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# CASPER AREA TRANSIT ELECTRIC FLEET FEASIBILITY STUDY

**CASPER AREA MPO**  
July 2023



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# CASPER AREA TRANSIT ELECTRIC FLEET FEASIBILITY STUDY

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## INTRODUCTION

The City of Casper (the City) is the operator of the Casper Area Transit (CAT) system, which includes the Casper Area Link deviated fixed-route service and the Casper Area Assist door-to-door paratransit service. In response to the growing battery electric vehicle (BEV) market and continued allocation of State and Federal funds for fleet electrification projects, the Casper Area Metropolitan Planning Organization (MPO) in conjunction with CAT have developed a plan for a potential transition to BEVs. The incorporation of BEVs in public transit fleets reflects a national trend to modernize fleets, reduce harmful greenhouse gas (GHG) emissions, and promote a cleaner and more environmentally friendly service to local communities.

The introduction of new technologies, however, has the potential to impact service, infrastructure requirements, and financial performance for fleet owners. This plan is intended to provide the foundation for a fleet transition when it is both logistically and financially feasible, without dictating one in the near term. Developing this plan prepares the MPO to pursue Federal funding opportunities, such as those allocated by the Federal Transit Administration (FTA), when it is ready. Leveraging funding opportunities like this can significantly reduce the capital requirements of a fleet transition for agencies looking to provide their customers with quieter, cleaner, and healthier conditions.



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# STAKEHOLDER ENGAGEMENT



## STAKEHOLDER ENGAGEMENT

Throughout the development of this plan, the MPO has engaged its partners through a presentation to the City Council, stakeholder interviews, and working group meetings. This section of the report discusses these engagement activities and highlights key takeaways from each.

### CITY COUNCIL WORK SESSION

The project team presented the project and some preliminary ideas on the feasibility of BEVs in a local context to the City Council during its work session on February 28, 2023. Attendees expressed interest in exploring hybrid vehicle replacements as an alternative to BEVs that may not have a driving range sufficient to complete daily service. It was also noted that, while funding is currently available, if a fleet transition is not feasible at present, it may also not make sense to pursue it for the near future. It is possible that the amount of Federal funding available for fleet transitions will decrease as more agencies electrify their fleets and the market becomes saturated with BEVs.

### STAKEHOLDER INTERVIEWS

In-person interviews were held with the Wyoming Department of Transportation (WYDOT) and Rocky Mountain Power (RMP), the local utility provider, on February 28, 2023, to discuss the feasibility of fleet electrification in Casper. The interview with WYDOT was focused on funding opportunities and WYDOT's role in assisting the MPO and CAT in a potential fleet transition. Although WYDOT is not considering electrifying their own fleet, they are willing and able to serve as a "pass-through" for Federal funding distributed at the state level.

The interview with RMP was used to review the electrical system near potential new charging sites, discuss fee structures, and identify challenges and/or opportunities for installing new charging infrastructure. RMP reported there is sufficient electrical system capacity and infrastructure for charging at the Bus Garage Facility and all proposed on-route charging locations. If the MPO decides to purchase BEVs and install chargers at any facility, RMP projects a timeline of about 16 months for site inspections, design, component delivery, and construction. Additional coordination would be needed to assign responsibility for associated capital costs, identify fee structures for power delivery, and discuss the anticipated demand on the local grid related to charging activities.

### WORKING GROUP MEETINGS

Two stakeholder working group meetings were held. The working group comprised staff from CAT, the MPO, WYDOT, and RMP, along with one representative from City Council. These meetings were used to provide progress updates, share findings, and discuss the feasibility of potential electrification strategies from local perspectives. The feedback received from the group was used to refine those strategies and develop a transition roadmap that reflects needs and priorities specific to Casper.



## **PUBLIC COMMENTS**

A draft version of this report was published online for public comment beginning June 14, 2023 and ending July 14, 2023. No comments were received during the 30-day public comment period.





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# EXISTING CONDITIONS



## EXISTING CONDITIONS

To plan for the future of CAT's fleet, it is important to understand current operations and maintenance practices. This section discusses CAT's typical service profiles, bus storage and maintenance facilities, and fleet makeup.

### FLEET VEHICLES

The current CAT fleet includes 22 internal combustion engine (ICE) vehicles—20 cutaway buses, a Dodge minivan, and a Ford commercial van. About half the fleet is gasoline-powered; the other half uses diesel fuel. Vehicle ages range from 2 to 13 years, and passenger capacities range from 7 to 30. All the cutaways have capacity for two wheelchairs (WC), while the minivan and commercial van have capacity for one. **Table 1** summarizes the existing CAT fleet.

**Table 1.** Inventory of Existing Fleet Vehicles

Existing ICE Fleet							
Vehicle ID #	Model Year	Vehicle Make / Model	Vehicle Class	Fuel Type	Service Type	Pass. Capacity	WC Capacity
230072	2010	Dodge Amerivan	Minivan	Gasoline	Assist	7	1
230074	2012	Ford E450	Cutaway	Gasoline	Assist	16	2
230075	2012	Freightliner Champion Defender	Cutaway	Diesel	Link	30	2
230076	2012	Freightliner Champion Defender	Cutaway	Diesel	Link	30	2
230079	2014	Ford E450	Cutaway	Gasoline	Assist	13	2
230080	2015	Ford Startrans F550	Cutaway	Diesel	Link	24	2
230081	2016	Ford E350	Cutaway	Gasoline	Assist	13	2
230082	2016	Chevrolet Elkhart EC II 4500	Cutaway	Diesel	Assist	16	2
230083	2016	Chevrolet Elkhart EC II 4500	Cutaway	Diesel	Assist	16	2
230084	2016	Chevrolet Elkhart EC II 4500	Cutaway	Diesel	Assist	16	2
230085	2016	Ford Startrans F550	Cutaway	Diesel	Link	24	2
230086	2016	Ford Startrans F550	Cutaway	Diesel	Link	24	2
230087	2017	Ford E450	Cutaway	Gasoline	Assist	16	2
230088	2018	Ford Startrans F550	Cutaway	Diesel	Link	24	2
230089	2018	Ford Startrans F550	Cutaway	Diesel	Link	24	2
230090	2018	Ford E450	Cutaway	Gasoline	Assist	16	2
230091	2018	Ford E450	Cutaway	Gasoline	Assist	16	2
230092	2019	Ford E450	Cutaway	Gasoline	Assist	16	2
230093	2019	Ford E450	Cutaway	Gasoline	Assist	16	2
230094	2019	Ford E450	Cutaway	Gasoline	Link	18	2
230095	2019	Ford E450	Cutaway	Gasoline	Link	18	2
230096	2021	Ford Transit 3500	Comm. Van	Gasoline	Assist	10	1



Existing vehicle usage data, derived from monthly odometer readings between May 2021 and December 2022, are summarized in **Table 2**. CAT's fleet vehicles travel up to 145 miles per day on average and up to 204 miles on a high-use day, completing a full day's service before returning to the Bus Garage Facility. They are typically in use for 8 to 10 hours per day but can be operated for up to 14 hours on a high-use day. Vehicle utilization, weather and road conditions, and the availability of maintenance staff have an impact on the overall condition of CAT's fleet vehicles. Extreme cold conditions in Casper should be given extra consideration for today's BEVs, as it can greatly reduce their driving range.

