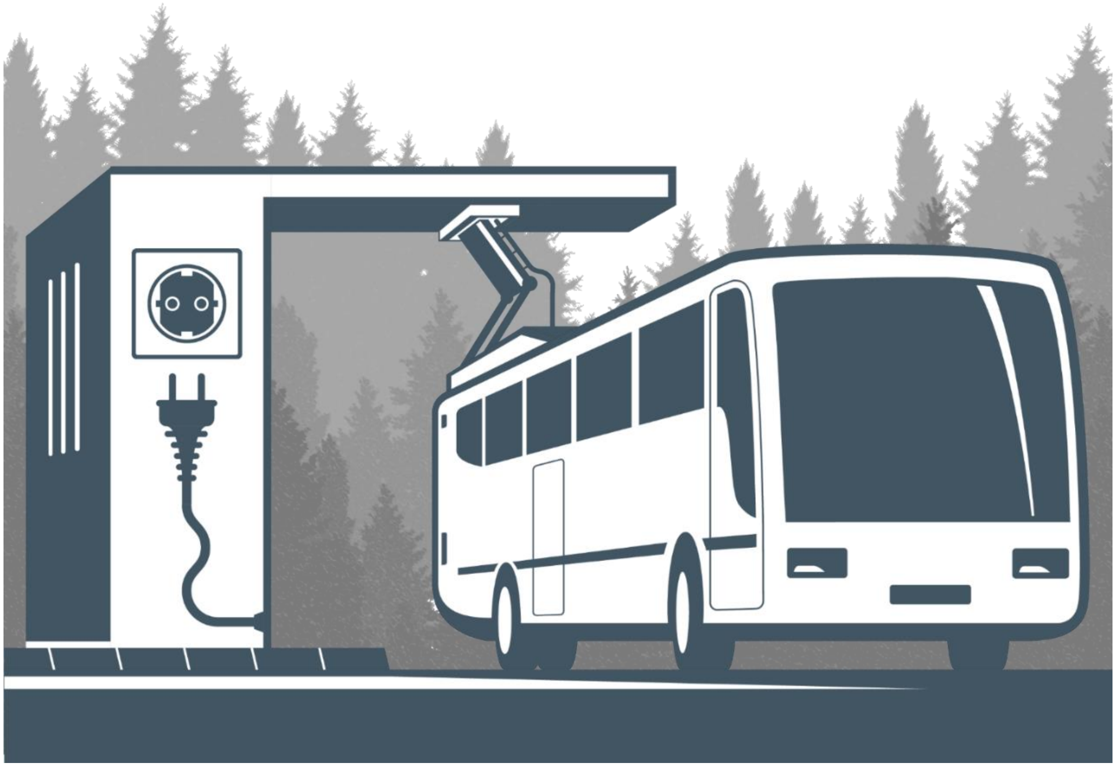

Bus Electrification Transition Plan for Downeast Transportation Inc. (DTI)

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1. Executive Summary

Downeast Transportation, Inc. (DTI), the transit agency serving Hancock County and Acadia National Park in Maine, is currently exploring transitioning its fossil fuel bus fleet to hybrid and battery electric vehicles. As the agency looks ahead to fleet electrification, a thorough analysis was conducted to develop a feasible transition 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, DTI has expressed a preference for fleet and infrastructure asset configurations that will provide a feasible transition to hybrid and battery electric drivetrain technologies while supporting the agency's operational requirements and financial constraints. The selected configuration maintains the agency's current active fleet size of 48 vehicles, with five additional vehicles planned for upcoming expansion, while ensuring viable operation for DTI's commuter, midday, and Island Explorer services. To support the battery electric buses, the agency also plans to procure, install, and commission fourteen charging systems at its depot that will have the capacity to support overnight charging of up to 42 buses simultaneously, as well as two lower-power chargers at Winter Harbor. The agency is also considering installing fast on-route chargers at the Bar Harbor Village Green and Hulls Cove Visitor Center, but plans to defer this decision until it gains operating experience with its first electric vehicles.

One of the primary motivations behind DTI's continued transition to hybrid and battery electric drivetrain technologies is to achieve emissions reductions compared to their existing fossil fuel operations. As part of this analysis, an emissions projection was generated for the proposed future fleet. The results of this emissions projection estimate that the new fleet will provide up to an 86% reduction in emissions compared to DTI's pre-electrification 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 DTI can anticipate a 74% increase in capital expenditures due to the transition. It is estimated, however, that there will be a 14% annual reduction in operational and maintenance costs due to the improved reliability and efficiency of hybrid and battery electric drivetrain technologies. In summation, the cost estimate predicts that DTI will see roughly 0.4% life cycle cost increase by transitioning to the proposed hybrid and battery electric bus fleet.

The conclusion of the analysis is that hybrid and battery electric buses can feasibly support DTI's operations. Furthermore, these buses offer the potential for the agency to greatly reduce emissions and to slightly reduce the life cycle costs required to operate its buses. Therefore, DTI 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.

In addition, 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.

Finally, the host and sponsor of the Island Explorer service – Acadia National Park – has been a longstanding advocate of low-emissions transportation. To meet this broad range of goals, DTI, 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 DTI's future route plans, vehicle technology options, building electrical capacity, emissions impacts, resiliency, and financial implications.

3. Existing Conditions

DTI is a transit agency providing commuter, midday circulator, and tourist transit service to Hancock County, Maine and Acadia National Park. The agency currently owns and operates a revenue fleet of sixty-nine vehicles including gasoline, diesel, and propane-fueled vehicles. These vehicles include 32' Island Explorer buses, 40' commuter buses, vans, and cutaway vehicles. Approximately 48 of these vehicles are actively used for revenue service, with the remainder serving non-revenue purposes or acting as a contingency reserve.

Section Summary

- DTI operates twenty-seven routes with a 69-bus fleet of mixed fuel types

Table 1 Current Vehicle Roster

Bus Type	Number of Buses	Useful Life Years	Procurement Date
Ford E450	1	5	2006
Ford E350	2	4	2005
Ford E350	2	4	2008
Ford Transit 350HD	2	4	2020
Orion	2	12	2008
El Dorado XHF	2	12	2010
Chevy 5500	2	10	2009
Ford F-550	2	7	2016
El Dorado MSTII	7	10	2006
El Dorado MSTII	7	10	2007
El Dorado MSTII	8	10	2010
Hometown	10	7	2018
Hometown	11	7	2019
Hometown	11	7	2021

DTI has five year-round commuter routes, nine year-round midday routes, and thirteen seasonal Island Explorer routes that provide service in and around Bar Harbor and Acadia National Park. Commuter routes operate once in the morning and once in the afternoon on weekdays. Midday routes operate on various schedules and service days, offering year-round service. The Island Explorer is a summertime seasonal operation, with some service continuing into the early fall. Although the routes are typically operated with the vehicle types indicated below, substitutions are made as necessary to provide service. Most services operate along the same route throughout the day, though circulator (midday) routes may deviate up to half a mile off route upon request. A map of the Island Explorer routes is shown in Figure 1 below.

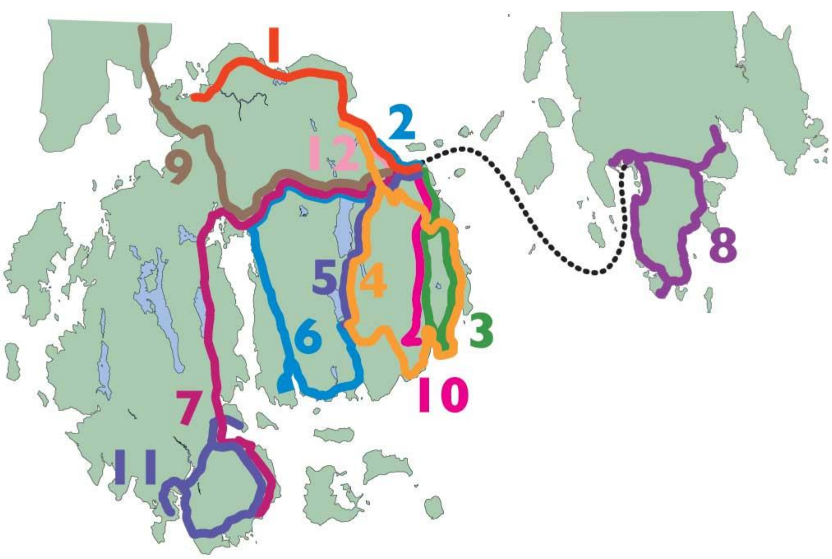

Figure 1 Map of Island Explorer Services

- **Transit Bus (Commuter) Routes to Jackson Lab**
  Operate weekdays, with a one-way morning trip and an afternoon return trip.
  Four routes include:
  - **Bangor to Jackson Lab**
  - **Brewer to Jackson Lab**
  - **Franklin to Jackson Lab**
  - **Milbridge to Jackson Lab**

- **Transit Bus (Midday) Route: Bar Harbor to Bangor**
  Serves Bangor, Ellsworth, Trenton, and Bar Harbor.
  Operates one round trip Monday through Friday.

- **Cutaway Vehicle (Commuter) Route: Ellsworth to Jackson Lab**
  Operates weekdays, with a one-way morning trip and an afternoon return trip.

- **Cutaway Vehicle (Midday) Routes: Ellsworth-Blue Hill**
  Operate September through June, with a one-way morning trip an afternoon return trip.
  Two routes include:
  - **Ellsworth City Hall to Blue Hill Town Hall** – weekdays
  - **Blue Hill Town Hall and Ellsworth City Hall** – Mondays, Tuesdays, Thursdays

- **Cutaway Vehicle (Midday) Route: Ellsworth to Bar Harbor**
  Serves Bar Harbor to Ellsworth City Hall, including Jackson Lab and shops.
  Operates three round-trips on weekdays with 3- to 4-hour headways.

- **Cutaway Vehicle (Midday) Route: Ellsworth Tuesday Shuttle**
  Serves Ellsworth, connecting Union River to Riverview, City Hall, and shops.
  Operates three round-trips on Tuesdays with approximately 1-hour headways.

- **Cutaway Vehicle (Midday) Route: Ellsworth Friday Shuttle**
  Serves Ellsworth, connecting City Hall to shops.
  Operates three round-trips on Fridays with 45-minute and 75-minute headways.

- **Cutaway Vehicle (Midday) Route: Bar Harbor Shuttle**
  Serves Bar Harbor, connecting Hannaford to hospital and YMCA.
  Operates six round-trips on Tuesdays with 1-hour headways.

- **Cutaway Vehicle (Midday) Route: Bucksport Shuttle**
  Serves shops and residences in Bucksport.
  Operates six round-trips on Wednesdays with various headways.

- **Cutaway Vehicle (Midday) Route: Stonington Bus**
  Serves Ellsworth, Blue Hill, Deer Isle, Stonington, Sedgwick, and Brooklin.
  Operates two 3-hour round-trips on Fridays, once in the morning and afternoon.

- **Island Explorer Routes**

  Serve Acadia National Park and neighboring village centers. The main hubs are Bar Harbor (BH) Village Green and Hulls Cove Visitor Center (VC). Routes operate on a seasonal schedule, with headways ranging from 20 minutes to 2 hours.

  - **Route 1** – Bar Harbor Road from Bar Harbor Village Green
  - **Route 2** – Eden Street from Bar Harbor Village Green
  - **Route 3** – Sand Beach from Bar Harbor Village Green
  - **Route 4** – Loop Road from Hulls Cove Visitor Center
  - **Route 5** – Jordan Pond from Hulls Cove Visitor Center
  - **Route 6** – Northeast Harbor from Bar Harbor Village Green
  - **Route 7** – Southwest Harbor from Bar Harbor Village Green
  - **Route 8** – Schoodic Peninsula
  - **Route 9** – Trenton from Bar Harbor Village Green
  - **Route 10** – Blackwoods from Bar Harbor Village Green
  - **Route 11** – Tremont
  - **Route 12** – Highbrook from Bar Harbor Village Green
  - **Bicycle Express** – van and bicycle trailer shuttle between Bar Harbor and Eagle Lake

The structure of the midday and Island Explorer routes described here, and modeled in this report, is the pattern that was operated during the summer of 2022. This pattern was developed taking into account post-COVID changes in driver availability and ridership. As these factors and further park development (for example, the construction of the Acadia Gateway Center) evolve in coming years, changes to both circulator and Island Explorer routes are expected. However, the basic structure of the networks will remain largely unchanged.

4. Vehicle Technology Options

Section Summary

- Manufacturers' advertised battery capacities do not reflect actual achievable operating range
- The Island Explorer has a small pool of available vehicles

As discussed in Section 3, DTI's revenue service fleet is composed of a variety of vehicle types (32' Island Explorer buses, 40' transit buses, cutaway shuttles, and vans) with diesel, gasoline, and propane-powered vehicles. 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 DTI to utilize. For battery electric buses, battery capacity can be varied on many commercially available bus platforms to provide varying driving range.

The Island Explorer route network, in particular, presents several challenging constraints on vehicle technology. Because the routes operate on historic roads, there are limitations on both length and height of the vehicles. Tight corners on certain roads require the vehicles to be no longer than 38 feet, including an allowance of approximately 5 feet for front and rear bicycle racks. Therefore, the body of the vehicle is restricted to approximately 33 feet long, eliminating from contention the more common 35' and 40' transit buses. Additionally, low bridges on several roads throughout the park impose a height limit of 10'-7"; this presents difficulties because many electric buses accommodate most of their batteries on the roof. As the Island Explorer operates in a National Park, engineering changes to raise bridges, lower underpasses, or ease road curvature are not feasible. Finally, as the Island Explorer largely serves visitors to the park who are interested in sightseeing, DTI prioritizes maximizing window size, including the front windshield, on Island Explorer vehicles. This may exclude certain styles of transit bus that are designed with comparatively small windows.

