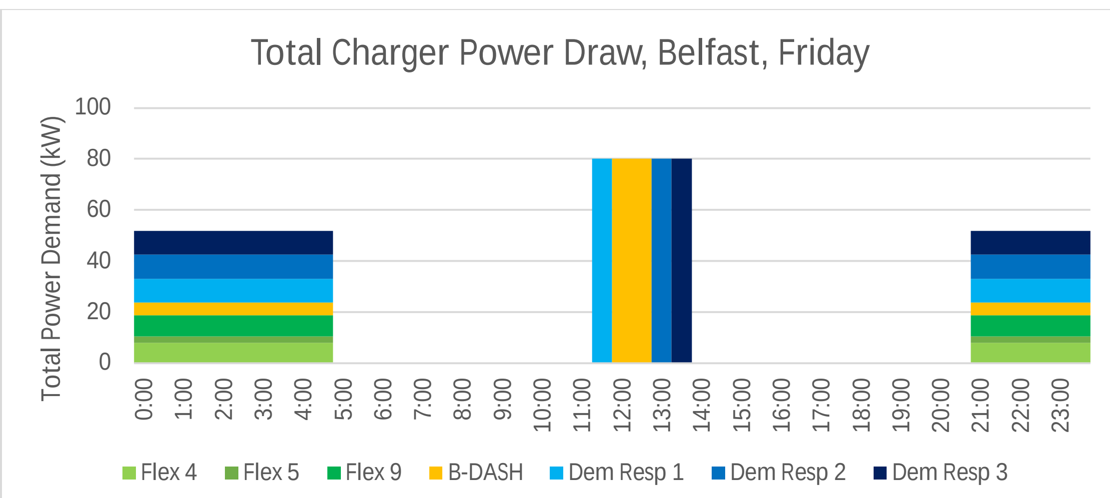

Figure 6 Proposed Charging Schedule for WCAP's Future Fleet

8. Asset Selection, Fleet Management and Transition Timeline

> ***Section Summary***
>
> - Hatch recommends procuring eight electric vehicles to enter service in 2026, with the remainder of the fleet remaining gasoline-powered.
> - Hatch recommends installing three DCFC and eight level 2 chargers at the new Belfast facility, with additional agreements reached to use the chargers at Rockland Plaza and the KVCAP Waterville facility.

With operational and charging plans established, it was then possible to develop procurement timelines for infrastructure and vehicles to support those plans. WCAP, 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. WCAP 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, WCAP currently operates a mix of cutaways, vans, and minivans. The market in these vehicle classes is small, and most manufacturers do not offer electric versions; the vendors that do often have range, passenger capacity, or vehicle availability limitations. Although alternatives like 30’ transit buses are more expensive and require complex maintenance skills, keeping a wide range of options open will help WCAP procure vehicles as efficiently as possible. To maintain a fair comparison, however, this analysis assumes that the existing fleet will be replaced approximately as expected by WCAP with vehicles of the same class (either cutaways, vans, or minivans, as appropriate).

With respect to infrastructure procurements, the construction of a new facility in Belfast presents an ideal opportunity for WCAP to build in space and electrical capacity for both the chargers needed for the initial EV deployment and for subsequent full-fleet electrification. Although the cost of one charger itself is more or less constant regardless of how many are being purchased, the additional costs such as utility feed upgrades, duct connections, structural modifications, and civil work make it economical to install all the support infrastructure at once. When additional electric vehicles arrive and more chargers are required, the only work that should be necessary is installation of the chargers themselves. A detailed engineering design will be required to develop an accurate estimate of the costs of such provisions, however.

Hatch recommends installation of three de-centralized plug-in style 80 kW DCFC chargers at the Belfast hub. These will allow vehicles to quickly replenish their range – typically during the driver’s lunch break – as would be required for the Belfast DASH and potentially for demand-response vehicles. During most of the year, when weather conditions are not extreme, this fast-charging opportunity could also allow Flex-routes 6 and 10 to operate using an electric vehicle. In addition to these DCFCs, WCAP should install eight 19.2 kW level 2 chargers at Belfast for overnight charging of the entire electric fleet. Level 2 chargers are advantageous for charging the vehicles overnight given that lower charging levels minimize peak power demand overnight and prolong battery life.