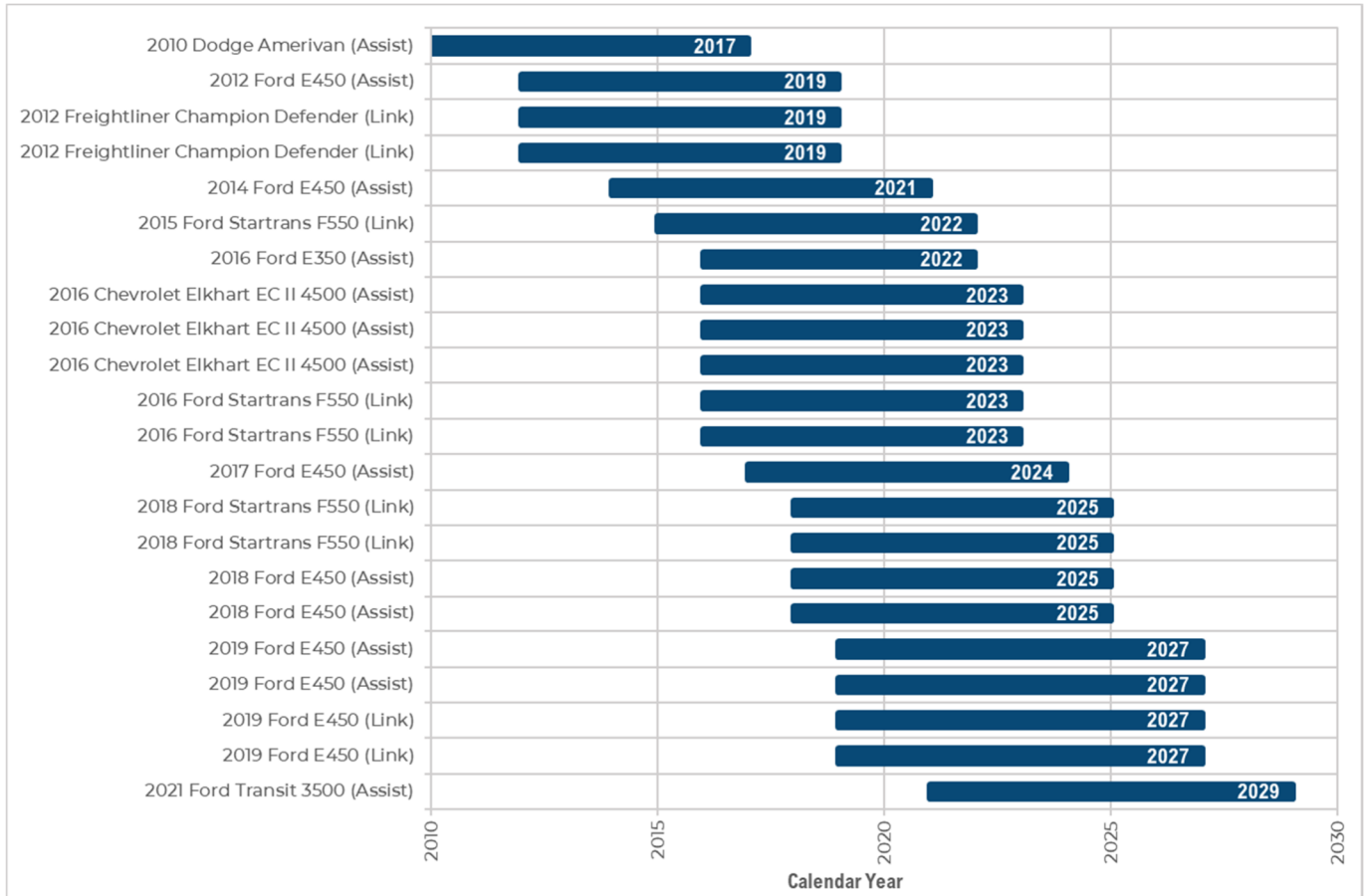
**Table 2.** Summary of Existing Fleet Vehicle Usage Data

Existing ICE Fleet							
Vehicle ID #	Model Year	Vehicle Make / Model	Service Type	Avg. Daily Miles	Max. Daily Miles	Avg. Daily Hours	Max. Daily Hours
230072	2010	Dodge Amerivan	Assist	70	145	10	14
230074	2012	Ford E450	Assist	119	193	10	14
230075	2012	Freightliner Champion Defender	Link	93	195	8	11
230076	2012	Freightliner Champion Defender	Link	100	196	8	11
230079	2014	Ford E450	Assist	104	196	10	14
230080	2015	Ford Startrans F550	Link	135	197	8	11
230081	2016	Ford E350	Assist	113	196	10	14
230082	2016	Chevrolet Elkhart EC II 4500	Assist	104	163	10	14
230083	2016	Chevrolet Elkhart EC II 4500	Assist	113	175	10	14
230084	2016	Chevrolet Elkhart EC II 4500	Assist	92	163	10	14
230085	2016	Ford Startrans F550	Link	127	196	8	11
230086	2016	Ford Startrans F550	Link	122	204	8	11
230087	2017	Ford E450	Assist	97	159	10	14
230088	2018	Ford Startrans F550	Link	134	197	8	11
230089	2018	Ford Startrans F550	Link	145	194	8	11
230090	2018	Ford E450	Assist	94	162	10	14
230091	2018	Ford E450	Assist	120	169	10	14
230092	2019	Ford E450	Assist	113	193	10	14
230093	2019	Ford E450	Assist	110	163	10	14
230094	2019	Ford E450	Link	126	162	8	11
230095	2019	Ford E450	Link	155	175	8	11
230096	2021	Ford Transit 3500	Assist	119	166	10	13

Finally, **Figure 1** outlines CAT's current fleet replacement schedule with respect to its 22 ICE vehicles. Note that 7 vehicles are overdue for replacement and another 5 are due for replacement this year. All vehicles are due for replacement by the year 2030.



**Figure 1. Existing Fleet Replacement Schedule**



## SERVICE PROFILES

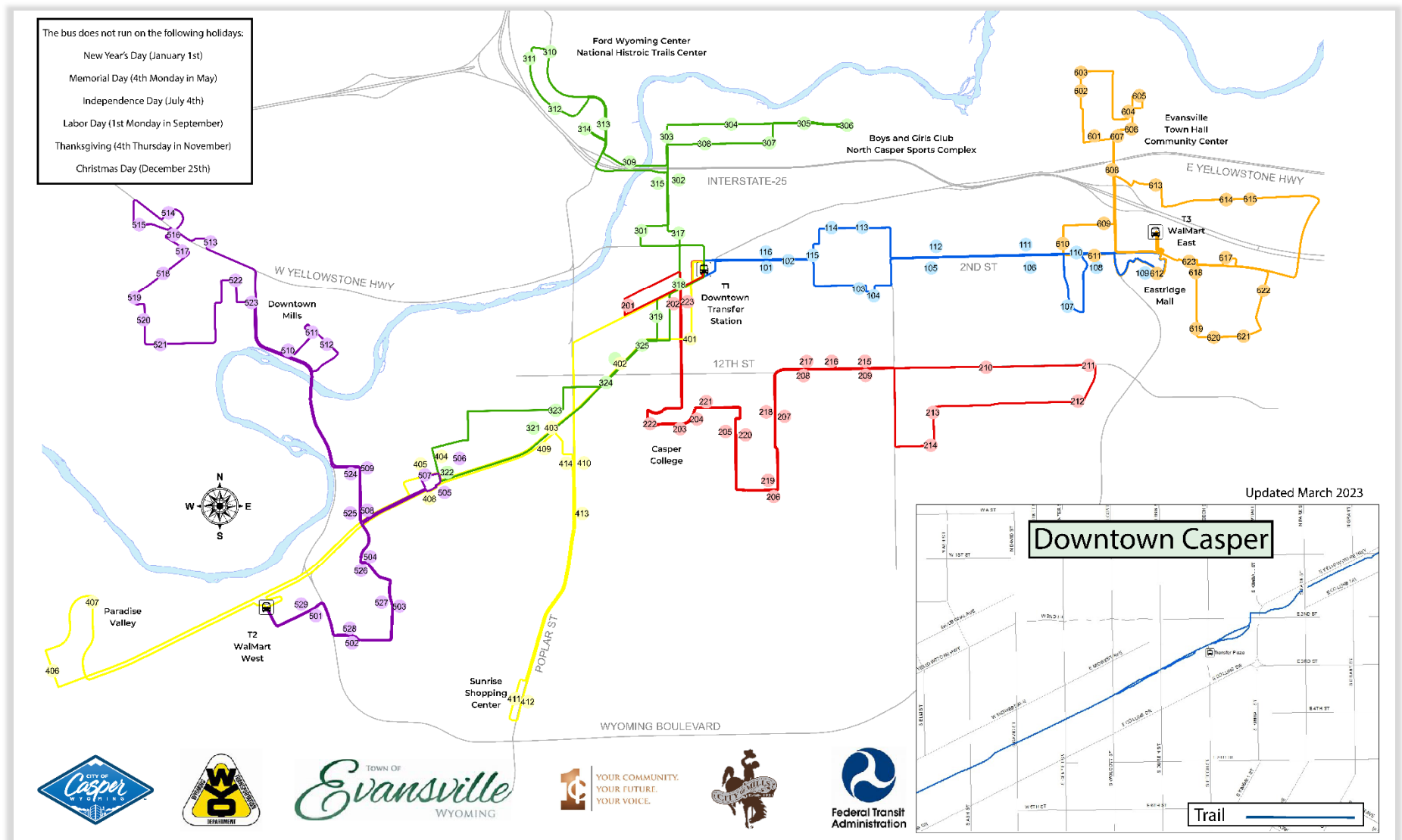
Two services are operated by CAT: Casper Area Link, offering deviated fixed-route service, and Casper Area Assist, offering door-to-door paratransit service. The fixed-route service has six routes that typically operate for 11 to 12 hours per day (**Figure 2**). Transfer points between routes currently occur at the Downtown Transfer Center (Blue, Red, Yellow and Green), Walmart West (Yellow and Purple), and Walmart East (Blue and Orange).