For this study, battery electric Island Explorer buses were assumed to have either 'short-range' 252 kWh or 'long-range' 350 kWh battery capacity (representing the capacities of two commercially available vehicles). 40' transit buses were assumed to have a 450 kWh battery, cutaway shuttles a 157 kWh battery, and vans a 120 kWh battery; these are typical values for the range of electric vehicles offered by the industry. The transit buses were assumed to have diesel heaters, which minimize electrical energy spent on interior heating during the winter months. (Cutaway vehicles are typically not equipped with diesel heaters, and the Island Explorer vehicles are intended for summer-season operation when air conditioning will place a larger demand on the battery than heating will). Two types of safety margins were also subtracted from the nominal battery capacities of the buses. First, the battery was assumed to be aged by its expected life cycle – six years old (i.e. shortly before its expected replacement at the midlife of the bus) for transit buses and at vehicle end-of-life for other, shorter-lifespan vehicles. As batteries degrade over time, their capacity decreases. To account for this, the battery capacity was reduced by 20%. Second, the bus 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 buses from becoming stranded on the road. Combining these two margins yields a usable battery capacity of 64% of the nominal value. 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

Most consumer-grade and smaller commercial vehicles, like cars and vans, can be charged with either AC or DC chargers. Because AC chargers are generally less expensive, they (particularly level 2 chargers) are the most widespread equipment found today. However, transit buses and other larger vehicles

Section Summary

- DTI can choose to install low-power level 2 chargers, similarly low-power DC chargers, or higher power (centralized or decentralized) DCFC units
- The choice of charging technology will depend on the type of charging occurring at each location

typically require DC chargers because they are not equipped with an on-board transformer that would allow them to be charged with AC chargers.

DC chargers typically come in two types of configurations:

1. Centralized
2. De-centralized

A decentralized 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. Similarly, centralized systems can support high-powered pantograph chargers. Examples of both configurations are shown in Figure 2.

Figure 2 Example Charging Systems (Source: ABB):

Left – Charging Cabinet (System) and Three Dispensers (Charge Boxes)

Right – Overhead Pantograph Charger and Centralized Cabinets

Like the vehicles, charging infrastructure to support battery electric vehicles is available in numerous configurations. One of the primary metrics that can be customized is the charging power. A range of products is available, ranging from low-power units with approximately 20 kW to high-power DC fast chargers (DCFCs) with up to 450 kW of power. Appendix A shows additional commercially available charging system options and configurations.

The choice of charging interface, and power level, depends on the vehicles charging and their service needs. Overhead pantograph chargers are typically only compatible with transit buses, because they require specialized overhead conductive rails on the roof of the bus, and are therefore not applicable to the majority of DTI's service. Plug-in style DC chargers, which are compatible with all likely DTI vehicles and even most light-duty vehicles, are the most widely applicable but must be customized to the required power level. Low-power units can only accommodate slow overnight charging, but are the most economical option. High-power centralized units are ideal for fast charging during short layovers, but are expensive and afford little flexibility in charging. The most versatile chargers – de-centralized units that can provide either low or high power depending on the number of vehicles connected – are the most operationally convenient but also the priciest. Section 8 provides detail on which chargers are most appropriate for DTI.

6. Route Planning and Operations

Section Summary

- Electric buses do not offer comparable operating range to fossil fuel vehicles – so detailed operations modeling is needed
- The commuter services can be operated with electric 40' buses with no operational changes (aside from charging midday in Bangor)
- The services operated with cutaways are not feasible for electrification due to their long distances and lack of network hubs; Hatch recommends adopting hybrids on these routes
- The Island Explorer network can be operated with electric vehicles, though several operating models are possible

DTI's current operating model is similar to that of many transit agencies across the country. Most vehicles leave the garage at the appropriate time in the morning, operate (usually on the same route) for as long as necessary, and then return to the garage. Although DTI's schedulers must account for driver-related constraints such as maximum shift lengths and breaks, and some vehicles can only be assigned to certain blocks because of fuel tank size limitations, in general the vehicles are not considered as an operating constraint. This assumption will remain true for hybrid vehicles, which have comparable range to fossil fuel buses, but may not always be valid for electric vehicles, which have reduced range due to their battery size. For year-round services, range is expected to be a particularly binding constraint in the winter; even when diesel heaters are installed, as was assumed in this study for commuter buses, icy road conditions and cold temperatures degrade electric bus performance. On the year-round and Island Explorer services alike, battery electric buses may not provide adequate range for a full day of service, particularly if recommended practices like pre-conditioning the bus before leaving the garage are not always followed.

6a. Operational Simulation

To assess how battery electric buses' range limitations may affect DTI'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

DTI's operations. As mentioned above, it was not necessary to simulate hybrid operations because the vehicles offer comparable range to fossil fuel buses.

Hatch conducted a route-specific electric bus analysis by generating "drive cycles" for several routes that represented the typical modes of DTI's operations, including high-speed commuter routes, slower-speed in-city circulators, and a range of services in Acadia National Park. For each representative route, the full geography (horizontal and vertical alignment), transit infrastructure (location of key stops), and road conditions (vehicle congestion, as well as traffic lights, stop signs, crosswalks, etc.) were modeled, and the performance of the vehicle was simulated in worst-case weather conditions (cold winter or hot summer, as applicable) to create a drive cycle. These DTI-specific drive cycles were used to calculate energy consumption per mile and therefore total energy consumed by a vehicle on each route.

All DTI services were evaluated against the representative electric bus configuration(s) outlined previously. As technology advances, Hatch assumed that these battery capacities will increase at a rate of 3% per year, allowing for additional range. In accordance with the expected first vehicle acquisition date in the fleet transition schedule in Section 8, this battery capacity increase was taken to 2029 for cutaway vehicles, 2030 for Island Explorer buses, 2033 for Island Explorer vans, and 2034 for commuter buses. Combined with the safety margins discussed in Section 4, this yielded usable battery energy of 136 kWh for cutaway vehicles, 205 kWh for short-range Island Explorer buses, 284 kWh for long-range Island Explorer buses, 106 kWh for Island Explorer vans, and 412 kWh for commuter buses. Clearly, if battery electric bus technology advances faster than anticipated, or if the existing fleet can be retained beyond its expected life, there will be a higher operating margin in bus electrification, allowing more service expansion, reduced or eliminated reliance on on-route chargers, and increased competition during procurements. Conversely, if technology develops more slowly or the existing fleet requires replacement sooner, less service expansion will be possible and more on-route chargers may be needed.

Table 2 below presents the mileage and energy requirement for each block, with green shading denoting those blocks that can be operated by the specified bus by the first vehicle acquisition date and red shading denoting those that cannot. It should be noted that the energy requirements are slightly higher for long-range buses because of their higher weight due to the increased number of battery cells.

Table 2 Energy Requirements by Block

Block	Mileage	'Short-Range' Bus		'Long-Range' Bus	
		kWh Required	Mileage Shortage/Excess	kWh Required	Mileage Shortage/Excess
Commuter Routes					
Bangor Route	209.3			396.2	8.3
Brewer Route	157.2			290.5	64.5
Franklin Route	109.4			219.9	91.8
Milbridge Route	168.4			311.1	53.6

Block	Mileage	'Short-Range' Bus		'Long-Range' Bus	
		kWh Required	Mileage Shortage/Excess	kWh Required	Mileage Shortage/Excess
Midday Routes					
Blue Hill/Bucksport	103.5			140.4	-11.9
MDI 1/2 + BH intown	189.7			275.3	-108.3
MDI 3	158.8			238.1	-81.8
MDI 4	110.8			165.2	-29.6
Island Explorer Routes					
Route 1	213.2	253.7	-41.1	317.7	-22.3
	231.6	275.6	-59.5	345.1	-40.7
Route 2	104.0	155.5	29.9	177.1	57.7
	138.8	213.0	-4.9	241.8	22.9
Route 3	149.2	173.8	26.5	215.9	46.9
	152.4	177.6	23.2	220.7	43.7
Route 4	100.8	117.4	73.4	145.1	93.5
	147.0	172.8	26.9	214.5	47.0
	147.0	172.8	26.9	214.5	47.0
	177.8	209.4	-3.9	260.4	16.2
	177.8	209.4	-3.9	260.4	16.2
	177.8	209.4	-3.9	260.4	16.2
Route 5	131.3	151.9	45.2	187.8	66.2
	146.6	169.9	29.9	210.2	50.9
Route 6	183.7	215.9	-9.3	268.1	11.0
	183.7	215.9	-9.3	268.1	11.0
Route 7	168.3	198.7	5.1	246.9	25.2
	187.6	221.9	-14.4	276.8	5.2
	239.6	283.8	-66.4	354.2	-46.8
Route 8	141.6	168.5	30.5	211.0	49.3
	176.0	204.4	0.4	251.6	22.1
Route 9	71.2	84.7	100.9	106.1	119.7
Route 10	215.6	253.0	-41.1	315.8	-21.5
Route 11	126.9	146.4	49.9	180.5	71.2
Route 12	102.9	146.5	35.4	170.9	61.1
Bicycle Express	98.2			99.0	7.2

6b. Operational Alternatives

As shown in Table 2, short-range buses cannot accommodate many of the currently operated blocks, and even long-range buses are insufficient for several key blocks. To address the operational shortcomings of the battery electric buses a few options were considered. To maintain study focus, changes to passenger-facing schedules were not considered; optimization of schedules for electric bus operation is recommended only after an operating model is chosen to avoid over-committing to one particular schedule. More information about the tradeoffs between the operating strategies below is presented in Appendix B.

The operationally easiest option is to maintain existing service, with electric vehicles operating on blocks where they can complete the entire day's service and hybrid vehicles covering all other blocks. This would allow DTI to continue operations without being impacted by vehicle range constraints. DTI prefers this alternative for the commuter vehicle services, which can be electrified by 2034 with no change to operations. However, the Bangor route's operating model is unusual and requires special consideration. Because that vehicle lays over during nights and middays at the Bangor Community Connector (CC) depot and does not visit the DTI facility except for maintenance, this study assumed that it is charged during the midday layover in Bangor. As Community Connector's buses will be in service during the midday period, there will likely be charging capacity available for the DTI bus. However, a payment agreement will need to be developed with Bangor CC to compensate for the cost of the power drawn.

DTI also prefers maintaining existing operations for the cutaway vehicle (circulator) routes, but with a hybrid rather than electric fleet. Because these services operate comparatively small vehicles with limited battery capacities, cover large distances, run too infrequently to justify an on-route charger, and are periodically subject to route changes, it is uneconomical for DTI to invest in any field charging infrastructure or swap vehicles at the depot for these routes. Although future vehicle developments will likely make these routes feasible for EV operation, for this study they were assumed to operate with hybrid cutaway vehicles.

The Island Explorer is by far DTI's largest and most complex service offering. The network includes one service – Route 8 on the Schoodic Peninsula – that is separate from the rest of the network; the vehicles on that route are generally stored overnight in Winter Harbor, which is the route's terminal. For this service DTI's preferred alternative is similar to that for the commuter routes; the buses would be charged overnight in Winter Harbor and would operate without charging for the duration of the day. As is done today, they would only return to the depot when needed for maintenance or driver convenience. For the remainder of the routes, operating on Mount Desert Island, there are several feasible options for adopting electric vehicles.

One possibility is to operate using "depot swapping," with electric buses operating as long as they are able to and then returning to the depot to charge while a fresh bus takes over their block. By cycling buses in and out of service periodically during the day, DTI would be able to mitigate the range limitations of battery electric buses without requiring field infrastructure. Although DTI's depot is far from its operating hubs at the BH Village Green and Hulls Cove VC, no extra deadheading would be required, because DTI plans to add frequent service connecting these two hubs to the Acadia Gateway Center (AGC) when that facility – located adjacent to the depot – opens around 2025. Interlining trips on routes to the AGC with trips on other routes would allow buses (and their drivers) to be brought in and out of service as needed without exceeding range or shift length limits. Even if today's service pattern (with no additional service to the AGC) is assumed to continue for future years, long-range buses could be operated with no on-route chargers, with buses being brought in and out of service by operating trips on the existing Route 9. Although this service option would introduce some scheduling and dispatching complexity due to the additional interlining, it would eliminate scheduling and operational reliance on chargers in the field, eliminate the cost of installing and maintaining these chargers, increase resilience to traffic congestion delays, and provide maximum flexibility for future route or schedule changes.

An alternative possibility for Island Explorer operation is to recharge buses during layovers over the course of the day. This would require layover times of reliable duration, as a layover period intended for charging could no longer be shortened for schedule recovery purposes. Operations with on-route chargers could be achieved with either “short-range” or “long-range” buses. Short-range buses, though they are less expensive to purchase, operate a shorter distance between charges. Operationally, this has an impact on the required number, and usage, of on-route chargers. Given DTI’s existing schedules, long-range buses can complete a full day of operation on the routes based at Hulls Cove VC (Routes 4 and 5) without charging; short-range buses cannot and therefore an on-route charger would need to be installed there. At BH Village Green, although one on-route charger would be sufficient for operations with either type of bus, short-range buses would require an estimated 18 charging windows throughout the day, compared to 13 for long-range buses. The advantage of installing on-route chargers is the resulting operational simplicity, with buses operating the same blocks as they do today. However, the need for buses to lay over and charge could reduce schedule reliability, as buses would not be able to shorten these layovers to get back on schedule and two buses would not be able to charge at once.