In the initial EV deployment, Hatch does not recommend installing chargers at the Rockland or Bath satellite hubs. As these facilities are not owned by WCAP, and they are comparatively far away from the main maintenance facility in Belfast, introducing chargers and electric vehicles in those areas will incur additional cost and pose challenges to implementation and vehicle maintenance. Although the Rockland DASH route is recommended for conversion to EV operation, for such a small (one-vehicle) fleet WCAP would be better served by negotiating a charger use agreement for the chargers at Rockland Plaza, or another location in Rockland. Similarly, to enable EV operation on the Flex 1 route, WCAP should negotiate an agreement to allow fast charging at the KVCAP facility in Waterville, rather than building its own charging station there.

If the pilot is successful and WCAP pursues further vehicle electrification, a more detailed planning study would be needed to determine the correct number of chargers, ensuring that some spares are available for resiliency while avoiding over-investment in infrastructure. However, given the currently proposed pilot, 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
2026	10 (5 electric cutaways, 3 electric vans, 2 gas minivans)	3 DCFCs and 8 level 2 chargers at new facility
2027	10 (9 gas vans, 1 gas minivan)	
2028	5 (4 gas vans, 1 gas minivan)	
2029	8 (2 gas cutaways, 5 gas vans, 1 gas minivan)	
2030	1 gas cutaway	

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

9. Building Spatial Capacity

WCAP's new storage and maintenance facility will be located at 45 Belmont Avenue in Belfast, shown in Figure 7. As the site is currently undeveloped, it presents an ideal opportunity for equipping the new facility with all the required chargers and maintenance spaces to support a full fleet of electric vehicles, as WCAP may have in the future.

Section Summary

- The proposed site of the new facility, at 45 Belmont Avenue, has ample space for all required infrastructure.
- The satellite hubs in Rockland and Bath have space for outdoor chargers but no indoor space.

The satellite hubs at Rockland and Bath are both leased facilities; both hubs have ample parking – and space for outdoor charging equipment – but no indoor space for charging or vehicle maintenance. These hubs are shown in Figure 8 and Figure 9.

Figure 7 Undeveloped Lot for Future Main Hub, Belfast (Source: Google Earth)

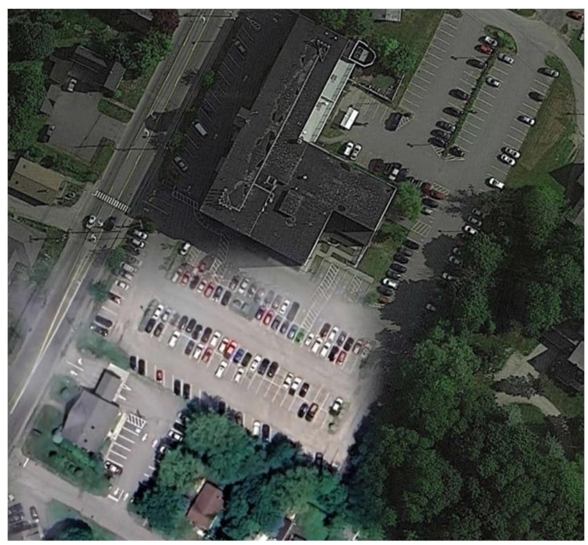

Figure 8 Satellite Hub, Rockland (Source: Google Earth)

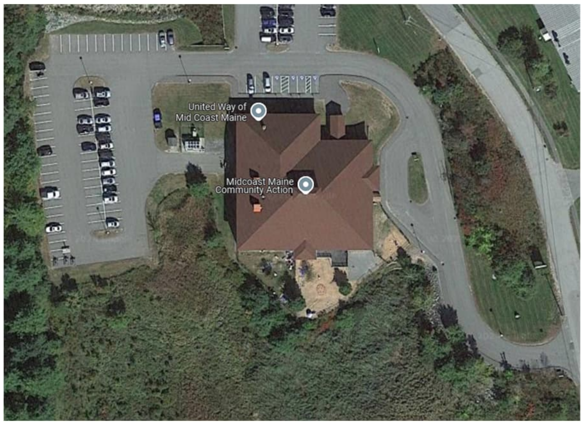

Figure 9 Satellite Hub, Bath (Source: Google Earth)

10. Electrical, Infrastructure, and Utility Capacity

> *Section Summary*
>
> + The existing transmission line at the garage is likely sufficient to support the charging infrastructure, although a new transformer will be needed.