Travel conditions vary between the routes. For example, the Green route traverses significant terrain changes, while the Yellow route travels the farthest distance. CAT does not necessarily assign each vehicle to the same route every day. Rather, each vehicle is assigned by passenger loads per route. Larger cutaways typically operate on the Blue and Green routes, while those with lower passenger capacities are used to serve the other four routes.





**Figure 2.** Existing Casper Area Link Service Routing





## **FACILITIES OVERVIEW**

Fleet vehicles are stored overnight at the Bus Garage Facility at 1715 E 4th Street (**Figure 3**). Most buses are stored outdoors in a secure fenced lot, but there are five indoor storage bays. These bus bays are designed for small vehicles, so some larger vehicles do not fit well in these spaces. However, they could possibly be configured to accommodate BEV charging for a small-scale charging solution. A larger-scale charging solution may include covered parking and/or charging stations in the secure outdoor lot. Any outdoor chargers and dispensers would need to be installed such that all buses can park in the lot and snow removal is not impeded. Each BEV parked outdoors would need to be plugged in overnight to warm its battery. BEVs parked indoors can be kept warm by plugging in overnight, or CAT can continue to use block heaters to maintain an acceptable ambient temperature. Conversations with RMP indicated there is sufficient power available at this site to support demand related to charging activities.

Maintenance activities for City-owned vehicles are conducted at the City Garage, which is located at 1800 E K Street (**Figure 4**). The garage has a dedicated transit maintenance area for the CAT fleet and is equipped with multiple vehicle lifts that can accommodate BEVs, despite their heavier weights compared to ICE vehicles. The City Garage has a diesel-powered generator that provides redundant power. Further research is needed to determine whether this generator can be used to support BEVs in the event of a lengthy power outage. Vehicle parts are supplied by an on-site NAPA Auto Parts distributor, which currently has additional parts storage space that could be utilized for future BEV parts storage.

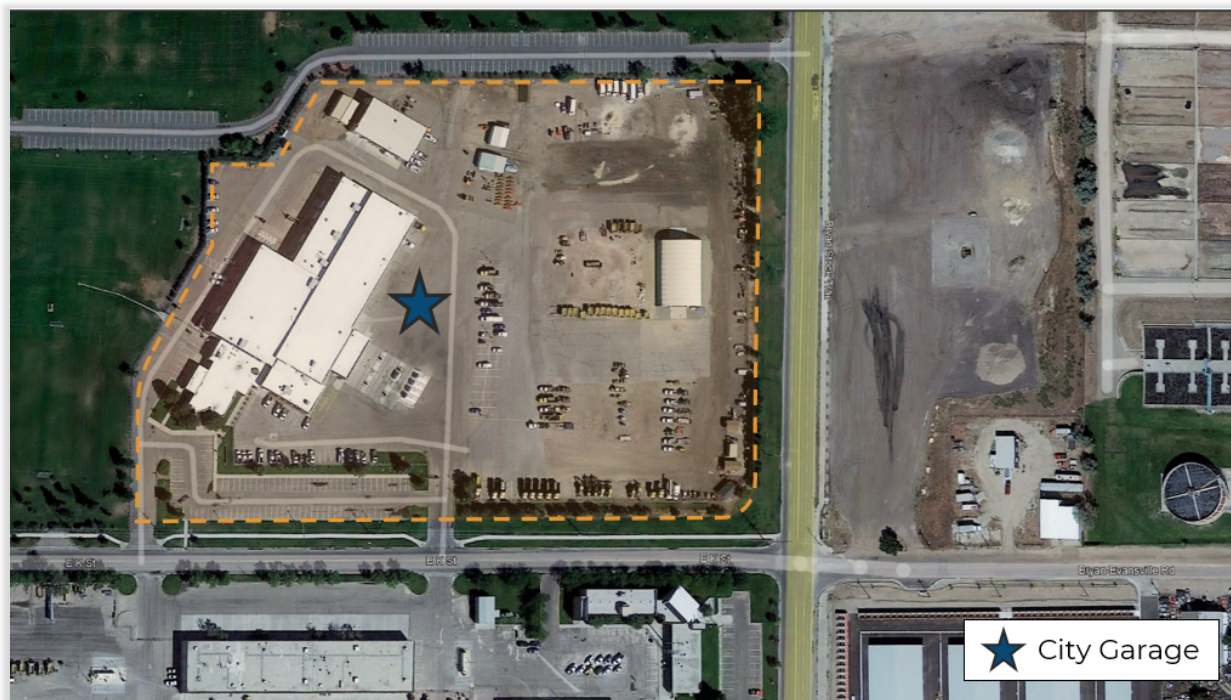
Conversations with RMP indicated there is ample power availability to support BEV charging activities at the City Garage. However, extreme cold temperatures can degrade a charger's ability to deliver power to a BEV, making it important to protect the charging equipment from these elements. This can be achieved by charging in a temperature-controlled environment or under covered parking. Note, however, that the latter may be less effective in keeping the vehicles' batteries from over-chilling in extreme cold weather conditions.



**Figure 3.** Aerial of Bus Garage Facility (1715 E 4th Street)



**Figure 4.** Aerial of City Garage Facility (1800 E K Street)







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# MARKET ASSESSMENT





## MARKET ASSESSMENT

This section outlines the current state of the battery electric cutaway vehicle and charging infrastructure markets that are relevant to CAT's current fleet. It also outlines relevant policies and incentives that can help local agencies reduce the financial burden associated with full fleet electrification.