For electric vehicle operations (under any operating model) to be most efficient, the schedule (and perhaps even the route structure) would need to be optimized for the needs of the buses. In general, coordination of driver meal breaks and shift changes with bus charging times is recommended to ensure that drivers are not waiting unproductively while the bus charges (and can even simplify scheduling, as a driver and a bus would stay together throughout the driver’s shift). For the depot swapping alternative, DTI’s plans to expand service to the AGC present a significant advantage, as buses and drivers can be cycled in and out of service as required by their charging and meal break / shift length requirements. If on-route charging is selected, strategic insertion of longer layover times at the BH Village Green (perhaps combined with lunch breaks) will help provide adequate charging time while maintaining schedule adherence.

As DTI’s young fleet gives the agency several years for planning before electrification begins, DTI leaders are encouraged to continue monitoring the state of electric vehicle technology on the market. If vehicle technology improves sooner than expected, fleet replacement can be accelerated, and on-route chargers may become superfluous even without depot swapping. However, if vehicle technology develops more slowly than this study’s forecast, more depot swaps or on-route chargers may be necessary.

6c. Island Explorer Operating Model Selection

For the Island Explorer routes on Mount Desert Island, DTI faces a strategic decision regarding its electric vehicle operating model. The agency could choose to install on-route chargers at BH Village Green, and potentially also at Hulls Cove VC, and charge buses there throughout the day; this would incur capital and operating costs for the chargers, and require consistently achievable layover durations, but would simplify scheduling and service management. On the other hand, the agency could choose to forgo one or both of these chargers and rely on switching buses at the depot when they are low on charge. Although this would require some scheduling and dispatching complexity associated with interlining, this would reduce the agency's reliance on field infrastructure and, by eliminating layover charging, is likely to improve on-time performance.

As discussed in Section 8, DTI will be procuring its future Island Explorer fleet on a staggered basis over several years. This will introduce a time interval between the procurement of the first electric bus and full conversion. Hatch recommends that DTI use this time to gain experience operating electric buses and understand the tradeoffs of the two operating models. Although the agency can draw some conclusions from studying the possibilities, a fully informed decision can only be made based on real operating experience.

When DTI receives its first order of Island Explorer electric buses, the agency should operate them across all twelve routes. Although this will require a spare driver and propane vehicle to be on standby in case the electric bus runs low on charge before finishing the day, such a trial will help calibrate this study's simulation results to factors like traffic congestion and bus driver behavior that are difficult to predict in advance. In addition, it will give the widest possible range of DTI staff exposure to electric vehicles.

DTI should next create a proposed schedule for each of three operating models: layover charging at both the BH Village Green and Hulls Cove VC, layover charging at BH Village Green only with depot swapping for Routes 4 and 5, and depot swapping for all routes with no layover charging. Using the vehicle range data gained from initial BEB operation, DTI's schedulers will be able to develop accurate timetables for each model that take vehicle range into account. This will help the agency understand the number of interlines and depot swaps, or on-route charge windows, that will be necessary. Understanding these tradeoffs will be key to making an informed decision about on-route charger installation.

Finally, during the first season of electric bus operation DTI should operate each schedule on a trial basis for a short period. (Although the on-route chargers will not yet be installed, operating propane vehicles on the blocks requiring on-route charging and enforcing minimum layover times of 10-15 minutes during the expected charge windows will simulate the operational effect of charging.) Conducting this type of operational trial will let the agency experience first-hand the pros and cons of interlining and on-route charging strategies. In addition, the agency will be able to experiment with operational recovery strategies (such as action plans in case a bus is low on battery and unable to complete its block), with the presence of propane vehicles minimizing the risk of actually needing to tow a vehicle or cancel scheduled trips. Doing so will let agency operators and dispatchers understand the operational tradeoffs of the three alternatives and will help inform a decision on whether to proceed with on-route charger installation. As these schedule trials will only affect the vehicle blocks and not the passenger-facing schedules, no public outreach will be required.

To provide a conservative estimate, this study assumed that chargers are installed at both BH Village Green and Hulls Cove VC.

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 DTI charge its buses economically
- DTI would operate most economically by adopting the EV Rate structure for all charging locations

Developing a charging schedule is recommended practice while developing a transition plan as charging logistics can have significant effects on bus operations and costs incurred by the agency. From an operational perspective, charging buses during regular service hours introduces operational complexity by requiring a minimum duration for certain layovers. The operational configuration and fleet composition selected by DTI, and described in the previous section of this report, assumes that buses will be charged during both the overnight period and during layovers throughout the day.

From a cost perspective, developing a charging schedule soon is important as the local utility, Versant, plans to adjust its rate schedules. The new rate structure will apply variable pricing depending on the time of use. DTI's current electricity rates are determined by Versant's 'M-2' rate. Under this rate table DTI pays a flat "customer charge" monthly, regardless of usage. DTI also pays a single distribution charge of $10.51 per kW and a single transmission charge of $14.57 per kW for their single highest power draw (kW) that occurs during each month. This totals to a single charge of $25.08 per peak kW draw per month to maintain Versant's distribution and transmission systems. This peak charge is not related to Versant's grid peaks and is local to DTI's usage. Finally, DTI is charged an 'energy delivery charge' of $0.00604 per kWh, and an 'energy cost' of $0.09952 per kWh. These costs are recurring and are dependent on the amount of energy used by DTI throughout the month.

To encourage the adoption of electric vehicles (EV), Maine's Public Utilities Commission (PUC) requested that utilities, including Versant, propose new rate structures for vehicle charging. In response to this request, Versant proposed 'EV Rate 5' though 'EV Rate 11' utility schedule for commercial EV charging under Docket No. 2021-00325.

DTI will be able to take advantage of the new rate structure 'EV Rate 5' for the proposed new on-route charging locations at Bar Harbor Village Green, Hulls Cove Visitor Center, and Winter Harbor since the peak load at these locations is less then 400kW which is the threshold for the 'EV Rate 5' schedule. As discussed later in the report, the peak load for DTI's garage charging location will exceed 400 kW threshold for the 'EV Rate 5' schedule, requiring DTI to adopt the 'EV Rate 7' rate structure instead.

To qualify for these special EV rates, Versant requires that customers like DTI install a new meter and dedicated service for their charging equipment at each location, to accurately account for the power draw associated with charging. Table 3 below outlines the other differences between the existing 'M-2' and the new 'EV Rate 5' and 'EV Rate 7' rate structures that would apply to DTI. The new rate structures would provide DTI with a lower monthly 'distribution charge' but introduce a Transmission charge that is calculated based on Versant'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 Versant's grid load is peaking. Under the 'EV Rate 7' the distribution charges also vary throughout the day which provides DTI with additional opportunities for saving by charging during the "off-peak" hours when the distribution charges are lower. The historic data indicates that the daily system peak for Versant happens between 3 PM and 7 PM. Therefore, it is advisable for DTI to develop a charging plan which avoids charging buses during these hours.

Table 3 Utility Rates Structure Comparison

	Current M-2 Rates	Proposed EV Rate 5 for DCFC (Modified M-2)	Proposed EV Rate 7 for DCFC (Modified D-4)
Customer Charge	$56.21 per month	$47.83 per month	$47.83 per month
Peak Demand Charge	$10.51 per non-coincidental peak kW (calculated monthly)	$8.97 per non-coincidental peak kW (calculated monthly)	$2.94 per non-coincidental peak kW (calculated monthly)
Shoulder Demand Charge	$10.51 per non-coincidental peak kW (calculated monthly)	$8.97 per non-coincidental peak kW (calculated monthly)	$2.94 per non-coincidental peak kW (calculated monthly)
Off-peak Demand Charge	$10.51 per non-coincidental peak kW (calculated monthly)	$8.97 per non-coincidental peak kW (calculated monthly)	$1.75 per non-coincidental peak kW (calculated monthly)
Transmission Charge	$14.57 per non-coincidental peak kW (calculated monthly)	$23.11 per coincidental peak kW (calculated monthly)	$22.32 per coincidental peak kW (calculated monthly)
Energy Delivery Charge	$0.00604 per kWh	$0.00604 per kWh	$0.00604 per kWh
Energy Cost	$0.09952 per kWh	$0.09952 per kWh	$0.09952 per kWh

Accordingly, a charging schedule was optimized around the operational plan developed in the previous section of the report and the above listed utility schedules. The results of this optimization are shown in Figure 3 through Figure 5. It can be seen in the figures that the optimized charging schedule assumes buses will be charged overnight (between 9 PM and 5 AM) at the depot and Winter Harbor using the plug-in chargers. The optimized charging schedule also includes midday and evening charging at the Bar Harbor and Hulls Cove Visitor Center, as well as limited midday charging at the depot. This charging schedule avoids charging during the Versant grid's 'coincidental peak' (between 3 PM and 7 PM), allowing DTI to avoid a monthly 'transmission charge', should the agency decide to adopt the Versant's special optional 'EV Rate 5' and 'EV Rate 7' schedule for its charging operations.

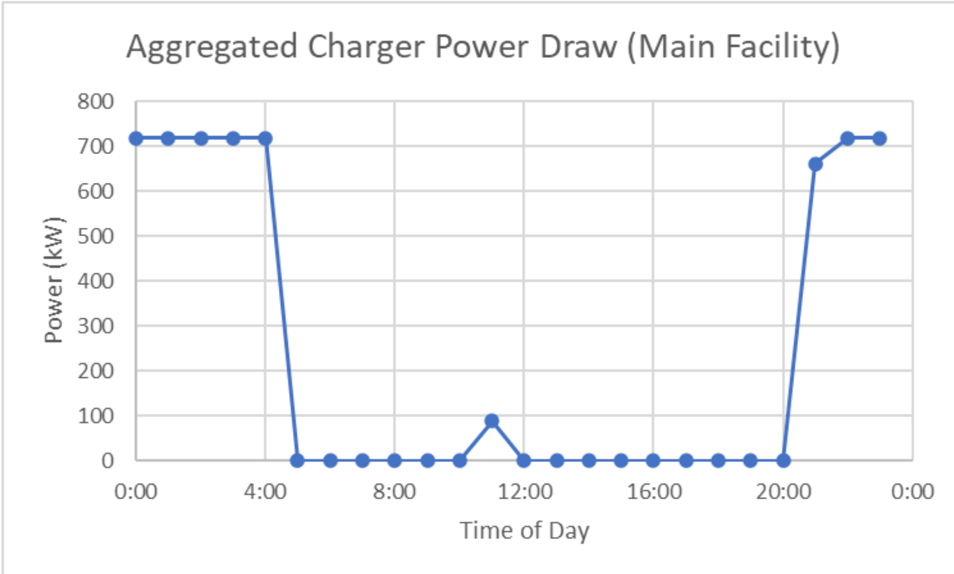

Figure 3 Proposed Depot Charging Schedule for DTI's Future Fleet

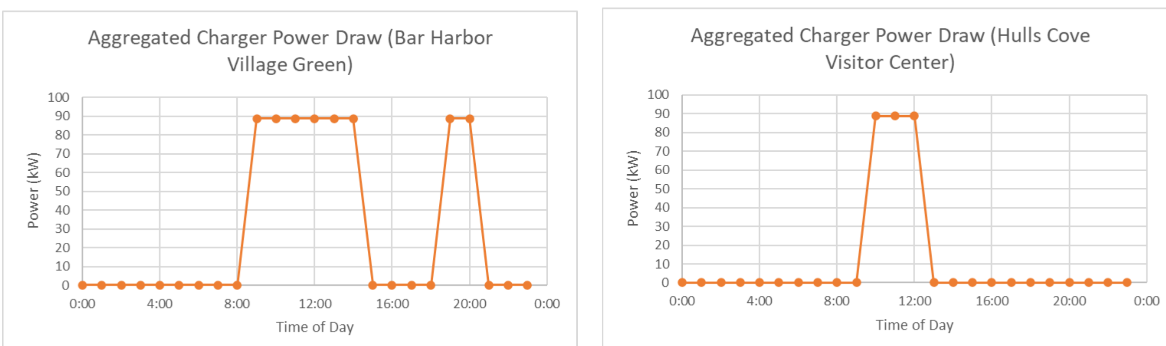

Figure 4 Proposed On-route Charging Schedules for DTI's Future Fleet (BH Village Green and Hulls Cove VC)

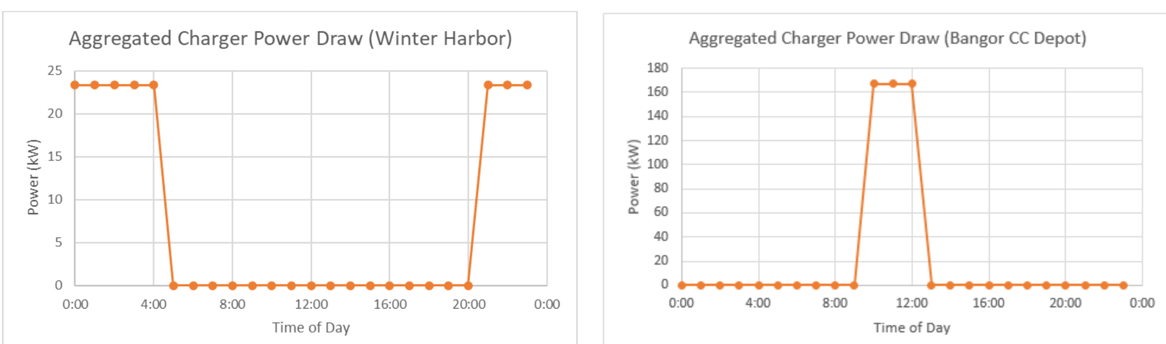

Figure 5 Proposed On-route Charging Schedules for DTI's Future Fleet (Winter Harbor and Bangor CC Depot)

Below is an estimate of expected operational costs associated with the proposed charging schedule, based on both the existing and the new optional rates.