Central Maine Power is the utility provider for WCAP's primary proposed charging location at 45 Belmont Avenue. Although there is currently no electrical connection to the site, the adjacent CMP transmission line is a three-phase line at 34.5 kV operating voltage. According to CMP data, it currently has 6.682 MW of available capacity, which will be ample for vehicle charging. The expected electrical load from the three 80 kW DCFC chargers and eight 19.2 kW level 2 chargers – even if all are used at maximum speed at once, which is unlikely – is less than 400 kW. This equipment will require the installation of a new 480V three-phase service. When building the new facility, WCAP may choose to install this as a separately metered service from the remainder of the building as a future-proofing measure in case any future utility rates are tailored to electrical services that exclusively serve EV chargers (as the now-defunct B-DCFC utility rate was). Additionally, as stated elsewhere, WCAP should make ample provision (in terms of space and electrical capacity) for additional chargers to minimize future cost.

11. Risk Mitigation and Resiliency

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:

> ***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.

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

- Require the electric vehicle vendor to have a technician nearby in case of problems. This is most economical when the technician is shared with nearby agencies such as KVCAP or WMTS.
- Reach a "mutual aid" agreement with another transit agency in Maine that would let WCAP borrow spare vehicles in case of difficulties with its fleet. For example, WCAP may arrange to borrow a cutaway vehicle from KVCAP if one of the electric cutaways is unavailable on a given day.
- Retain gasoline vehicles for at least two years after they are retired to ensure they can substitute for electric vehicles if any incidents or weather conditions require it.
- Develop contingency plans in case of charger failure, particularly for high-speed chargers required for midday use. This may include using another charger in the area, swapping vehicles more often than planned, or borrowing a vehicle from a nearby operator.
- Conduct a fire detection, suppression and mitigation study as part of the design of the new 45 Belmont Avenue facility (see section 12b).

11b. Electrical Resiliency

Electricity supply and energy resilience are important considerations for WCAP 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 WCAP 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.	GHG emitter.

	Lower upfront cost.	Maintenance and upkeep are required and can be costly.
Solar Arrays	Can provide power generation in the event of prolonged outages. Cut utility costs.	Cannot provide instantaneous power sufficient to support all operations. Constrained due to real-estate space and support structures. Requires Battery Storage for resiliency usage.

12. Conceptual Infrastructure Design

12a. Conceptual Layout Considerations

The 45 Belmont Avenue property has ample space for outdoor charger installation to support a large electric fleet. However, the following factors affect the optimal placement of chargers:

Section Summary

- Charger layout and facility design needs to consider a variety of safety, operations, and maintenance factors.

- Snow Clearance
  - In a snowy environment like Maine's, it is critical for chargers to be easily accessible year-round. This is especially important in winter months, when batteries deplete quickly, and more charging will therefore be needed. If snowbanks are piled up in front of the charger, vehicles will be unable to access it; furthermore, there is a risk of damage to the chargers from the snow (or snowplow) hitting it. To mitigate this risk, it is recommended to place the chargers on concrete islands slightly offset from the rear curb of the parking area, allowing space for snowbank buildup without interfering with the chargers. An overhead canopy, if installed, may reduce the amount of snowfall near the chargers.
- Vehicle Access
  - Particularly for the DCFC units, which will be used for fast charging during the midday period, each minute of charging is important to maximize range and minimize vehicle downtime. Therefore, the chargers should be positioned in an easily-accessed area close to the entrance of the parking lot. Longer cable reels on the charger are also helpful because they reduce the required parking precision to access the charger. Finally, as vehicles will be required to dwell near chargers (particularly overnight level 2 chargers) for hours at a time, chargers should not be placed near entrances/exits to maintenance bays or other areas where a parked vehicle could interfere with the turning radius of other traffic.
- Ease of Maintenance
  - There are two broad categories of chargers available: ground- or wall-mounted, which constrain vehicle circulation the most but are easiest to access and repair, and ceiling- or canopy-mounted, which allow vehicles to be parked anywhere within range of their suspended reels but are more difficult to maintain. Ground- or wall-mounted chargers are most typical in outdoor applications, largely

because of their lower cost and ease of maintenance, but the vehicle circulation advantages of a canopy-mounted charger should also be considered.