### VEHICLE TECHNOLOGY

#### Battery Electric Vehicles

The market for electric transit buses (30 to 60 feet in length) is well developed, but there are also newer applications for battery electric cutaway vehicles. Cutaway vehicle electrification is often achieved through 'repowering,' where the vehicle operates on the original equipment manufacturer's (OEM) chassis but the powertrain and other internal components are produced by a brand-independent manufacturer. Maintaining the warranty and certifications is a primary consideration for repowered vehicles. There are multiple options for these vehicles, and this market sector is growing rapidly. **Table 3** inventories the options that are market-available on the market as of Q1 2023 and shows vehicle specifications for each manufacturer. It is important to note that the actual range of each vehicle will vary by operational conditions, so the values above represent a best-case-scenario with new batteries. BEVs in Casper would experience decreased range during cold weather conditions.

**Table 3.** Available Battery Electric Cutaway Vehicles (Q1 2023)

Battery Electric Fleet					
Vehicle Make	Vehicle Model	# of Seats	Battery Capacity (kWh)	Driving Range (mi)	Max. DC Rate (kW)
Forest River	E-450 EV Shuttle	22	157	160	80
Forest River	F-550 EV Shuttle	24	128	120	80
Forest River	Transit Passenger Van EV	15	120	170	80
Green Power	AV Star	19	118	150	61
Green Power	EV STAR+	24	118	150	61
Lightning Electric	FE4-86	24	86	80	80
Lightning Electric	FE4-129	24	129	120	80
Motiv / TurtleTop	EPIC 4	16	127	105	50
Optimal EV	SILF (E-450 Chassis)	16	113	125	60
Phoenix Motorcars	ZEUS 400	23	156	160	50
Sunset Vans	Electric Low Floor Minibus	8	75	200	100
US Hybrid	Ford Transit T-350HD DRW	15	180	210	80

kWh = kilowatt-hours (energy)

mi. = miles (distance)

kW = kilowatts (power)



Example battery electric equivalents for the CAT's existing ICE fleet are shown in **Table 4**. The vehicles identified have similar passenger capacities to their ICE counterparts, and all accommodate at least two wheelchairs. Future vehicles may have increased battery capacities and driving ranges compared to those available on the market today. Compared to the 80- or 100-kW power input that current battery electric cutaways can accept, future BEVs may be able to accept higher inputs and charge faster.

**Table 4.** Example Equivalent Battery Electric Cutaway Vehicles

Existing ICE Fleet			Example Battery Electric Fleet		
Vehicle Make / Model	Pass. Capacity	WC Capacity	Vehicle Make / Model	Max. Pass. Capacity	Max. WC Capacity
Chevrolet Elkhart EC II 4500	16	2	Forest River E450 EV	16	2
Dodge Amerivan	7	1	SV Electric Low Floor Minibus	8	3
Ford E350	13	2	Forest River E450 EV	16	2
Ford E450	16	2	Forest River E450 EV	16	2
Ford E450	18	2	Forest River E450 EV	16	2
Ford Startrans F550	24	2	Forest River F550 EV	24	2
Ford Transit 3500	10	1	SV Electric Low Floor Minibus	8	3
Freightliner Champion Defender	30	2	Forest River F550 EV	24	2

### Hybrid Electric Vehicles

If BEVs are determined to not be appropriate for CAT's fleet operations at this time, the MPO might explore a low-emission alternative until zero-emission vehicles (ZEV) as a more feasible alternative. Hybrid electric vehicles (HEV) are powered by an internal combustion engine and one or more electric motors, which use energy stored in the vehicle's battery. The battery is charged via regenerative braking and the gasoline-powered engine rather than being plugged in. Plug-in hybrid electric vehicles (PHEV) can be plugged in, but there are currently no plug-in hybrid cutaways on the market. The Ford Transit Passenger Van can be converted to operate as an HEV by a qualified vehicle modifier, and the modified vehicle is delivered through Ford without impacting OEM warranties or service agreements.

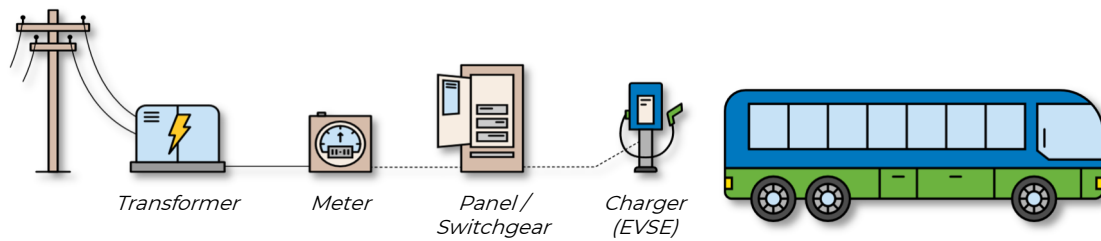
## CHARGING TECHNOLOGY

### Components of Charging

Charging infrastructure for BEV charging is well developed. It includes electrical delivery through the communications wiring, transformer, meter, and switchgear, as well as the charger (i.e., the cabinet used to supply power). A simplified diagram showing the components of charging infrastructure is shown in **Figure 5**. Today's charging technologies can support current demand and can be scaled to meet the growing needs of new vehicle and fuel markets.



**Figure 5.** Charging Infrastructure Equipment Layout



### Levels of Charging

Level 2 alternating current (AC) chargers charge vehicles over extended periods of time, with an average power output of 3.5 to 19.2 kilowatts (kW). A Level 2 charger may entail introducing or upgrading the existing electrical system to support 208- or 240-volt (V) capabilities. Level 2 chargers can typically provide a BEV with around 20 miles of range per hour plugged in regardless of vehicle type. This rate is typically adequate for overnight charging. Four examples of Level 2 AC chargers that are available as of Q1 2023 are shown in **Table 5**.

Direct current fast chargers (DCFC) utilize three-phase AC power to provide fast charging at power levels ranging up to 450 kW. The power output from each charging cabinet can be split into multiple dispenser connections. The cost for a DCFC system is greater than that for a Level 2 system because the higher level of power exchange requires larger and more expensive equipment. Even at lower power levels, however, DCFCs can supply over 100 miles of range per hour plugged in. This fast charge rate can enable rapid midday and/or on-route recharging for BEVs that lack the range needed to complete daily service. **Table 5** shows five examples of DCFCs that are available as of Q1 2023.

### Methods of Charging

There are three ways to charge a BEV: a plug-in dispenser, a pantograph dispenser, and an inductive charging pad (i.e., wireless). Plug-in dispensers and inductive charging pads are the only charging types available for the battery electric cutaways that could replace CAT's existing fleet vehicles. A Level 2 charge is delivered through a plug-in dispenser, while fast charging can be delivered through both a plug-in

**Table 5.** Examples of Available Chargers

Charging Infrastructure		
Manufacturer	Model	Power Output (kW)
Level 2 Chargers		
Blink	IQ 200	19.2 kW
ChargePoint	CPF50	12.0 kW
ClipperCreek	HCS-60	11.5 kW
Wallbox	Pulsar Plus (40A)	9.6 kW
DC Fast Chargers		
ABB	Terra 124	120 kW
BTC Power	L3R-100	100 kW
FreeWire	Boost Charger 150	150 kW
Heliox	Flex 180	180 kW
Siemens	VersiCharge Ultra 175	175 kW



dispenser and an inductive charging pad. **Figure 6** shows examples of both plug-in chargers and a wireless inductive charging pad.

**Figure 6.** Plug-In and Wireless Inductive Charging



Plug-in charging uses a cord and plug, similar to charging other electronics. The cord connects the charging cabinet to the vehicle, and the speed of charge depends on the power output of the charging cabinet. All BEVs are equipped to charge using a plug-in dispenser, which typically has the lowest capital and installation costs. However, the cords can pose maintenance and operational challenges if they are vandalized, run over by vehicles, or simply break from repetitive and regular use.