Main Facility

Daily kWh consumption = 5,556 kWh
Monthly Non-coincidental peak = 718 kW
Monthly coincidental peak = 0 kW

Under Current Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 5{,}556\ kWh\ \times (\$0.00604 + \$0.09952)$$
$$= \$586.49$$

$$Monthly\ Charge = Max\ ((Highest\ Power\ during\ Peak\ Period\ \times Peak\ Demand\ Charge), (Highest\ Power\ during\ Shoulder\ Period\ \times Shoulder\ Demand\ Charge), (Highest\ Power\ during\ Off - Peak\ Period\ \times Off - Peak\ Demand\ Charge))$$
$$= Max\left((118\ kW \times \$17.14), (0\ kW \times \$3.45), (718\ kW \times \$2.06)\right)$$
$$= Max\ (\$2{,}022.52, \$0, \$1{,}479.08)$$
$$= \$2{,}022.52$$

Under New Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 5{,}556\ kWh\ \times (\$0.00604 + \$0.09952)$$
$$= \$586.49$$

$$Monthly\ Charge = Monthly\ Charge = Max\ ((Highest\ Power\ during\ Peak\ Period \times Peak\ Demand\ Charge), (Highest\ Power\ during\ Shoulder\ Period \times Shoulder\ Demand\ Charge), (Highest\ Power\ during\ Off - Peak\ Period\ \times Off - Peak\ Demand\ Charge)) + (Monthly\ coincidental\ Peak\ \times Transmission\ Charge)$$
$$= Max\left((118\ kW \times \$2.94), (0\ kW \times \$2.94), (718 \times \$0)\right) + (0\ kW\ \$22.32)$$
$$= Max\ (\$346.92, \$0, \$0)) + (\$0)$$
$$= \$346.92$$

On-Route – Bar Harbor Village Green

Daily kWh consumption = 399 kWh
Monthly Non-coincidental peak = 89 kW
Monthly coincidental peak = 0 kW

Under Current Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 399\ kWh\ \times (\$0.00604 + \$0.09952)$$
$$= \$42.12$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non - coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (89\ kW\ \times \$10.51) + (89\ kW \times \$14.57)$$
$$= \$2{,}232.12$$

Under New Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 399\ kWh\ \times (\$0.00604 + \$0.09952)$$
$$= \$42.12$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (89\ kW\ \times \$8.97) + (0\ kW \times \$23.11)$$
$$= \$798.33$$

On-Route – Hulls Cove Visitor Center

Daily kWh consumption = 193 kWh
Monthly Non-coincidental peak = 89 kW
Monthly coincidental peak = 0 kW

Under Current Rate Structure:

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 193\ kWh\ \times (\$0.00604 + \$0.09952)$$
$$= \$20.37$$

$$Monthly\ Charge = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non - coincidental\ Peak\ \times Transmission\ Charge)$$
$$= (89\ kW\ \times \$10.51) + (89\ kW \times \$14.57)$$
$$= \$2{,}232.12$$

Under New Rate Structure:

$$\begin{aligned}
&Daily\ Charge = \\
&\qquad Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost) \\
&= 193\ kWh\ \times (\$0.00604 + \$0.09952) \\
&= \$20.37
\end{aligned}$$

$$\begin{aligned}
&Monthly\ Charge \\
&= (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) \\
&\qquad + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge) \\
&= (89\ kW\ \times \$8.97) + (0\ kW \times \$23.11) \\
&= \$798.33
\end{aligned}$$

On-Route – Winter Harbor

Daily kWh consumption = 187 kWh
Monthly Non-coincidental peak = 23 kW
Monthly coincidental peak = 0 kW

Under Current Rate Structure:

$$\begin{aligned}
&Daily\ Charge = \\
&\qquad Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost) \\
&= 187\ kWh\ \times (\$0.00604 + \$0.09952) \\
&= \$19.74
\end{aligned}$$

$$\begin{aligned}
&Monthly\ Charge \\
&\quad = (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) + (Monthly\ Non \\
&\qquad - coincidental\ Peak\ \times Transmission\ Charge) \\
&= (23\ kW\ \times \$10.51) + (23\ kW \times \$14.57) \\
&= \$576.84
\end{aligned}$$

Under New Rate Structure:

$$\begin{aligned}
&Daily\ Charge = \\
&\qquad Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost) \\
&= 187\ kWh\ \times (\$0.00604 + \$0.09952) \\
&= \$19.74
\end{aligned}$$

$$\begin{aligned}
&Monthly\ Charge \\
&= (Monthly\ Non - coincidental\ Peak\ \times Distribution\ Charge) \\
&\qquad + (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge) \\
&= (23\ kW\ \times \$8.97) + (0\ kW \times \$23.11) \\
&= \$206.31
\end{aligned}$$

On-route – Bangor CC depot

Daily kWh consumption = 453 kWh
Monthly Non-coincidental peak = N/A
Monthly coincidental peak = N/A

$$Daily\ Charge = Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$$
$$= 453\ kWh\ \times (\$0.00604 + \$0.09952)$$
$$= \$47.82$$

$Monthly\ Charge$:
This study assumed that DTI will not incur the monthly charges associated with maintaining the service, or the demand charges, at this location as the service will be owned by Bangor CC and the charging peak will occur overnight. The study assumed that DTI will reimburse Bangor CC for the electricity that is consumed by its fleet during on-route charging at this location.

As this estimate shows, the proposed rate structures for EV charging would save DTI $4,749.49 per month in utility costs. These savings are, again, achieved by avoiding charging during the coincidental peak between 3 PM and 7 PM, and the reduced monthly 'peak demand' 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 $16,025.76 per month from a 'transmission charge' at the Depot, up to $2,056.79 at Bar Harbor Village Green and Hulls Cove Visitor Center each, and $531.53 at Winter Harbor. Therefore, it is critical that DTI only charges the buses, outside the coincidental peak window between 3 PM and 7 PM or procures a smart charging management system which is programmed to avoid charging during the coincidental peak. Furthermore, it is also important that DTI monitors changes in Versant's coincidental peak window and adjusts its charging schedule accordingly.

It should also be noted that the above charges are calculated based on a typical weekday load during the summer season. 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 DTI's operation.

8. Asset Selection, Fleet Management and Transition Timeline

Section Summary

- Hatch recommends considering a broad range of vehicles, particularly for the Island Explorer, to lower cost and favor adopting a service-proven vehicle
- A variety of chargers is recommended depending on the application

With operational and charging plans established, it was then possible to develop procurement timelines for infrastructure and vehicles to support those plans. DTI, like almost all transit agencies, acquires buses on a rolling schedule. This helps lower average fleet age, maintain stakeholder competency with new vehicle technology, and minimize scheduling risks. However, this also yields a high number of small orders. For any bus procurement – and especially for a newer technology like electric buses – there are advantages to larger orders, such as lower cost and more efficient vendor support. DTI 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 buses.

As an additional complication, DTI currently operates a mix of vehicle types. This is done to tailor the vehicle operated to the service type provided (commuter, circulator, tourist-focused). The drawback to this decision, in the context of electric buses, is that it may pose a constraint on the number of possible vendors. As discussed in Section 4, Acadia National Park imposes width and height limitations on the Island Explorer vehicles, which will limit the use of standard electric vehicles. As of this writing, Hometown, Vicinity, and Arboc are some of the only vendors that offer a compatible EV. These vendors are comparatively small and inexperienced with electric vehicles, posing potential issues with procurement cost and vehicle reliability. Although the market is changing quickly, and within the next few years more diverse electric bus models are likely to be introduced, Hatch recommends that DTI keep its specifications as broad as possible to allow the largest possible range of vendors to participate. In addition, DTI is encouraged to participate in electric vehicle industry conferences to stay up to date with new technology and coordinate with other agencies that may face similar constraints.

For DTI's existing fleet, the cutaways and 40' buses procured in 2022 were assumed to be replaced in accordance with their FTA useful lives of 7 and 12 years, respectively. The vans used for the Bicycle Express service were assumed to need one additional procurement cycle of fossil fuel vans before electrification is feasible in 2033. Replacement dates for the Island Explorer buses, however, were estimated based on the performance of the existing fleet. According to DTI stakeholders, the existing fleet has been operating very reliably, and the COVID-caused idle seasons of 2020 and 2021 have reduced the wear and tear on the buses as well. Therefore, although the first buses were procured in 2018 with a 7-year useful life, this study assumed replacement of the fleet to begin in 2030. As with previous procurement cycles, the vehicles were scheduled to be ordered on a staggered basis; this will allow DTI sufficient EV operating time and experience to choose an Island Explorer operating model as discussed in Section 6c. Propane buses planned for purchase in 2025, intended for service expansion, were assumed to need replacement in 2035.

With respect to infrastructure procurements, the maintenance facility will eventually need to have enough chargers to accommodate all of DTI's electric buses. 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 installation, structural modifications, and civil work make it economical to install all the support infrastructure at once. Hatch recommends that all of the depot chargers are installed at once to minimize the number of separate installation projects.

To serve the charging requirements described in the previous section for the proposed electric fleet, installing a centralized charging architecture is recommended for the maintenance facility.

Centralized chargers will give DTI the most flexibility in its charging operation by providing a minimum of 50kW per vehicle but allowing for charging power of up to 150 kW when other dispensers on the same charger are not in use. Because each charger typically has three dispensers, DTI will require a minimum of fourteen chargers, with forty-two dispensers, to ensure there is a dedicated dispenser for each of the 30 electric buses needed to provide peak service. A dedicated dispenser per vehicle allows overnight charging without requiring a staff member to move buses or plug in chargers overnight. This will also provide the recommended allowance of spare dispensers to accommodate the already-planned 5-bus fleet expansion, dispenser cable failures, “hot standby” buses, vehicle maintenance, and possible additional expansion beyond what is currently planned.

At other locations, smaller-scale charging infrastructure will be needed. At Winter Harbor, two chargers will be necessary to support Route 8 operations. Because many potential Island Explorer buses cannot charge from AC power, a DC charger is recommended (as opposed to a typical level 2 charger) for maximum vehicle flexibility. However, as these chargers will only be needed for overnight charging, a comparatively low power level – of approximately 25 kW – should be sufficient. This charger could be used for public charging during the daytime and off-season, generating revenue for the agency, and reserved for DTI’s vehicles overnight during the summer.

If the agency chooses to install on-route chargers at BH Village Green and Hulls Cove VC, the short available layover times will require these chargers to be DCFC units. Hatch recommends a power level of approximately 80 kW, though the exact value will depend on the power levels DTI’s selected vehicles can accept. These chargers will need to be installed no later than the last procurement of electric vehicles, but sufficiently far after the first procurement that DTI leaders have had time for an informed decision regarding the Island Explorer’s operating model. Table 4 summarizes the proposed vehicle and infrastructure procurement schedules.

Table 4 Proposed Fleet and Charging System Transition Schedule

Year	Buses Procured	Infrastructure Procured	Purpose
2025	5 Propane 32’ Buses		Planned fleet expansion
2026	4 Gasoline Vans		Bicycle Express fleet replacement
2027			
2028			
2029	8 Hybrid Cutaways		Circulator fleet replacement
2030	10 Electric 32’ Buses	14 depot chargers (42 dispensers) + generators, transformers, switchgear	Island Explorer fleet replacement
2031	11 Electric 32’ Buses		Island Explorer fleet replacement
2032	11 Electric 32’ Buses	Two on-route DC fast chargers (if necessary) and two DC chargers at Winter Harbor	Island Explorer fleet replacement

Year	Buses Procured	Infrastructure Procured	Purpose
2033	4 Electric Vans		Bicycle Express fleet replacement
2034	4 Electric 40’ Buses		Commuter fleet replacement
2035	5 Electric 32’ Buses		Island Explorer expanded fleet replacement

As discussed in Section 6c, Hatch recommends that DTI operate its first electric buses across all of its routes. This experience will help DTI continue to gain experience with electric bus operations and make an informed decision regarding on-route charger installation. Finally, spreading electric buses out across the network will ensure that the benefits of electric vehicles (elimination of tailpipe emissions, reduced noise, etc.) are distributed equitably across the service region. This may also prove valuable from a Title VI perspective, as demographics in the towns Island Explorer serves continue to change over the coming years. Rotating the electric vehicles across the routes will ensure that no area is disproportionately negatively impacted by DTI operations.