12b. Fire Mitigation

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

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

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

13. Policy Considerations and Resource Analysis

Section Summary

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

WCAP's current operating budget is roughly $1.6 million per year. The agency's funding sources are summarized in Figure 10. As can be seen in the figure, WCAP's largest source of funding comes from the "other funds" category, which includes WCAP service contracts with other entities. For vehicle, facility, and infrastructure costs the agency's primary federal funding comes from the Formula Grants for Rural Areas program (49 U.S.C. 5311), and the Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b)) through the FTA.

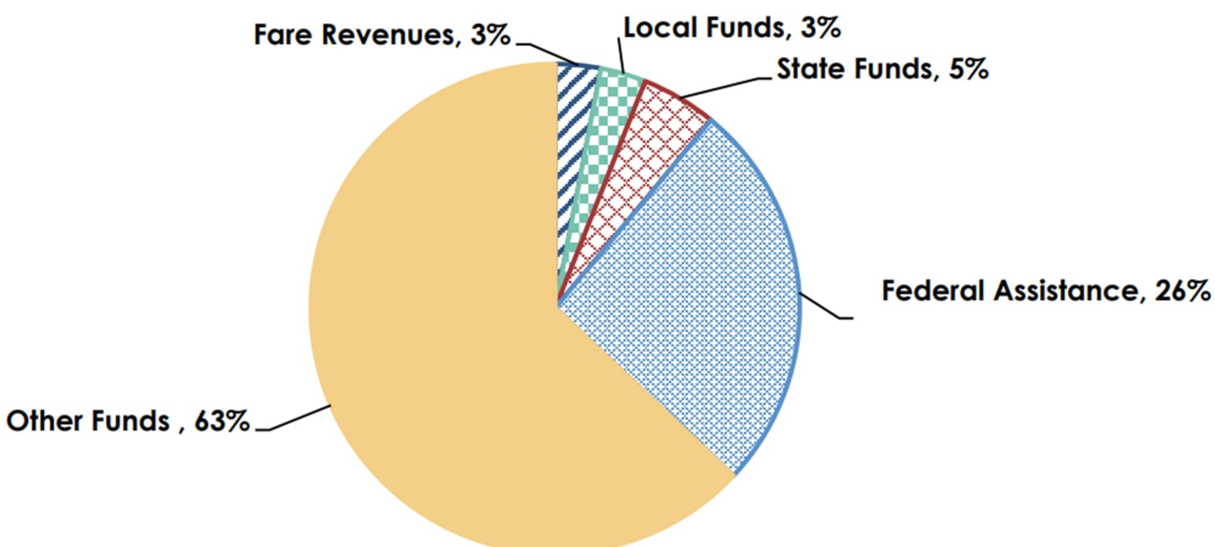

Figure 10 Current Agency Funding Summary (Source: Maine DOT)

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

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

+ Formula Grants for Rural Areas (49 U.S.C. 5311),
+ Low or No Emission Grant Program (FTA 5339 (c)
+ Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b))