Inductive charging pads charge a BEV without a physical cord connection via coils buried beneath the pavement. Inductive charging is initiated when a vehicle parks over the charging pad, after which a current is sent through the underground coils. This induces a magnetic field, which in turn induces current in coils within the bus. Vehicles must be outfitted with a communications antenna, a system interface controller, a user display, and an undercarriage-mounted power receiver to charge wirelessly. Unlike plug-in charging ports, outfitting a vehicle to enable wireless charging capabilities will incur an additional cost. Typically, inductive charging is used by transit vehicles at an on-route layover. **Table 6** outlines the advantages and disadvantages of plug-in fast charging versus inductive fast charging with respect to transit vehicles.





**Table 6.** Comparison of Plug-In and Wireless Inductive Charging

Charging Comparison			
Type of Fast Charging	Typical Installation	Advantages	Disadvantages
<b>Plug-In Fast Charging</b>	Typically used to charge overnight or between blocks		Slower charge rate than wireless inductive charging
	1-2 buses per charger based on number of dispensers	Lower unit and construction costs than wireless inductive charging	Need to identify available space for equipment with large-scale deployments
	Typical charge power ranges from 50 kW to 150 kW	Additional chargers can be added for redundancy	Requires staff to manually plug/unplug the vehicle
	Compliant with SAE J1772 and J3068 standards		Chargers subject to weather and external damage
<b>Wireless Inductive Fast Charging</b>	Typically used to charge buses at on-route layovers	No manual connections or moving parts	Higher per-charger unit and construction costs
	One charger can serve as many buses as needed over a service day	Can be used by multiple vehicle types once vehicles have pads installed	Charging efficiency varies based on bus alignment
	Charge power from 50 kW to 350 kW	Infrastructure is protected from external elements	No interoperability among different charger providers
		No impacts to right-of-way or aesthetics	Not offered by all OEMs

### Charge Management Technologies

Fleet operators can manage chargers in-house since there is no fare collection for charging fleet vehicles, or they may opt to contract with a third party to manage charger operations. Charging as a Service (CaaS) is a third-party turnkey solution that can help charger owners manage availability, usage, and, if appropriate, fare collection. The CaaS solution provides charger equipment, installation, software, maintenance, and customer support for a fixed monthly fee to the property owner. The provider is then able to meter vehicle use and payments. CaaS can also provide charging demand management for fleet vehicles housed and charged in a secure lot, regulating when they receive charge to minimize monthly utility costs without compromising the needs of the fleet.



## **POLICIES AND INCENTIVES**

There are no local-level policies or incentives related to fleet electrification, but the Federal government and State of Wyoming have enacted some relevant legislation. At the Federal level, the U.S. Environmental Protection Agency's (EPA) Conversion and Tampering Regulations ensure aftermarket vehicle conversions are completed according to national standards. The Federal government has also implemented standards for the design of electric vehicle supply equipment (EVSE) and requires utility providers to promote affordable and equitable charging. Specific to Wyoming are the State's Alternative Fuel Tax Rate and EV Decal Fee, which can help to recover some of the costs lost due to EV drivers not paying gasoline taxes.

The Federal government provides multiple incentives for personal drivers and transit fleet owners to purchase BEVs. The MPO may be able to obtain a clean vehicle credit under Internal Revenue Code 45W. Businesses and tax-exempt organizations that purchase a qualified commercial clean vehicle are eligible for a tax credit of up to \$7,500 for qualified vehicles with gross vehicle weight ratings (GVWR) of under 14,000 pounds and \$40,000 for all other vehicles. The credit equals the lesser of 15% of the agency's basis in the vehicle (30% if the vehicle uses an alternative fuel) or the incremental cost of the vehicle.<sup>1</sup>

The U.S. Department of Transportation (USDOT) provides funding for electrification projects specific to charging-related infrastructure through the RAISE Discretionary Grant program.<sup>2</sup> Finally, the FTA operates the Low or No Emission Grant (Low-No) Program, which provides funding specifically for transportation agencies looking to electrify their vehicle fleets. In FY 2023, nearly \$1.7 billion was allocated to the Low-No Program to support state and local efforts to buy or modernize buses, improve bus facilities, and support workforce development.<sup>3</sup>

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<sup>1</sup> U.S. Internal Revenue Service: <https://www.irs.gov/credits-deductions/commercial-clean-vehicle-credit>

<sup>2</sup> U.S. Department of Transportation: <https://www.transportation.gov/RAISEgrants/about>

<sup>3</sup> U.S. Federal Transit Administration: <https://www.transit.dot.gov/lowno>



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# ENERGY MODELING



## ENERGY MODELING

This section summarizes modeling conducted to evaluate the feasibility of an all-electric fleet in Casper based on fleet needs, infrastructure requirements, power demand, and daily energy consumption related to charging activities.

### MODELING METHODS

The energy analysis was conducted to understand if CAT could maintain its current level of operations using BEVs. The analysis was based on monthly odometer readings of existing vehicles from May 2021 through December 2022, as well as the specifications of various example BEV equivalents. These BEVs were chosen because they have passenger and wheelchair capacities comparable to CAT's existing fleet.

Battery capacities and operational ranges for today's battery electric cutaways are very low relative to CAT's existing ICE vehicle fleet and may not be sufficient to satisfy existing service levels. If it is determined the modeled BEV cannot complete existing service on a single charge, the energy model will supply alternate strategies such as increasing the fleet size or adding high-power fast chargers on-route for charging during scheduled layovers. The energy modeling can also determine the impacts of charging vehicles on-route during scheduled layovers using wireless inductive fast chargers. Daily energy consumption is computed using both average and maximum operational profiles for each vehicle. The model will also identify the time needed for each vehicle to reach a full charge; if it exceeds the vehicle's inactive time, the model will show a higher power output is needed.

**Table 7** summarizes the operating metrics of the existing fleet, the BEVs selected to represent each existing vehicle's all-electric replacement, and the battery capacity and operational range of each BEV equivalent. Each vehicle's usable battery capacity and range were assumed to be 70% of their nameplate values. Limiting the amount of power stored in the battery considered 'usable' keeps the battery from reaching zero charge, prolongs the life of the battery, and provides a buffer that accounts for cold weather impacts to the operating range of currently available BEVs.



**Table 7.** Modeled Battery Electric Fleet Inputs

Existing ICE Fleet		Example Battery Electric Fleet					
Vehicle Make / Model	Vehicle Make / Model	Avg. Daily Miles	Max. Daily Miles	Avg. Daily Hour	Max. Daily Hour	Usable Capacity (kWh)	Usable Range (mi)
Chevrolet Elkhart EC II 4500	Forest River E450 EV	104	163	10	14	110	119
Chevrolet Elkhart EC II 4500	Forest River E450 EV	113	175	10	14	110	119
Chevrolet Elkhart EC II 4500	Forest River E450 EV	92	163	10	14	110	119
Ford E350	Forest River E450 EV	113	196	10	14	110	119
Ford E450	Forest River E450 EV	119	193	10	14	110	119
Ford E450	Forest River E450 EV	104	196	10	14	110	119
Ford E450	Forest River E450 EV	97	159	10	14	110	119
Ford E450	Forest River E450 EV	94	162	10	14	110	119
Ford E450	Forest River E450 EV	120	169	10	14	110	119
Ford E450	Forest River E450 EV	113	193	10	14	110	119
Ford E450	Forest River E450 EV	110	163	10	14	110	119
Ford E450	Forest River E450 EV	126	162	8	11	110	119
Ford E450	Forest River E450 EV	155	175	8	11	110	119
Ford Startrans F550	Forest River F550 EV	135	197	8	11	90	70
Ford Startrans F550	Forest River F550 EV	127	196	8	11	90	70
Ford Startrans F550	Forest River F550 EV	122	204	8	11	90	70
Ford Startrans F550	Forest River F550 EV	134	197	8	11	90	70
Ford Startrans F550	Forest River F550 EV	145	194	8	11	90	70
Freightliner Champion Defender	Forest River F550 EV	93	195	8	11	90	70
Freightliner Champion Defender	Forest River F550 EV	100	196	8	11	90	70
Dodge Amerivan	SV Electric Low Floor Minibus	70	145	10	14	53	140
Ford Transit 3500	SV Electric Low Floor Minibus	119	166	10	13	53	140

## MODELING RESULTS

### Baseline Scenario

First, a baseline scenario was modeled to determine whether the BEV equivalents representing CAT's fleet can satisfy existing service requirements based on a one-to-one replacement ratio. The results of the modeling indicate that none of the BEV equivalents can complete existing service profiles in the baseline scenario—all would exceed their respective maximum battery capacities. Many vehicles would even require double the amount of energy today's batteries can store to accomplish a complete service day on a single charge. These results show a near-term transition to BEVs at a one-to-one ratio is virtually impossible without significant modifications to existing service patterns. **Table 8** summarizes the baseline scenario results.