9. Building Spatial Capacity

DTI’s main storage and maintenance facility is located at 117 Gateway Center Drive in Trenton, Maine, halfway between Bar Harbor and Ellsworth. The facility, shown in Figure 6, is owned by Maine DOT and leased to DTI at no cost. There is indoor space for storing twelve 32’ buses, shown in Figure 7, as well as a four-bay maintenance area for light maintenance. Most buses are typically stored outside the garage, as shown in Figure 8. Therefore, it is logical to place most of the overnight chargers outdoors, for which there is sufficient space available. The facility is located on regulated wetlands, which limit expansion. There is a parking lot nearby, adjacent to the proposed Acadia Gateway Center, that is also a feasible location for some overnight charging equipment; this is shown in Figure 9.

Section Summary

- The depot has sufficient space to accommodate charging of the full fleet
- Winter Harbor, BH Village Green, and Hulls Cove VC also have space available
- Other locations can accommodate chargers but do not require them

Figure 6 DTI Maintenance Facility

Figure 7 DTI Maintenance Facility Indoor Storage Area

Figure 8 DTI Outdoor Storage Area

Figure 9 Parking Lot Near Proposed Acadia Gateway Ctr.

There are several other locations that are not transit hubs but are planned for vehicle charging. One such location is recommended on the Schoodic Peninsula to support Route 8 service. Although the specific location will need to be agreed upon with local landowners, this study assumed that chargers can be installed at the ferry terminal at 88 Sargent St. in Winter Harbor. As seen in Figure 10, there is ample space available for parking and vehicle charging.

Figure 10 Ferry Terminal, Winter Harbor (Source: Bing Maps)

As discussed in Section 6, the Bangor commuter bus does not visit the depot on a daily basis, but rather lays over during midday and overnight periods at the Bangor Community Connector depot at 475 Maine Avenue in Bangor, Maine. There is an existing agreement for vehicle fueling and light maintenance, though this rarely proves necessary. This study assumed that that facility can be used for charging during the midday period, when most of Bangor's fleet will be operating and not requiring charging. As shown in Figure 11, Bangor's bus barn, which is the planned location for charger installation, can easily accommodate a DTI bus.

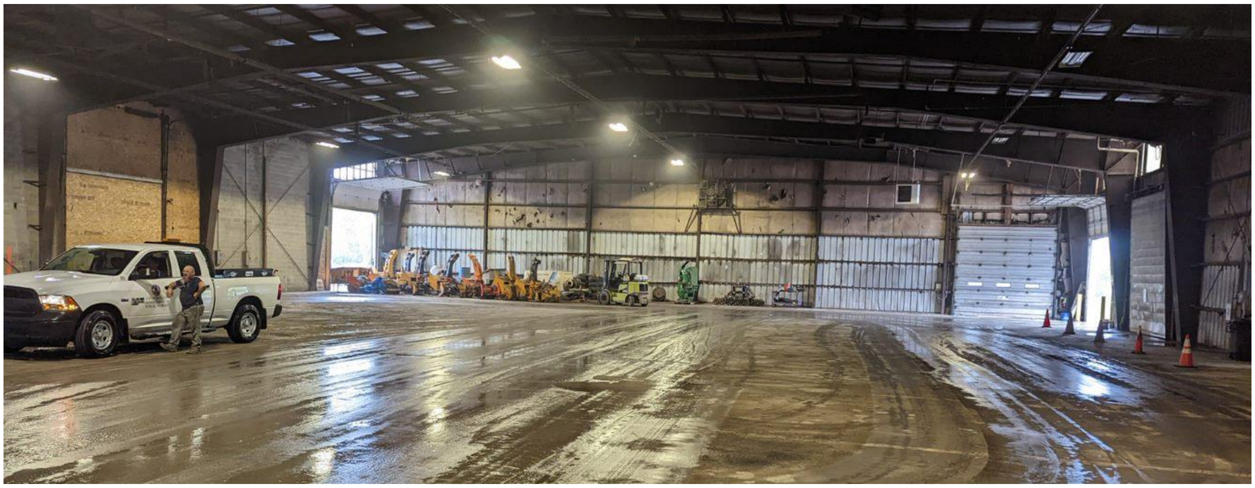

Figure 11 Bangor Community Connector Bus Barn

One final potential non-hub location for charging is the Ferry Terminal at the Regency in Bar Harbor. As the terminal of Route 2 (Eden Street), it would have potential as an uncongested layover area for vehicle charging. As shown in Figure 12, there is space available for charger installation and vehicle layover. However, this location is only served by one route, posing operational challenges for charging vehicles on other routes. In addition, charger installation at the Ferry Terminal would semi-permanently constrain DTI to operating a route terminating there; unlike the transit hubs discussed below, the Regency is not certain to remain a route terminal in coming years. Therefore, the Ferry Terminal is not recommended as a charging location.

Figure 12 Ferry Terminal at the Bar Harbor Regency

DTI has several transit hubs, including the Bar Harbor Village Green, the Hulls Cove Visitor Center, and Jackson Laboratory. These are intuitive locations to consider for vehicle charging because of the large number of DTI routes serving them, both today and in the future.

Almost all Island Explorer routes stop at the bus stop located at the Bar Harbor Village Green, shown in Figure 13. Buses typically layover for 5-10 minutes, and there is enough space for five buses to dwell at one time. Particularly near the northwestern corner of the Green, the sidewalk is wide enough to accommodate installation of a plug-in charger. If DTI chooses to install a charger here, there is also sufficient space to install the nearby transformer equipment. Further details on the proposed layout of equipment here are provided in Section 12.

Figure 13 Bar Harbor Village Green

The Hulls Cove Visitor Center is located at 25 Visitor Center Rd. This location is served by four routes, with two originating/terminating there. The bus boarding area shown in Figure 14, closest to the visitor center itself, is congested with bus traffic during the peak season and does not have sufficient space for charging equipment. However, there is an existing layover space for buses on Paradise Hill Road directly northwest of the main parking lot; this area, shown in Figure 15, is currently used for bus layover during driver lunch breaks. With improvements to paving and signage, this area would be suitable for an on-route charger should DTI choose to install one here.

Figure 14 Hulls Cove Visitor Center Bus Stop

Figure 15 Hulls Cove Visitor Center Potential Bus Charger Area

The Jackson Lab is the primary hub of DTI's commuter routes. This destination, located at 600 Main St. in Bar Harbor and shown in Figure 16, has space for bus layover charging after commuter morning runs or before afternoon runs. However, DTI's current operating model does not require buses to lay over at the Lab during the midday hours; vehicles are either used on other routes or return to the depot after they complete their morning runs. For this reason, charger installation is not recommended at Jackson Lab.

Figure 16 Jackson Laboratory Drop Off Area

10. Electrical, Infrastructure, and Utility Capacity

Section Summary

- The existing transformer at the main facility is insufficient for full electrification
- A new utility service and infrastructure is required at Bar Harbor Village Green for on-route charging
- The on-route chargers at Hulls Cove and Winter Harbor might not need substantial additional investments

Versant is the utility provider for DTI's charging locations. As part of its electrification efforts, DTI has been coordinating with Versant to discuss the anticipated need for new electrical infrastructure.

The Main Facility has 34.5 kV 3-phase service that is stepped down to 480/227V through a 300 kVA step-down transformer located outdoors, as shown in Figure 17. This transformer is not sufficient for the previously described charging needs at the main facility which is estimated to be 718kW (assuming optimal use of charge management software) during the overnight charging period when all the commuter and Island Explorer vehicles are charging simultaneously. As a result, a new dedicated 750 kVA 480V 3-phase service with a separate meter is recommended for the charging infrastructure. A separate meter for charging operation is also advisable to be able to qualify for the future proposed special EV charging rate structure.

Figure 17 Existing Transformer at the Depot

As discussed in Section 7, the Bar Harbor Village Green location is estimated to require 89kW (assuming a single 80 kW charger is installed) for mid-day charging. This location does not have any transit facility/building. Hence, there is no electrical infrastructure at the site that could provide power for the vehicle charging. A brand new separately metered 100 kVA service will need to be installed at this location for the required mid-day charging that is discussed previously.

Like the Bar Harbor Village Green, the Hulls Cove Visitor Center is also estimated to require 89kW (assuming a single 80 kW charger is installed) for mid-day charging. The size and spare capacity for the Visitor Center electrical infrastructure could not be determined since the drawings and electrical information was not available at the time of this analysis. However, the Visitor Center is planned to be rebuilt as per the 2019 Transportation Plan. The additional electrical capacity should be included in the new building design to account for this charging need. The cost associated with this should be minimal since the building is currently in early stages of the design.

The last suggested charging site is at the Ferry Terminal in Winter Harbor. Although, electrical data for this location were not available as of this writing, the charging requirement at this location is low at 23kW. Therefore, the current infrastructure and the utility feed might be able to accommodate this small charging load. A load study will need to be conducted to determine the available spare capacity. Even though a separate meter is required to quality for the special EV utility rate, the additional cost to bring a new service location might not be justified given the small load; if submetering is acceptable to qualify for the EV rate this may be desirable.

11. Risk Mitigation and Resiliency

> ***Section Summary***
>
> - As with any new technology, electric bus introduction carries the potential for risks that must be managed
> - As lengthy power outages have occurred, resiliency options should be considered
> - Solar in conjunction with on-site energy storage system can be viable for partial resiliency, reducing GHG and offsetting electricity cost

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 fossil fuel buses, 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. Bus electrification makes some failure modes impossible – for example by eliminating the fossil fuel engine – but introduces others. For example, the ability to provide service becomes dependent on the continuous supply of electricity to the charging location. As electrification begins in the coming years and DTI becomes increasingly reliant on BEBs, it will remain important to understand these risks and the best ways to mitigate them.

11a. Technological and Operational Risk

The vehicle and wayside technology required for electric bus operation is in its early stages; few operators have operated their electric fleets or charging assets through a complete lifecycle of procurement, operation, maintenance, and eventual replacement. As detailed in the earlier Transit Vehicle Electrification Best Practices Report, this exposes electric bus 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 fossil fuel buses, and new vehicles are required to undergo Altoona testing, some of the new designs will inevitably have shortcomings in reliability. This is especially important for the Island Explorer vehicles, which are more likely to be niche products due to the geometric restrictions they must meet.
+ Battery performance: The battery duty cycle required for electric buses – 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, diesel heater installation, and preferring lower power charging to short bursts of high power, best practices in bus charging and battery maintenance will become clearer in coming years.
+ Supply availability: Compared with other types of vehicles, electric buses 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 bus 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 diesel buses, which can refuel at any public fueling station, many electric buses require DC chargers, and specifically high-power DC chargers for midday charging. Particularly early on, when there is not a widespread network of public fast chargers, this may pose an operating constraint in case of charger failure.
- Fire risk: The batteries on electric buses require special consideration from a fire risk perspective (see Section 12b).

All these risks are likely to be resolved as electric bus technology develops. DTI is in a good position in this regard, as its young fleet allows it to wait for the technology to mature before placing an order. Nevertheless, given DTI's large fleet and high ridership it will be prudent for the agency to plan its transition to electric vehicles with an eye toward operating robustness in case of unexpected issues. Hatch recommends several strategies to continue maximizing robustness:

- Require the electric bus vendor to have a technician on site or nearby in case of problems. This is most economical when the technician is shared with nearby agencies.
- Reach a "mutual aid" agreement with another urban transit agency in Maine, such as Bangor CC, that would let DTI borrow spare buses in case of difficulties with its fleet.
- Retain fossil fuel buses for at least two years after they are retired to ensure they can substitute for electric buses if any incidents or weather conditions require it.
- If on-route chargers are installed, develop contingency plans in case they fail unexpectedly and midday depot swapping is required.

11b. Electrical Resiliency

Electricity supply and energy resilience are important considerations for DTI when transitioning from fossil fuel to electric bus fleets. As the revenue fleet continues to be 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 DTI will need to be determined based on a cost benefit analysis.

Table 5 Comparison of 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

Although the depot has a generator that can power the entire building for 24 hours, and a solar panel used to heat water, these will not be sufficient to also provide power to the proposed vehicle charging equipment, particularly during the Island Explorer season. The other proposed charging locations are, similarly, not equipped with generators large enough to accommodate vehicle charging.

11.b.2. Outage Data and Resiliency Options

After noting no viable resiliency systems in place, 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 DTI's five main hubs 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 Versant for reference.

- Depot – This facility has seen 12 outages in the last 5 years. Out of these, 10 lasted approximately 1 hour or less. Two outages were long enough to impact operation of BEBs, lasting for approximately 5.5 hours and nearly 91 hours.
- Bar Harbor Village Green – This location had 9 outages over the time period analyzed. Two were of significant duration, lasting approximately 1 and 4 hours.
- Hulls Cove Visitor Center – This location had 7 outages in the last 5 years. Two were of significant duration, lasting approximately 1 and 35 hours.
- Ferry Terminal in Winter Harbor – This location had 18 outages in the last 5 years. Out of these, one lasted less than half an hour. Nine outages lasted between 1 and 3 hours. Eight outages were long enough to impact operation, lasting for approximately 4, 4, 5, 5.5, 8, 17.5, 20, and 32.5 hours.

+ Jackson Laboratory – This location has seen 14 outages over the time period analyzed. Out of these, 7 were long enough to impact operation, lasting for approximately 1, 2, 2.5, 3.5, 4, 6, and 8 hours.

The resiliency system requirements are determined below based on the worst outage instance outlined above and the charging needs for the full fleet during this type of outage scenario.