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

Table 6 Policy and Resources Available to WCAP

Policy	Details	Relevance to Agency Transition
The U.S. Department of Transportation's Public Transportation Innovation Program	Financial assistance is available to local, state, and federal government entities; public transportation providers; private and non-profit organizations; and higher education institutions for research, demonstration, and deployment projects involving low or zero emission public transportation vehicles. Eligible vehicles must be designated for public transportation use and significantly reduce energy consumption or harmful emissions compared to a comparable standard or low emission vehicle.	Can be used to fund electric vehicle deployments and research projects. (*Competitive funding)
The U.S. Department of Transportation's Low or No Emission Grant Program	Financial assistance is available to local and state government entities for the purchase or lease of low-emission or zero-emission transit buses, in addition to the acquisition, construction, or lease of supporting facilities. Eligible vehicles must be designated for public transportation use and significantly reduce energy consumption or harmful emissions compared to a comparable standard or low emission vehicle.	Can be used for the procurement of electric vehicles and infrastructure (*Competitive funding)
The U.S. Department of Transportation's Urbanized Area Formula Grants - 5307	The Urbanized Area Formula Funding program (49 U.S.C. 5307) makes federal resources available to urbanized areas and to governors for transit capital and operating assistance in urbanized areas and for transportation-related planning. An urbanized area is an incorporated area with a population of 50,000 or more that is designated as such by the U.S. Department of Commerce, Bureau of the Census.	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities. (*Competitive funding)
The U.S. Department of Transportation's Grants for Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b))	This grant makes federal resources available to states and direct recipients to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities, including technological changes or innovations to modify low or no emission vehicles or facilities. Funding is provided through formula allocations and competitive grants.	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities. (*Competitive funding)

Policy	Details	Relevance to Agency Transition
The U.S. Department of Energy (DOE) Title Battery Recycling and Second-Life Applications Grant Program	DOE will issue grants for research, development, and demonstration of electric vehicle (EV) battery recycling and second use application projects in the United States. Eligible activities will include second-life applications for EV batteries, and technologies and processes for final recycling and disposal of EV batteries.	Could be used to fund the conversion of electric vehicle batteries at end of life as on-site energy storage. (*Competitive funding)
Maine Renewable Energy Development Program	The Renewable Energy Development Program must remove obstacles to and promote development of renewable energy resources, including the development of battery energy storage systems. Programs also available to provide kWh credits for solar and storage systems.	Can be used to offset costs of solar and battery storage systems at the main facility. (*Non-Competitive funding)
Energy Storage System Research, Development, and Deployment Program	The U.S. Department of Energy (DOE) must establish an Energy Storage System Research, Development, and Deployment Program. The initial program focus is to further the research, development, and deployment of short- and long-duration large-scale energy storage systems, including, but not limited to, distributed energy storage technologies and transportation energy storage technologies.	Can be used to fund energy storage systems for the agency. (*Competitive funding)
The U.S. Economic Development Administration's Innovative Workforce Development Grant	The U.S. Economic Development Administration's (EDA) STEM Talent Challenge aims to build science, technology, engineering and mathematics (STEM) talent training systems to strengthen regional innovation economies through projects that use work-based learning models to expand regional STEM-capable workforce capacity and build the workforce of tomorrow. This program offers competitive grants to organizations that create and implement STEM talent development strategies to support opportunities in high-growth potential sectors in the United States.	Can be used to fund EV training programs. (*Competitive funding)
Congestion Mitigation and Air Quality Improvement (CMAQ) Program	The U.S. Department of Transportation Federal Highway Administration’s CMAQ Program provides funding to state departments of transportation, local governments, and transit agencies for projects and programs that help meet the requirements of the Clean Air Act by reducing mobile source emissions and regional congestion on transportation networks. Eligible activities for alternative fuel infrastructure and research include battery technologies for vehicles.	Can be used to fund capital requirements for the transition. (*Competitive funding)

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

14. Cost Considerations

Section Summary

- The electrification pilot is expected to increase capital costs by 85%.
- However, reduced recurring expenses are expected, as electric vehicles cost less to maintain and fuel; this will lead to an increase in total cost of ownership of only 1%.

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

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

Electrifying a transit fleet often requires major infrastructure investment as well, to ensure that three separate items – the chargers themselves, the facility, and the utility connection – are suited for electric vehicles. Chargers are, of course, a prerequisite to EV operation; they must be purchased, installed, and commissioned. Particularly for heavy-duty applications like transit service, the required chargers are often high-powered and expensive. The facility itself must also be designed for EV charging. As WCAP will have a modern facility, this will only require installation of additional conduit to connect to the electrical panel. Finally, the facility's utility connection will need to be larger than would otherwise be required, as detailed in Section 10. Although bus depots are industrial facilities, the electrical load imposed by charging typically exceeds that of a regular maintenance shop environment. Although the cost of utility and facility enhancements varies on a case-by-case basis, the price of chargers themselves is relatively consistent and is presented below.