**Table 8.** Energy Modeling Results for Baseline Scenario

Existing ICE Fleet	Modeled Battery Electric Fleet			
Vehicle Make / Model	Vehicle Make / Model	Max. Capacity (kWh)	Daily Energy (kWh)	% Daily Use on Battery
Chevrolet Elkhart EC II 4500	Forest River E450 EV	157	205	<b>131%</b>
Chevrolet Elkhart EC II 4500	Forest River E450 EV	157	207	<b>132%</b>
Chevrolet Elkhart EC II 4500	Forest River E450 EV	157	203	<b>129%</b>
Ford E350	Forest River E450 EV	157	208	<b>132%</b>
Ford E450	Forest River E450 EV	157	209	<b>133%</b>
Ford E450	Forest River E450 EV	157	206	<b>131%</b>
Ford E450	Forest River E450 EV	157	204	<b>130%</b>
Ford E450	Forest River E450 EV	157	203	<b>130%</b>
Ford E450	Forest River E450 EV	157	208	<b>133%</b>
Ford E450	Forest River E450 EV	157	208	<b>132%</b>
Ford E450	Forest River E450 EV	157	206	<b>131%</b>
Ford E450	Forest River E450 EV	157	208	<b>132%</b>
Ford E450	Forest River E450 EV	157	214	<b>136%</b>
Ford Startrans F550	Forest River F550 EV	128	284	<b>222%</b>
Ford Startrans F550	Forest River F550 EV	128	280	<b>219%</b>
Ford Startrans F550	Forest River F550 EV	128	279	<b>218%</b>
Ford Startrans F550	Forest River F550 EV	128	283	<b>221%</b>
Ford Startrans F550	Forest River F550 EV	128	287	<b>224%</b>
Freightliner Champion Defender	Forest River F550 EV	128	178	<b>139%</b>
Freightliner Champion Defender	Forest River F550 EV	128	270	<b>211%</b>
Dodge Amerivan	SV Electric Low Floor Minibus	75	100	<b>133%</b>
Ford Transit 3500	SV Electric Low Floor Minibus	75	103	<b>138%</b>

### Expanded Fleet with Depot Charging Only Scenario

As the baseline scenario analysis identified operational concerns with replacing the existing fleet with BEVs at a one-to-one ratio, a second scenario was developed to evaluate overnight depot charging using Level 2 chargers at the Bus Garage Facility. The selected BEV equivalents can accept between 7.2 kilowatts (kW) and 11.5 kW of power from a Level 2 charger, replenishing 10 to 15 miles of range per hour plugged in. BEVs could receive 100 to 150 miles of range over a 10-hour window at these rates.

**Table 9** summarizes the energy demand and battery usage results for this scenario. The results show the current 22-vehicle fleet would need to more than double in size to confidently maintain current service with a BEV fleet relying entirely on overnight depot charging.





**Table 9.** Energy Modeling Results for Expanded Fleet with Depot Charging Only Scenario

Existing ICE Fleet			Modeled Battery Electric Fleet								
Vehicle Make / Model	Current # of Vehicles	Inactive Time (hr)	Vehicle Make / Model	Needed # of Vehicles	Minimum Charger Level	Veh. Power (kW)	Total Power (kW)	Veh. Daily Energy (kWh)	Total Daily Energy (kWh)	Time to Full SOC (hr)	% Daily Use on Battery
Chevrolet Elkhart EC II 4500	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	102.7	205.3	8.9	65.4%
Chevrolet Elkhart EC II 4500	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	103.6	207.2	9.0	66.0%
Chevrolet Elkhart EC II 4500	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	101.6	203.1	8.8	64.7%
Ford E350	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	103.8	207.7	9.0	66.1%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	104.4	208.7	9.1	66.5%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	103.0	206.0	8.9	65.6%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	102.0	204.0	8.9	65.0%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	101.7	203.5	8.8	64.8%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	104.2	208.4	9.0	66.4%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	103.8	207.6	9.0	66.1%
Ford E450	1	10	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	103.2	206.4	9.0	65.7%
Ford E450	1	13	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	104.0	208.0	9.0	66.2%
Ford E450	1	13	Forest River E450 EV	2 (+1)	48A Level 2	11.5	23.0	106.8	213.6	9.3	68.0%
Ford Startrans F550	1	13	Forest River F550 EV	3 (+2)	32A Level 2	7.7	23.0	94.5	283.6	8.2	<b>73.9%</b>
Ford Startrans F550	1	13	Forest River F550 EV	3 (+2)	32A Level 2	7.7	23.0	93.5	280.5	8.1	<b>73.0%</b>
Ford Startrans F550	1	13	Forest River F550 EV	3 (+2)	32A Level 2	7.7	23.0	93.0	278.9	8.1	<b>72.6%</b>
Ford Startrans F550	1	13	Forest River F550 EV	3 (+2)	32A Level 2	7.7	23.0	94.4	283.2	8.2	<b>73.8%</b>
Ford Startrans F550	1	13	Forest River F550 EV	3 (+2)	32A Level 2	7.7	23.0	95.8	287.3	8.3	<b>74.8%</b>
Freightliner Champion Defender	1	13	Forest River F550 EV	2 (+1)	30A Level 2	7.2	14.4	89.1	178.2	7.7	69.6%
Freightliner Champion Defender	1	13	Forest River F550 EV	3 (+2)	30A Level 2	7.2	21.6	90.0	270.1	7.8	<b>70.3%</b>
Dodge Amerivan	1	10	SV Electric Low Floor Minibus	2 (+1)	30A Level 2	7.2	14.4	49.9	99.7	4.3	66.5%
Ford Transit 3500	1	11	SV Electric Low Floor Minibus	2 (+1)	30A Level 2	7.2	14.4	51.7	103.5	4.5	69.0%
<b>Total ICE Fleet</b>	<b>22</b>	<b>-</b>	<b>Total BEV Fleet</b>	<b>50 (+28)</b>	9 30A Level 2	<b>-</b>	<b>479.5 kW</b>	<b>-</b>	<b>4754.5 kWh</b>	<b>-</b>	<b>-</b>
					15 32A Level 2						
					26 48A Level 2						



To be feasible, this scenario would require 50 BEVs, incurring a peak load on the local electrical grid of about 480 kW. This falls well below the 1-megawatt (MW) threshold that triggers RMP's Large General Service rate structure, so the standard General Service rate structure would be applied to the Bus Garage Facility. Over a day, the expanded BEV fleet would be expected to consume 4.75 MW of energy.

### **Full BEV Fleet with On-Route Fast Charging Scenario**

As an alternative to more than doubling the current fleet size, a third scenario was modeled to evaluate the feasibility of a BEV transition using on-route fast charging. This scenario assumes wireless inductive charging pads are installed at transfer points along CAT's existing routes where vehicles would charge during scheduled layovers. This extends each vehicle's operational range and mitigates the need for additional fleet vehicles.