The on-site energy storage requirement to charge the fleet during that outage period at the main facility would be 23.1 MWh. 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 28.9 MWh. The power requirement for generator capacity was assumed to be the aggregated power draw required during overnight charging for the fleet, which is 718 kW. Assuming an efficiency of 90%, and a 20% spare capacity, the resulting on-site generation capacity required would be approximately 1000 kVA. There is an existing 375 kVA diesel generator at the depot which will clearly not be sufficient for charging the fleet during the outages.

At the Bar Harbor Village Green site, the on-site energy storage requirement to charge the fleet during the 4-hour outage period would be 356 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 445 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 Hulls Cove Visitor Center, the on-site energy storage requirement to charge the fleet during the 1.5-hour outage period would be 133.5 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 175 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. Since this facility is planned for a rebuild, the charging requirements could be added to the resiliency option, if there is one, planned for the new building.

Finally, the on-site energy storage requirement for charging at Ferry Terminal during 32.5-hour outage period would be 374 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 470 kWh. The power requirement for generator capacity was assumed to be the aggregated power draw required during overnight charging for the fleet, which is 23 kW. Assuming an efficiency of 90%, and a 20% spare capacity, the resulting on-site generation capacity required would be approximately 32 kVA. This site does not have any backup power option so a new system, on-site storage or generator, will need to be considered for resiliency.

Hatch next generated cost estimates associated with the two resiliency system options for all the locations. 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	Main Facility	28.9 MWh	$18M
	Bar Harbor Village Green	445 kWh	$280,000
	Hulls Cove Visitor Center	175 kWh	$110,000
	Ferry Terminal, Winter Harbor	470 kWh	$300,000
Option 2 On-site Diesel Generation	Main Facility	1000 kVA	$600,000
	Bar Harbor Village Green	125 kVA	$75,000
	Hulls Cove Visitor Center	125 kVA	$75,000
	Ferry Terminal, Winter Harbor	32 kVA	$20,000

The above analysis and corresponding options are based on the historic outage data, and an assumption that full summertime service is operated during the outage. Since outages like these occur very rarely, the above resiliency options may be oversized for most use cases resulting in a poor return on the capital investments. As the utility industry evolves over the course of DTI's electrification transition, the agency will have to choose an appropriate level of resiliency investment based on historical and anticipated needs.

11.b.3. Solar Power

In addition to the above two options for backup power, on-site solar generation should also be considered to add resiliency, offset the energy cost, and further reduce DTI'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. The 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 arrays would primarily be to offset energy from the grid and reduce utility costs.

An on-site solar system was evaluated for the Depot because the roof of the facility structure provides a large surface area that could be utilized for a solar array as illustrated in Figure 18 below. However, as an existing facility, the depot building will need a structural analysis to determine if the existing building will be able to carry the weight of the solar panels and equipment. In addition, a study would need to confirm that the new solar panels would not impact existing roof-mounted skylights, rainwater collection systems, etc.

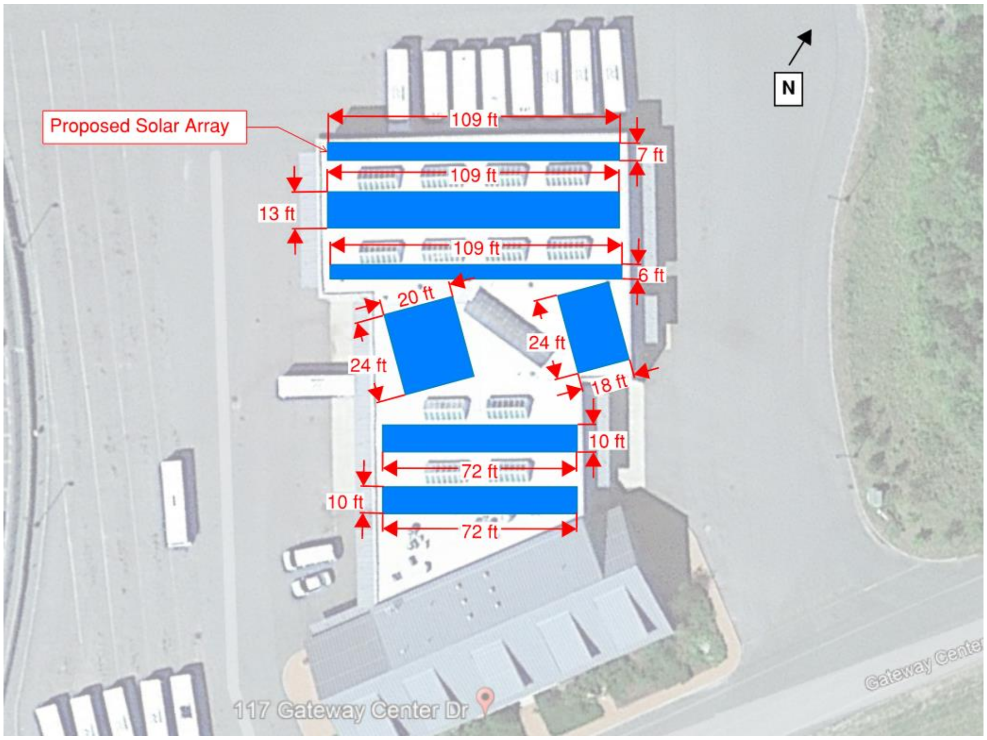

Figure 18 Depot Proposed Solar Array

Assuming that the panels can be installed on the roof, Table 7 outlines parameters for the solar power system that the facility roof can accommodate as well as the expected annual energy production and resulting cost savings from offsetting energy consumed from the grid.

Table 7 Depot Roof Solar Parameters

Solar System Design Parameters	
Solar System Sizing Method:	Available Area
Cumulative Solar Array Area	5,186 ft^2
Maximum Number of Panels	233 panels
Maximum System Power	99 kW
Annual Production Coefficient	1,297 hours
Sunny Days Per Year	192 days
Annual Solar Energy Production	128,605 kWh
Annual Electric Usage	665,737 kWh
Maximum Percent of Electrical Usage Offset	19%
Electricity Rate	$0.09952 / kWh
System Cost	**$273,189**
Utility Bill Savings Per Year	**$12,799**
Simple Payback Period Without Grants	**21.3 years**
Payback Period with 80% Federal Grants	**4.3 years**

Based on the above parameters, the maximum daily production for sunny days is estimated to be approximately 670 kWh. Since the energy requirement for a full day charging is 5,773 kWh, solar does not provide enough energy to support operations in the event of an outage even on sunny days.

Solar power generation is also not recommended as a primary resiliency system as power outages are not evenly distributed throughout the year. They are most likely to occur due to winter storms – during the time of the year when the least amount of solar energy is available due to cloud cover.

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

If solar is considered for the site, the on-site storage system should be sized according to the full solar production. A more detailed study should be conducted to determine the battery energy requirements.

12. Conceptual Infrastructure Design

12a. Conceptual Layouts

To assist DTI with visualizing the required infrastructure transition, conceptual plans were next developed based on the previous information established in this report. As outlined previously, Hatch recommends that overnight charging infrastructure be installed at the Depot and at the Ferry Terminal in Winter Harbor, with on-route chargers installed (should DTI choose to do so) at the Bar Harbor Village Green and potentially also at the Hulls Cove Visitor Center.

Section Summary

- Hatch recommends considering bus maneuverability, sidewalk space, nearby underground utilities, sight lines around parked buses, snow clearance, and security when choosing charger locations
- The risk of a BEB fire is low but must be considered and mitigated

Given the spatial constraints at the depot, only limited vehicle charging is possible indoors. Hatch recommends installing two chargers, with six dispensers, indoors and using these for charging during the winter, when only the four commuter buses will typically require charging. This will reduce the impact of weather on the chargers themselves and will ensure that the buses (and their batteries) are kept warm during charging and before entry into service. The majority of the chargers will, however, have to be located outdoors. To avoid constructing overhead gantries or charging islands or draping charging cables across vehicle drive paths, the parking areas used for charging should be laid out using back-in angled parking. Hatch recommends that all chargers be installed in or near the depot itself; although the parking lot near the proposed Acadia Gateway Center (shown in Figure 9) is lightly used, under its present layout the westernmost parking stalls are not long enough to accommodate back-in bus parking, and under the proposed future layout (shown in Figure 19) the pull-through bus bays would not be suitable for plug-in charging dispensers with charging cables as no adjacent island for dispenser installation would be available.

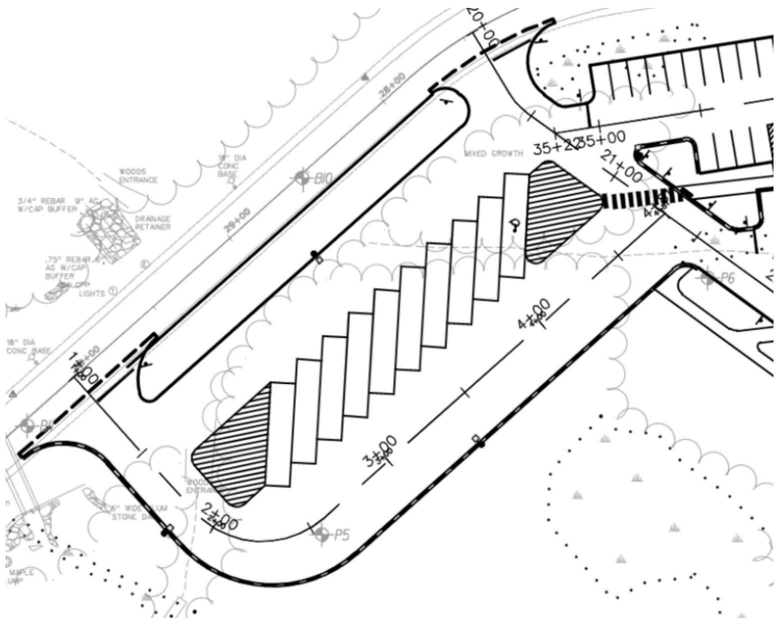

Figure 19 Proposed Layout of Western Parking Area at Acadia Gateway Center

One possible layout for future charger installation near the depot is shown in Figure 20. Aside from the charging infrastructure itself, DTI would also need to invest in security measures to deter overnight bus vandalism (such as fences, cameras, and lighting), install fire detection measures as outlined in Section 12b, and develop snow-clearing procedures to ensure that the plow operators clear the areas adjacent to the chargers without damaging the chargers themselves.

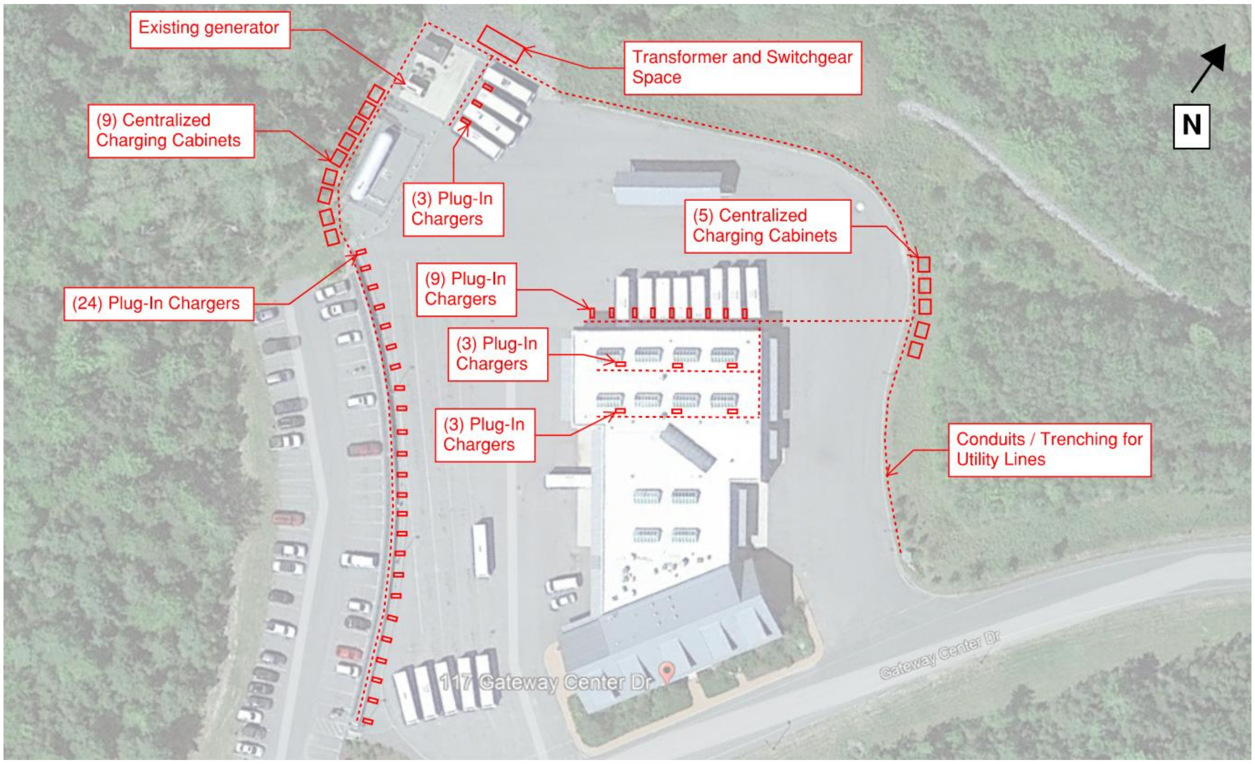

Figure 20 Depot Overnight Charger Layout Option

At the Ferry Terminal in Winter Harbor, Hatch recommends that the chargers be installed as shown in Figure 21 below. This layout will allow buses to pull in and out of the charging areas most easily and avoid obstructing other vehicles while parked. This would also provide two designated spaces for charging of personal electric vehicles when the DTI vehicles do not require them.