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

Table 10 lists the operating and capital costs that Hatch assumed for this study. These are based on WCAP's figures and general industry trends and have been escalated to 2024 dollars where necessary.

Table 7 Cost Assumptions

Asset	Estimated Cost Per Unit (2024 $'s)
Gasoline Minivan	$40,000
Gasoline Transit van	$50,000
Gasoline Cutaway	$80,000
Electric Transit van	$180,000
Electric Cutaway	$280,000

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

The financial analysis outlined below makes the following assumptions:

Capital Investment

- Cutaways were assumed to be replaced after 7 years of service, and other vehicles after 5 years.
- All vehicles are replaced with minivans, vans, or cutaways, as appropriate, in their expected retirement year.

Funding

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

Costs

- Discount rate (hurdle rate) of 7%
- Inflation rate of 3%

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

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

Table 8 Lifecycle Cost Comparison

Category	Gasoline Baseline	Future Fleet	Cost Differential (Future Fleet vs. Baseline)
Vehicle Capital Costs	$267,973	$451,960	+85%
Infrastructure Capital Costs	$0	$44,280	
Vehicle Maintenance Costs	$6,598,421	$6,355,832	-1%
Infrastructure Maintenance Costs	$0	$79,031	
Operational Cost	$9,054,128	$9,109,307	
Total Life Cycle Cost	$15,920,521	$16,040,410	+1%