Based on existing service profiles, fleet vehicles can arrive at each transfer point from 15 to 0 minutes prior to the start of their next trip. Uncertainty in arrival times will likely create concerns related to the level of charge a vehicle can receive if it arrives to a charger later than anticipated. Service profiles may need to be revisited and/or simplified to ensure fleet vehicles are arriving as planned and have time to charge to a level sufficient to complete their next two trips.

To determine the minimum power output needed for each inductive charger, it was assumed that each vehicle has a 10-minute window to charge every 2 hours. Half the fleet would charge on 'even' hours, while the other half would charge on 'odd' hours. This charging strategy would require four inductive charging pads—two at the Downtown Transfer Center, one at or near the existing stop at Walmart West, and one at or near the existing stop at Walmart East. This combination of charging pads would accommodate vehicles on all six routes operated by CAT.

**Table 10** summarizes the power output needed for five charges per day to provide a sufficient state of charge (SOC) such that each vehicle can return to the Bus Garage Facility at the end of a service day. Because vehicles would share charging pads, the highest required power output (250 kW) would be applied to each charger unless a per-route analysis was conducted. However, the peak load on the electrical grid at each charging location will be based on the accepted power input of each vehicle actively charging. For example, if all four proposed charging pads provided an output of 250 kW, the peak load on the electrical grid would be 500 kW at the Downtown Transfer Center and 250 kW at the transfer points to the east and west. Even in this high-demand scenario, each location would fall under RMP's General Service rate structure. At a lower power input such as 80 kW, the peak load at the Downtown Transfer Center would be 160 kW and the peak load at the other transfer points would be just 80 kW each.



**Table 10.** Energy Modeling Results for Expanded Fleet with Depot Charging Only Scenario

Vehicle Make and Model	Usable Battery Capacity (kWh)	Distance Traveled per Shift (miles)	Power Used per Shift (kWh)	Available Time per Charge (min)	End of Service SOC [at 80 kW]	End of Service SOC [at 100 kW]	End of Service SOC [at 150 kW]	End of Service SOC [at 200 kW]	End of Service SOC [at 250 kW]	Minimum Charger Power Output
Sunset Vans Electric Low Floor Minibus	52.5	29.0	13.3	10	82%	82%	82%	82%	82%	80 kW
Forest River E450 EV	109.9	38.6	28.0	10	36%	46%	73%	82%	82%	80 kW
Forest River F550 EV	89.6	39.0	29.8	10	12%	25%	58%	77%	77%	150 kW
Forest River F550 EV	89.6	39.2	31.6	10	4%	17%	50%	75%	75%	150 kW
Forest River E450 EV	109.9	39.2	25.2	10	46%	57%	83%	84%	84%	80 kW
Forest River F550 EV	89.6	39.4	40.6	10	-38%	-25%	8%	40%	68%	200 kW
Forest River E450 EV	109.9	39.2	26.9	10	40%	50%	77%	83%	83%	80 kW
Forest River E450 EV	109.9	32.6	25.2	10	46%	57%	83%	84%	84%	80 kW
Forest River E450 EV	109.9	35.0	26.9	10	40%	50%	77%	83%	83%	80 kW
Forest River E450 EV	109.9	32.6	23.0	10	55%	65%	85%	85%	85%	80 kW
Forest River F550 EV	89.6	39.2	38.5	10	-28%	-15%	17%	50%	70%	200 kW
Forest River F550 EV	89.6	40.8	37.2	10	-22%	-9%	23%	56%	71%	200 kW
Forest River E450 EV	109.9	31.8	23.9	10	51%	62%	85%	85%	85%	80 kW
Forest River F550 EV	89.6	39.4	40.3	10	-37%	-24%	9%	41%	69%	200 kW
Forest River F550 EV	89.6	38.8	43.1	10	-50%	-37%	-4%	28%	61%	250 kW
Forest River E450 EV	109.9	32.4	23.4	10	53%	64%	85%	85%	85%	80 kW
Forest River E450 EV	109.9	33.8	28.2	10	35%	45%	72%	82%	82%	80 kW
Forest River E450 EV	109.9	38.6	26.9	10	40%	50%	77%	83%	83%	80 kW
Forest River E450 EV	109.9	32.6	26.3	10	42%	53%	79%	83%	83%	80 kW
Forest River E450 EV	109.9	32.4	29.3	10	31%	41%	68%	81%	81%	80 kW
Forest River E450 EV	109.9	35.0	34.6	10	10%	21%	47%	74%	78%	150 kW
Sunset Vans Electric Low Floor Minibus	52.5	33.2	16.9	10	53%	76%	77%	77%	77%	80 kW



Based on this analysis, wireless inductive charging at 80 kW would be sufficient to support 14 BEVs at a one-to-one replacement ratio, but the remaining 8 vehicles need to accept at least 150 kW to complete service with bihourly 10-minute top-offs (**Table 11**). However, the maximum power input today's battery electric cutaways can accept is 80 to 100 kW. Until available BEVs can accept higher power inputs, CAT will not be able to leverage the benefits of faster charging or continue to provide service at today's levels with a full BEV fleet.

**Table 11.** Number of Feasible BEVs by Required Power Output

Vehicle Make and Model	# of Feasible Vehicles by Required Charger Power Output					Fleet Size
	80 kW	100 kW	150 kW	200 kW	250 kW	
Sunset Vans Electric Low Floor Minibus	2	0	0	0	0	2
Forest River E450 EV	12	0	1	0	0	13
Forest River F550 EV	0	0	2	4	1	7
<b>FLEET TOTAL</b>	<b>14</b>	<b>0</b>	<b>3</b>	<b>4</b>	<b>1</b>	<b>22</b>

Note that implementing this scenario would still require 22 Level 2 chargers at the Bus Garage Facility to bring each vehicle to a full charge after its final two trips in a service day and protect the batteries (i.e., keep them warm) in cold weather. At 7.2 kW, the peak load on the electrical grid would be just 79.2 kW and overnight energy consumption would be about 670 kilowatts per hour (kWh).

## CONCLUSIONS

Though the benefits of electrified transportation are clear, the MPO must consider the feasibility of fully transitioning to BEVs when they currently have lower ranges and higher costs than their ICE vehicle counterparts. Based on the energy modeling results described above, it is infeasible for the CAT fleet to fully transition at this time without incurring logistical concerns, operational impacts, and significant costs related to a combination of vehicle purchases, charger installations, and facility reconfigurations.

The Transition Roadmap section of this plan identifies a series of benchmarks at which the MPO may again consider an electric fleet transition using only Level 2 depot charging. It also outlines the potential to conduct a potential pilot project using a small number of vehicles and a single charger that would enable CAT to evaluate wireless charging technologies against local conditions and its specific operational constraints.



**CASPER AREA**  
METROPOLITAN PLANNING ORGANIZATION  
Casper - Mills - Evansville - Bar Nunn - Natrona County

# FINANCIAL ANALYSIS



## FINANCIAL ANALYSIS

This section describes a financial analysis undertaken to determine the budgetary requirements associated with potential fleet electrification in Casper, including both capital and ongoing operations and maintenance (O&M) costs. The analysis was used to determine a high-level total cost of ownership over the 17-year period from 2023 through 2040, based on today's dollars.