Figure 21 Ferry Terminal in Winter Harbor Charger Layout Option

At Bar Harbor Village Green, buses currently use a dedicated area along the sidewalk for layovers. Hatch recommends installing the layover charger in the location shown in Figure 22 below. Key considerations when choosing a specific charger location include bus maneuverability, sidewalk space, nearby underground utilities, sight lines around parked buses, snow clearance, and security. As mentioned previously, the charger could be used by the public during the off-season.

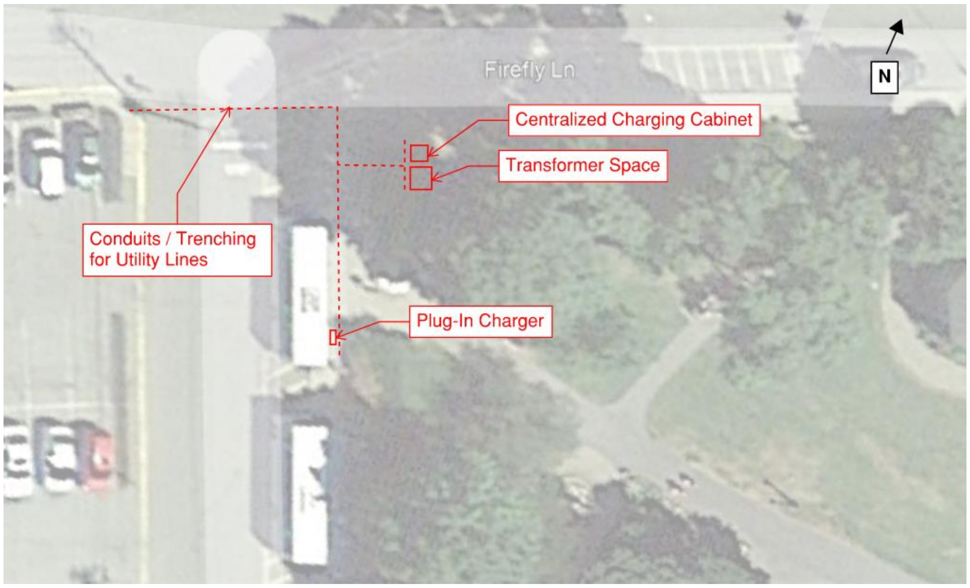

Figure 22 Bar Harbor Village Green Charger Layout Option

At the Hulls Cove Visitor Center, buses lay over on a dedicated section of Paradise Hill Road. Hatch recommends installing the layover charger as shown in Figure 23 below, once paving and other upgrades are completed. If appropriate signage is installed, this charger's proximity to the public parking lot would allow the public to use it during morning/evening hours and the off-season.

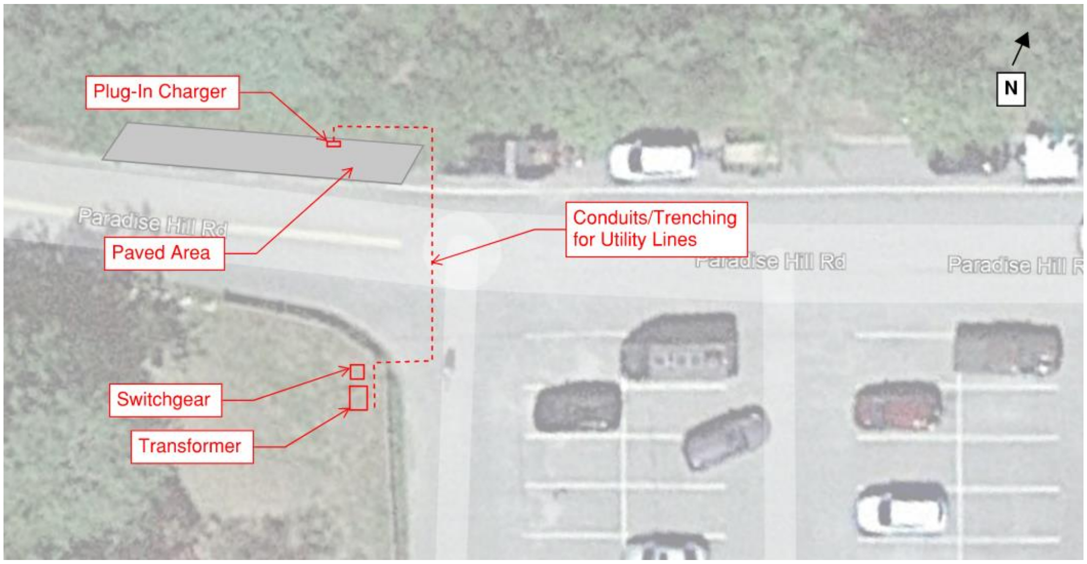

Figure 23 Hulls Cove Visitor Center Charger Layout Option

12b. Fire Mitigation

An electric bus'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 bus. If this is another electric bus then a chain reaction can occur, with the heat emanating from one bus overheating (and likely igniting) the batteries of another bus. This can endanger all the buses in the overnight 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 DTI's risk is partially mitigated because the majority of the buses will be stored outdoors while charging, Hatch still recommends that DTI 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 buses, the maintenance facility, or nearby propane infrastructure. In terms of staffing, it is recommended that staff be located nearby to respond in case of a fire and move unaffected buses out of harm's way. If DTI staff are not present at the depot overnight, Hatch recommends coordinating with the local fire department to ensure that first responders are trained on procedures to prevent a vehicle fire from spreading. Each of these factors requires specific consideration with respect to DTI's operations. Hatch recommends that DTI commission a fire safety study as part of detailed design work for the next charger installation project to consider these factors.

13. Policy Considerations and Resource Analysis

Section Summary

- A wide range of funding sources is available to DTI to help fund electrification
- National Park and other partner support will be needed

In 2021, DTI's operating budget was roughly $3.25 million per year. The agency's funding sources are summarized in Figure 24. As can be seen in the figure, DTI's largest source of funding comes from "other" funds;

unlike most transit agencies, DTI has developed a wide range of partners to help fund its services.

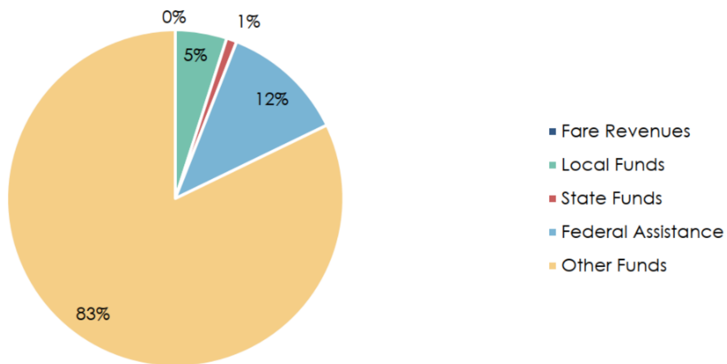

Figure 24 Current Agency Funding Summary (Source: Maine DOT)

The commuter service to Jackson Lab is funded by the laboratory itself (which covers approximately half of its operating cost) as well as federal 5311 allocations and grants. The midday services are also funded through federal allocations. DTI's primary expenses, however, relate to the Island Explorer, which has the largest number of funding sources. The National Park Service is a key contributor, with a portion of park entrance fee revenue redirected to the Island Explorer. LL Bean, the retailer, contributes $250,000 in annual sponsorship revenue as well. Finally, $1.2 million in federal Category 3 funding is provided to finance new bus purchases.

Despite the large number of potential funding opportunities available to transit agencies seeking to shift to BEBs, these programs are competitive and do not provide DTI with guaranteed funding sources. Therefore, this analysis assumes that DTI will only receive funding through the largest grant programs that provide the highest likelihood of issuance to the agency. Specifically, this analysis assumed that DTI will receive 80% of the capital required to complete the bus, charging system, and supporting infrastructure procurements outlined in this transition plan through the following major grant programs (perhaps via the National Park Service as an intermediary):

+ 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, local, or partner funds as described above. As discussed in Section 14, the shift to hybrid and electric vehicles is expected to reduce operating costs, easing the annual financing requirements from the National Park and LL Bean. Alternatively, the freed-up funds could be reinvested in providing additional service. However, as these newer vehicle types are more expensive, the upfront capital cost of vehicle purchases is expected to increase. This will require additional funding through the Category 3 program, federal grants, dedicated allocations from the National Park Service, or other sources.

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

Table 8 Policy and Resources Available to DTI

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 bus 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 buses 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 buses 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 buses 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 bus 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 DTI's fossil-fuel operations as a baseline, using a net present value (NPV) model. This allows all costs incurred throughout the fleet transition to be considered in terms of today's dollars. The costs, which are based on the weekday summer service levels analyzed above and scaled to account for weekends, holidays, and other seasons, include initial capital as well as operations and maintenance costs of the vehicles and supporting infrastructure for fossil fuel and battery electric buses. Table 9 outlines the LCC model components, organized by basic cost elements, for fossil fuel, hybrid, and battery electric bus technologies.

Section Summary

- Bus electrification will save DTI money over the long term, as electric vehicles cost less to maintain and fuel
- Upfront capital costs increase by approximately 74% and annual operating cost will decrease by approximately 14%, yielding a net 0.4% increase in total cost of ownership

Table 9: Life Cycle Cost Model Components

Category	Fossil fuel (Base case)	Hybrid-Electric	Battery-Electric Buses
Capital	Purchase of the vehicles	Purchase of the vehicles	Purchase of the vehicles
	Mid-life overhaul	Mid-life overhaul	Mid-life overhaul
			Battery replacement
			EV charging Infrastructure
			Electrical infrastructure upgrades
			Utility feed upgrades
Operations	Diesel Fuel/Gasoline/Propane	Diesel Fuel/Gasoline/Propane	Electricity
	Operator's Cost	Operator's Cost	Operator's Cost
			Demand charges for electricity
			Diesel Fuel for Auxiliary Heaters
Maintenance	Vehicle maintenance costs	Vehicle maintenance costs	Vehicle maintenance costs
			Charger maintenance costs
Financial Incentives	Grants	Grants	Grants

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

Capital Investment

- The lifespan of a bus is 10 years for Island Explorer buses, 7 years for cutaways and vans, and 12 years for 40’ transit buses, in accordance with DTI practice.
- 40’ transit buses are overhauled at midlife. This is recommended for electric buses as the lifespan of a transit bus battery is approximately 6-7 years.

Funding

- Federal grants and partner funds cover 80% of the procurement cost for buses (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 DTI’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)
40’ Diesel Transit Bus	$551,000
40’ Battery Electric Transit Bus (450 kWh)	$1,019,000
Gasoline Cutaway Vehicle	$70,000
Gasoline-Electric Hybrid Cutaway Vehicle	$125,000
Propane Bicycle Express Van	$50,000
Electric Bicycle Express Van	$180,000
Propane Island Explorer Bus	$250,000
Electric Island Explorer Bus	$380,000
DC Fast Charger – Plug-in Garage (de-centralized unit and 3 dispensers)	$270,000
DC Charger – Plug-in Streetside (25 kW)	$25,000
DC Fast Charger – Plug-in Streetside (80 kW)	$150,000

Expense	Estimated Cost (2022 $’s)
Fossil fuel bus maintenance	$0.96 / mile
Electric bus maintenance	$0.72 / mile
Operator salary, benefits, overhead	$23.69/ hour
Diesel fuel and gasoline	$3.25 / gallon
Propane	$1.73 / gallon

Because the electrification transition process will be gradual, life cycle cost calculations would necessarily overlap multiple bus procurement periods. Hatch addressed this issue by setting the start of the analysis period to be the year when the last propane bus is proposed to be retired

(2035), with the analysis period stretching for a full lifespan of each vehicle type. 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 bus stop 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 25 summarize the NPV for both technologies by cost category.