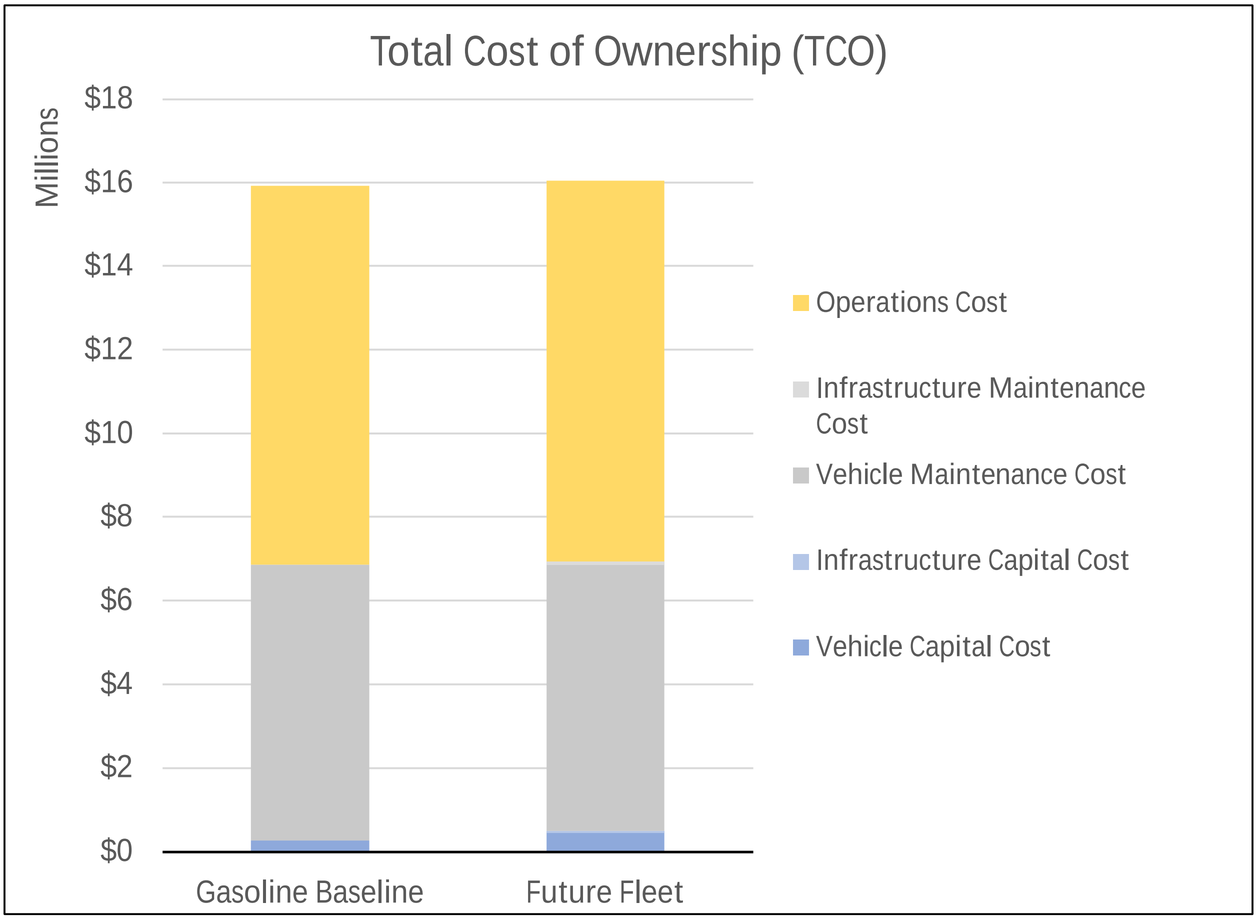

Figure 11 Lifecycle Cost Comparison

As shown above, vehicle electrification reduces system operating cost at the expense of increasing initial capital cost. Although there is some expense related to the charging equipment at the 45 Belmont Avenue facility, the bulk of the extra capital spending is on the vehicles themselves. While electric vehicles are much simpler mechanically, they command a cost premium due to their large battery systems. Although only four electric vehicles are proposed for procurement, these factors yield an 85% increase in fleet-wide capital costs over the fossil fuel baseline. This initial, non-recurring cost is balanced out by the maintenance and operating savings over the lifetime of the vehicles. Because electric vehicles have fewer components to maintain and are cheaper to refuel than gasoline, the maintenance and operating costs of the proposed fleet (which will remain 94% gasoline-powered) are 1% lower than of the all-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 nearly outweigh the initial extra capital spending, yielding a net-present-value increase of only 1%.

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

The electric vehicle market is a fairly new and developing space, with rapid advancements in technology. Although 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 WCAP 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 WCAP to change the speed of its electrification transition or change the desired end-state altogether.

15. Emissions Impacts

One of the motivations behind WCAP'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 WCAP.

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

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

Section Summary

- Vehicle electrification will be critical to helping meet State emission goals.
- Forecasted grid conversion to clean energy will maximize the benefit of vehicle electrification.
- The transition is expected to reduce emissions by 18-19%.

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

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 WCAP 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 9 and Figure 12 summarize the results of the emissions calculations. These results demonstrate that the transition plan will achieve 18% emissions reduction assuming the grid mix that existed in 2020, or 19% 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, WCAP's transition plan will help reduce emissions but will not meet the 45% goal established by the State of Maine.

Table 9 CO_2 Emissions Estimate Results

Scenario	Well-to-Tank (kg)	Tank-to-Wheel (kg)	Grid (kg)	Total (kg)	Reduction over Baseline
Gasoline Baseline	608,753	1,029,348	-----	1,638,101	----------
Future Fleet (2020 grid mix)	489,553	827,792	31,134	1,348,480	18%
Future Fleet (2030 grid mix)	489,553	827,792	10,274	1,327,620	19%

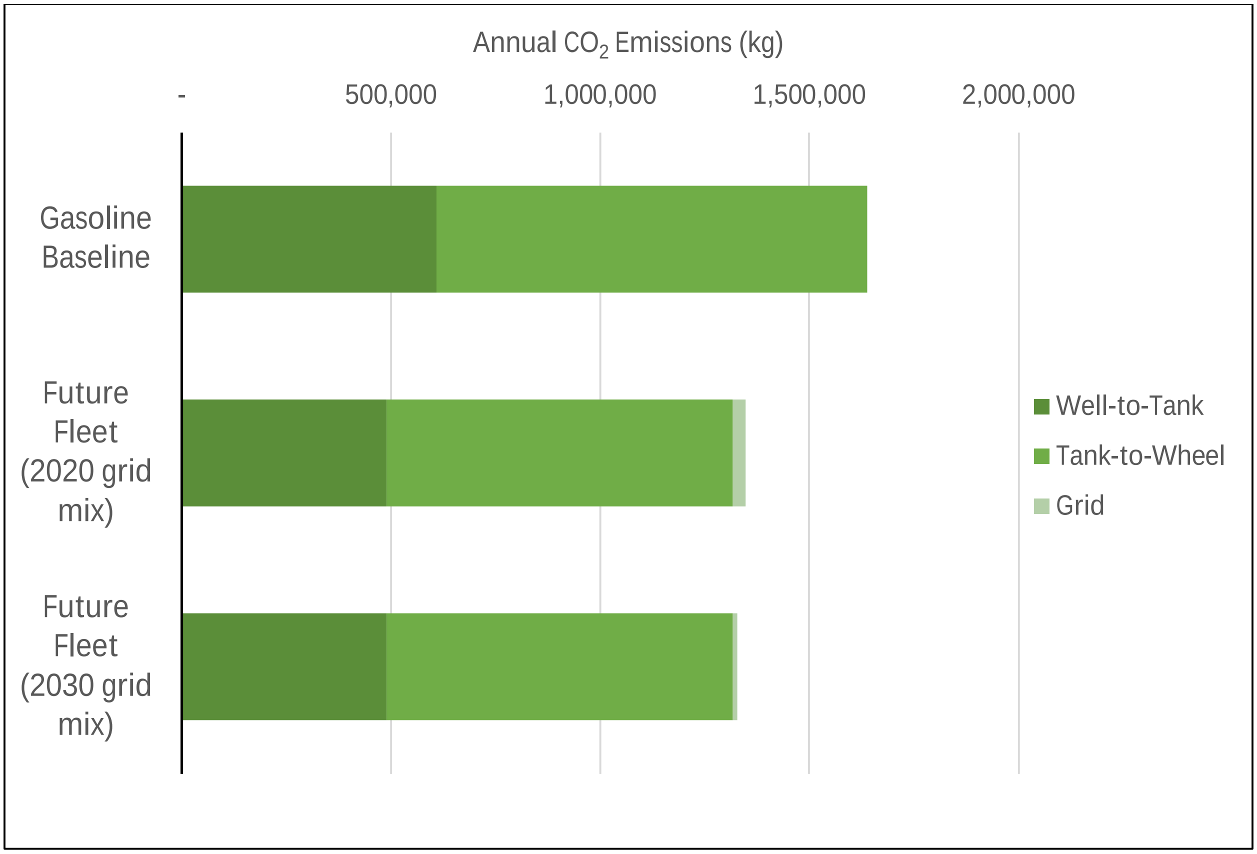

Figure 12 Graph of CO_2 Emissions Estimate Results

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

- Purchase green energy agreements through energy retailers to reduce or eliminate the emissions associated with grid production
- Assuming the initial pilot is successful, purchase additional electric vehicles
- Explore installation of additional chargers, or partnerships to use existing public chargers, in locations like Augusta that are the endpoints of particularly long routes

16. Workforce Assessment

WCAP 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 WCAP's future system a workforce assessment was conducted. Table 10 details skills gaps for the workforce groups within the agency and outlines training requirements to properly prepare the staff for future operations.

Section Summary

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

Table 10 Workforce Skill Gaps and Required Training

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

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

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

17. Alternative Transition Scenarios

Section Summary

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

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

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

- Proceed with transitioning the agency's vehicles and infrastructure in the manner described in this report.
- For the vehicles:
    - Consider ordering vehicles as part of larger orders or partnering with other agencies or the DOT to form large joint procurements.
    - Develop specifications for battery electric vehicles.
    - Consider a broad range of vehicles during procurements, ensuring maximum competitiveness in procurements.
    - Operate the demand-response vehicles on as wide a variety of cycles as possible to gain maximum knowledge of their advantages and limitations.
    - Retain gasoline vehicles for at least two years after they are retired to ensure they can substitute for electric vehicles if incidents or weather require it.
- For the infrastructure at 45 Belmont Avenue:
    - Develop specifications for chargers and other required infrastructure.
    - Conduct a fire safety analysis in accordance with Section 12b and standards UL9540, NFPA 70 and 230.
    - Consider energy storage and solar panel installation.
    - Develop contingency plans for alternate charging locations to use in case of a charger malfunction.
    - Include provisions in the electrical utility connections to support charging infrastructure for the entire fleet.
- 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.
    - Review this transition plan annually to update based on current assumptions, plans, and conditions.