Table 11: Net Present Value Summary

Category	Baseline	Future Fleet	Cost Differential (Future Fleet vs. Baseline)
Vehicle Capital Costs	$1,930,622	$2,763,710	+74%
Infrastructure Capital Costs	$0	$603,250	
Vehicle Maintenance Costs	$3,537,855	$2,784,148	-14%
Infrastructure Maintenance Costs	$0	$164,538	
Operational Cost	$6,067,427	$5,276,366	
Total Life Cycle Cost	**$11,535,904**	**$11,592,012**	**+0.4%**

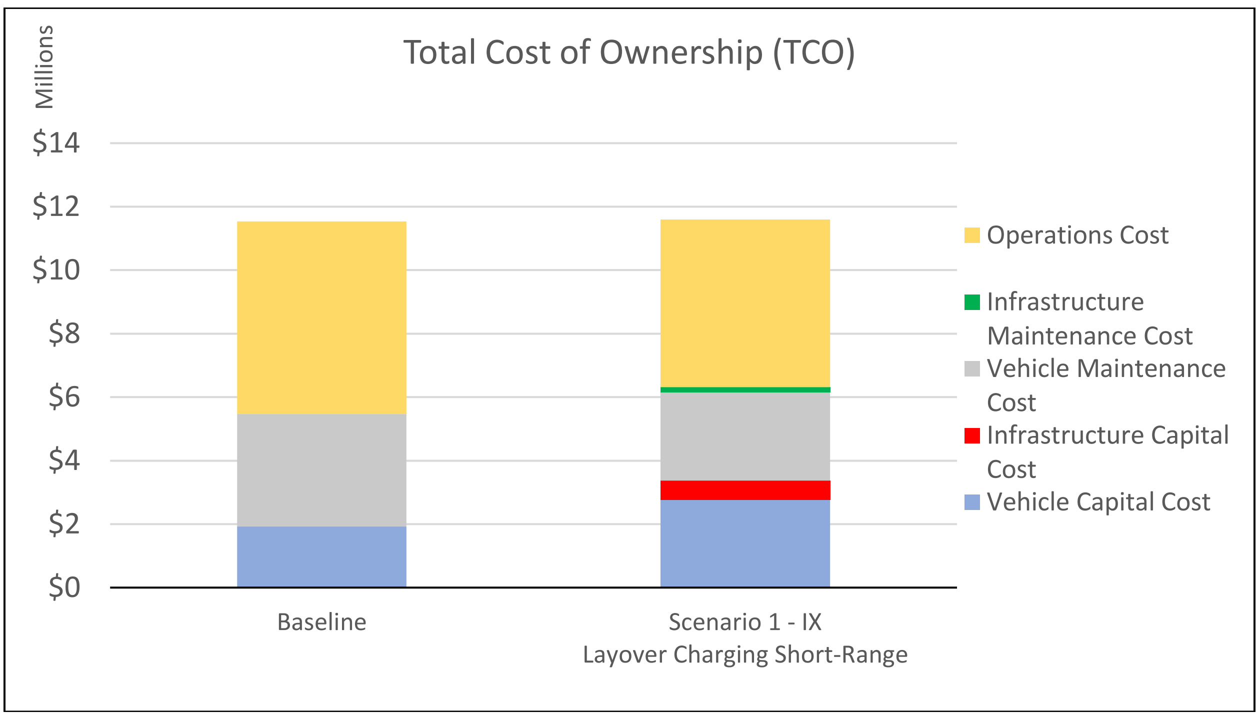

Figure 25 Life Cycle Cost Comparison

As shown in Figure 25, bus electrification reduces recurring cost at the expense of increasing initial capital cost. Although there is significant expense related to the charging equipment at the depot and locations in the field, much of the extra capital spending is also on the vehicles themselves, as electric buses are much simpler mechanically than fossil fuel buses but command a cost premium due to their large battery systems. This yields a 74% increase in capital costs over the fossil fuel baseline. This initial, non-recurring cost is balanced out by the maintenance and operating savings over the lifetime of the vehicles. Because electric vehicles have fewer components to maintain and are cheaper to refuel than fossil fuel vehicles, and even hybrids experience less wear and tear on brakes and other components, the maintenance and operating costs of the proposed fleet are 14% lower than of the 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 approximately 0.4%.

The proposed fleet transition requires initial capital spending to reduce recurring 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 electric bus 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 DTI 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 DTI to modify vehicle procurement schedules or quantities, 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 DTI 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 DTI.

State purchasing contracts offer financial savings for several reasons. First, the overhead expenses associated with an order – specification development, vendor negotiation, training, and post-acceptance technical support – can be divided across several agencies. Second, the number of orders required by each agency can also be reduced. State purchasing contracts typically have a duration of five years, allowing a large portion of the agency's fleet to be replaced in one lifecycle. For example, in accordance with the procurement schedule in Table 4, DTI expects to place nine vehicle orders over the next 12 years. With five-year purchasing contracts, this number can be reduced to five, saving on many of the same per-order expenses outlined previously. These two factors are estimated to reduce DTI's cost per bus by approximately 4%, or $40,000, for a typical BEB. Third, the increase in total order size is likely to reduce cost per vehicle as well. Like agencies, BEB 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 bus 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 BEB fleet. Recent BEB orders across the US show that, on average, for each additional bus in an order the per-bus cost decreases by 0.63%. In other words, combining five two-bus orders into one ten-bus order would reduce purchase cost by 5%, or $500,000, due to order size alone.

DTI plans to order 61 vehicles over the next 12 years, and these orders can easily be allocated to purchasing contracts. The 2033 order for vans can be part of a 46-vehicle order purchased together with RTP and YCCAC; the 2034 order for 40' buses can be part of a 49-vehicle order purchased together with Bangor CC, BSOOB, Metro, and South Portland Bus Service (SPBS); the 2029 hybrid cutaway order can be part of a 16 vehicle order purchased together with RTP and YCCAC; and the 2036 hybrid cutaway order can be part of a 16 vehicle order purchased together with RTP and YCCAC. The 2030, 2031, 2032, and 2035 order for 32' buses would be purchased solely by DTI.

In summary, although this analysis assumed that DTI 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 23% cost saving for the agency.

15. Emissions Impacts

Section Summary

- Bus electrification will be critical to helping meet State emission goals
- Forecasted grid conversion to clean energy will maximize the benefit of bus electrification
- The transition is expected to reduce emissions by 82-86%

One of the motivations behind DTI's transition towards battery electric buses is Acadia National Park's and the State of Maine's goal to reduce emissions. Historically, DTI has taken the comparatively unusual step of operating propane vehicles on its Island Explorer service to generate fewer emissions than would be possible with diesel buses. While specific emissions 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 DTI.

Hatch calculated the anticipated emissions reductions from DTI'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

The tank-to-wheel emissions impact considers the emissions reduction in the communities, where the buses are operated. As a tank-to-wheel baseline, the 'tailpipe' emissions associated with DTI's existing fossil fuel fleet were calculated. These calculations used industry emissions averages for diesel, gasoline, and propane buses and assumed average fuel economies for each vehicle type based on the performance of DTI's existing fleet.

Battery electric bus propulsion systems do not create emissions, and therefore there are no 'tailpipe' emissions. As explained in Section 6, this transition plan does, however, assume that diesel heaters will be used on the battery electric transit buses during the winter months. Therefore, the emissions associated with diesel heaters are included in the tank-to-wheel estimates for battery electric transit buses.

Well-to-tank emissions are those associated with energy production. For fossil fuel vehicles well-to-tank emissions are due to fuel production, processing and delivery. This emissions estimate used industry averages for the well-to-wheel emissions associated with the delivery of fuel to DTI. For battery electric vehicles, well-to-tank emissions are due to the production, processing and delivery of diesel fuel for the heaters.

Battery electric vehicles have a third emissions source: grid electricity generation. The local utility, Versant, was not able to provide specific details on the emissions associated with its electricity production as part of this project. Therefore, the emissions calculations assumed an EPA and EIA average grid mix for Maine. Similar to the state's overall goals to reduce emissions, the state has also set the goal of reducing grid emissions by roughly 67% by 2030 by transitioning to more renewable energy production. To account for these future grid emissions reduction goals, calculations were completed based on the most recent actual data available (2020), as well as projections that assume that the 2030 targets are met. Table 12 and Figure 26 summarize the results of the emissions calculations. These results demonstrate that the transition plan will achieve 82% emissions reduction assuming the grid mix that existed in 2020, or 86% emissions reduction assuming that Versant is able to meet the state's goals to reduce grid emissions by the year 2030. In either case, DTI's transition plan will achieve a reduction in emissions in excess of 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
Baseline	875,380	1,271,728	---	2,147,108	---
Future Fleet (Assuming 2020 grid mix)	90,575	153,326	153,478	397,380	82%
Future Fleet (Assuming 2030 grid mix)	90,575	153,326	50,648	294,550	86%

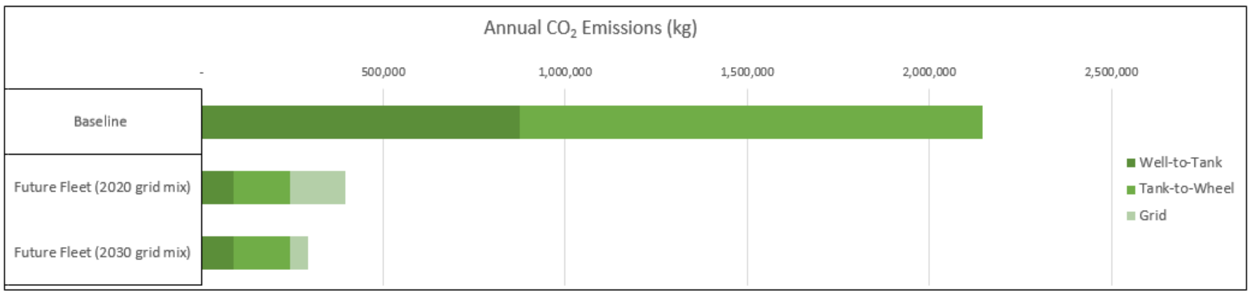

Figure 26 Graph of CO_2 Emissions Estimate Results

Should DTI 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.
- Use spare buses, particularly Island Explorer buses during the winter off-season, as mobile peak-shaving batteries (allowing them to feed the grid during periods of high demand) to reduce grid emissions and potentially generate revenue

16. Workforce Assessment

> ***Section Summary***
>
> - Staff and stakeholder training will be critical to successful operation of BEBs and hybrids
> - Hatch recommends partnering with local colleges and other transit agencies to share skills

DTI staff currently operate a revenue fleet composed entirely of fossil fuel vehicles. As a result, the staff have skill gaps related to hybrid and 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 DTI'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.

Table 13 Workforce Skill Gaps and Required Training

Workforce Group	Key Skills and Required Ongoing 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 DTI 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 buses 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. If no nearby programs are available, consider partnering with a school to develop a curriculum.

It is recommended that DTI begin training staff and other stakeholders on these technologies ahead of the delivery of the first vehicles and charging systems.

17. Alternative Transition Scenarios

Section Summary

- Hatch recommends reviewing this report annually for comparison with technology development and DTI operations, particularly in the context of choosing an operating model for the Island Explorer

As part of this study, DTI was presented with alternative fleet and infrastructure transition scenarios that would also satisfy the agency's operational requirements. These alternatives considered other vehicle battery configurations, fewer charging locations, and different operational plans. Through discussions, however, DTI currently favors the transition plan presented in this report. Details on the alternative plans are presented in Appendix B and D. Particularly in the context of choosing whether to install on-route chargers at the Bar Harbor Village Green and Hulls Cove Visitor Center, DTI is encouraged to review this report and its underlying assumptions annually. Changes in technology, agency operations, external stakeholder preferences, or other factors may make one of the alternative transition plans more desirable. Hatch recommends that DTI 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 fossil fuel-powered vehicles in favor of battery-electric. By facilitating this study DTI has taken the first step toward fleet electrification, and the agency stands well-positioned to begin converting its fleet in the coming years. In partnership with Maine DOT, other transit agencies in Maine, as well as other key stakeholders, DTI will be able to reduce emissions, noise, operating cost, and other negative factors associated with diesel operations, while complying with the Clean Transportation Roadmap and operating sustainably for years to come.

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

- Proceed with transitioning the agency’s buses and infrastructure in the manner described in this report.
- For the vehicles:
  - Consider ordering buses as part of larger orders or partnering with other agencies or the DOT to form large joint procurements.
  - Consider flexibility in vehicle types, particularly for Island Explorer vehicles, to increase competition, reduce cost, and potentially increase vehicle reliability
  - With BEB orders, require the electric bus vendor to have a technician on site or nearby in case of problems. This is most economical when the technician is shared with several nearby agencies.
  - Reach a “mutual aid” agreement with another urban transit agency in Maine that would let DTI borrow spare buses in case of difficulties with its fleet.
  - Retain a small fleet of non-electric backup buses to ensure they can substitute for electric buses if any incidents or weather conditions require it.
- For the infrastructure at the depot:
  - Upgrade the electrical utilities to support charging infrastructure.
  - Explore upgrading the roof to support additional solar panels.
  - Install all proposed chargers at once to reduce future piecemeal work.
  - Conduct a fire safety analysis in accordance with Section 12b and standards UL9540, NFPA 70 and 230, including staff training for fire response.
- For the infrastructure at the Ferry Terminal in Winter Harbor:
  - Negotiate with local property owners to facilitate charger installation.
  - Coordinate with Versant to determine a metering arrangement.
- For the infrastructure at the Bar Harbor Village Green:
  - Determine if the agency would like to install a charger.
  - If so, negotiate with the town government and Versant to install an electrical connection to facilitate charger installation.

  - If so, develop contingency plans in case the layover charger fails and midday depot swapping is required.
- For the infrastructure at the Hulls Cove Visitor Center:
  - Determine if the agency would like to install a charger.
  - If so, negotiate with the National Park Service and Versant to upgrade the electrical utilities.
  - If so, develop contingency plans in case the layover chargers fail and midday depot swapping is required.
- For other components of the transition:
  - Select an operating strategy for the Island Explorer.
  - Add requirements to future procurements for staff training.
  - Participate in industry conferences and coordination with other Maine transit agencies to share best practices for staff training programs, as described in Section 16. Coordinate with local education institutions as well.
  - Coordinate electrification with peer transit agencies, Versant, and Maine DOT.
  - Continually monitor utility structures and peak charge rates and adjust charging schedules accordingly.
  - Develop a funding strategy to account for the 74% 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