### ANALYSIS METHODS

#### Analysis Scenarios

Four transition scenarios were evaluated to compare the financial impacts of a BEV fleet in terms of both capital and ongoing O&M expenditures through 2040. The four scenarios were:

- **Baseline: Maintain ICE Fleet**  
This scenario reflects CAT maintaining an ICE vehicle fleet to enable a direct comparison of the costs associated with owning and operating BEVs versus ICE vehicles. It includes two replacement cycles (2024-2029 and 2032-2037), with overdue vehicles being replaced between now and the end of 2027.
- **Expanded Fleet with Depot Charging Only** (BEV Cycle Begins 2024)  
This scenario reflects an immediate start to CAT's fleet transition, which would entail the purchase of 50 BEVs and their associated Level 2 chargers over the next five years. One Level 2 charger was assigned to each vehicle based on discussions with CAT staff, which identified the need for convenience and resiliency if a charger breaks. During the following replacement cycle, it was assumed that the fleet size would return to 22 vehicles as battery technology and driving ranges improve. Note that the energy modeling determined this strategy is infeasible due to operational and logistical concerns.
- **Delayed Transition with Depot Charging** (BEV Cycle Begins 2032)  
This scenario reflects one ICE vehicle replacement cycle (2024-2029) before BEVs are introduced to the fleet beginning in 2032. This strategy entails the purchase of 22 BEVs and their associated Level 2 chargers from 2032 to 2037. It is anticipated that the driving ranges of all-electric cutaways in 10 years will be sufficient for CAT's service, so the fleet size was not increased. Note that, although 2032 was assumed to be the start of a potential fleet transition based on CAT's current vehicle replacement cycle, this assumption is predicated on future improvements in battery technology and driving range.
- **Fast Charging with Near-Term Pilot Project**  
This scenario reflects initiation of a pilot project to test wireless inductive on-route charging prior to a full fleet transition. Two BEVs, one on-route fast charger, and two Level 2 chargers would be purchased in 2025 then delivered and installed in 2026/2027 to test the technology with the Link service. A BEV equivalent for one Assist vehicle and one more Level 2 charger would then be purchased in 2028 and delivered in 2029, assuming OEM lead times decrease. The remainder of the fleet would be transitioned to BEVs in the 2032-2037





replacement cycle, with the addition of 3 more on-route chargers and 19 more Level 2 chargers, dictated by future advancements in vehicle and charger technologies. It is important that each BEV has its own charger to maintain an acceptable temperature for its battery when charging overnight.

**Table 12** outlines the assumed replacement schedules for each of the scenarios described above. The values shown represent the number of vehicle purchases per year. Bold values indicate initial BEV purchases, while italicized values indicate the next BEV replacement after the initial BEV purchase. Unformatted values represent ICE vehicle purchases. Note that the vehicle purchases proposed for a potential pilot project would be made in advance of the project's start year to accommodate longer lead times from today's BEV and charging infrastructure manufacturers to deliver BEVs and install needed chargers.

**Table 12.** Assumed Fleet Replacement Schedules by Analysis Scenario

Existing ICE Fleet		Example BEV Fleet	Number of Vehicle Procurements																									
Vehicle Make / Model	Service Type	Vehicle Make / Model	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total	
Maintain ICE Fleet																												
Chevrolet Elkhart EC II 4500	Assist												3								3							6
Dodge Amerivan	Assist									1								1										2
Ford E350	Assist												1							1								2
Ford E450	Assist										2	3		2					2	3		2						14
Ford E450	Link													2								2						4
Ford Startrans F550	Link											2	1	2						2	1	2						10
Ford Transit 3500	Assist															1								1				2
Freightliner Champion Defender	Link										2								2									4
Total			0	0	0	0	0	0	0	5	5	2	9	0	1	0	0	5	5	2	9	0	1	0	0	0	44	
Expanded Fleet with Depot Charging Only (BEV Cycle Begins 2024)																												
Chevrolet Elkhart EC II 4500	Assist	Forest River E450 EV											6								3							9
Dodge Amerivan	Assist	SV Electric Low Floor Minibus								2								1										3
Ford E350	Assist	Forest River E450 EV										2								1								3
Ford E450	Assist	Forest River E450 EV								4	6		4					2	3		2							21
Ford E450	Link	Forest River E450 EV											4						3		2							6
Ford Startrans F550	Link	Forest River F550 EV									6	3	6						2	1	2							20
Ford Transit 3500	Assist	SV Electric Low Floor Minibus													2				2	1				1				3
Freightliner Champion Defender	Link	Forest River F550 EV								5								2										7
Total			0	0	0	0	0	0	0	11	12	5	20	0	2	0	0	5	5	2	9	0	1	0	0	0	72	
Delayed Transition with Depot Charging Only (BEV Cycle Begins 2032)																												
Chevrolet Elkhart EC II 4500	Assist	Forest River E450 EV											3					0	0	0	3	0	0	0	0	0	0	6
Dodge Amerivan	Assist	SV Electric Low Floor Minibus								1								1										2
Ford E350	Assist	Forest River E450 EV										1						0	0	1	0	0	0	0	0	0	0	2
Ford E450	Assist	Forest River E450 EV								2	3		2					2	3		2							14
Ford E450	Link	Forest River E450 EV											2					0	0	0	2	0	0	0	0	0	0	4
Ford Startrans F550	Link	Forest River F550 EV									2	1	2						2	1	2							10
Ford Transit 3500	Assist	SV Electric Low Floor Minibus													1			0	0	0	0	0		1	0	0	0	2
Freightliner Champion Defender	Link	Forest River F550 EV								2								2										4
Total			0	0	0	0	0	0	0	5	5	2	9	0	1	0	0	5	5	2	9	0	1	0	0	0	44	
Fast Charging with Near-Term Pilot Project																												
Chevrolet Elkhart EC II 4500	Assist	Forest River E450 EV											3								3	0	0					6
Dodge Amerivan	Assist	SV Electric Low Floor Minibus								1								1										2
Ford E350	Assist	Forest River E450 EV										1								1		0	0					2
Ford E450	Assist	Forest River E450 EV								2	3		2					2	3		2							14
Ford E450	Link	Forest River E450 EV									2										2	0	0					4
Ford Startrans F550	Link	Forest River F550 EV									2	1	2						2	1	2							10
Ford Transit 3500	Assist	SV Electric Low Floor Minibus												1									1					2
Freightliner Champion Defender	Link	Forest River F550 EV								2	0							2										4
Total			0	0	0	0	0	0	0	5	7	2	7	1	0	0	0	5	5	2	9	0	1	0	0	0	44	



## Capital Expenditures

This section discusses the methods used to identify the capital requirements of a BEV transition in Casper. Capital expenditures associated with fleet transitions are largely frontloaded, driven by initial vehicle purchases and charger installations.

### VEHICLE PURCHASES

Although the purchase prices of smaller BEVs like sedans and crossovers are close to their ICE vehicle equivalents, the purchase prices of battery electric cutaways are more than 100 percent higher. **Table 13** summarizes the estimated costs to replace CAT's fleet vehicles with ICE vehicles or the example BEVs selected to inform this study. They are represented in 2023 dollars based on reported MSRPs and industry averages. For the example BEV fleet shown, price markups compared to the cost of equivalent ICE vehicles can range from 60 to 175 percent. Note that this analysis does not include the resale value of the existing fleet, which would help to reduce the capital required for new vehicle procurements.

**Table 13.** ICE Vehicle and Example BEV Purchase Prices

Existing ICE Fleet				Example Battery Electric Fleet	
Vehicle Make / Model	Service Type	# of Vehicles	Est. Cost (2023 \$)	Vehicle Make / Model	Est. Cost (2023 \$)
Chevrolet Elkhart EC II 4500	Assist	3	\$160,000	Forest River E450 EV	\$290,000
Dodge Amerivan	Assist	1	\$80,000	SV Electric Low Floor Minibus	\$220,000
Ford E350	Assist	1	\$135,000	Forest River E450 EV	\$290,000
Ford E450	Assist	7	\$160,000	Forest River E450 EV	\$290,000
Ford E450	Link	2	\$160,000	Forest River E450 EV	\$290,000
Ford Startrans F550	Link	5	\$220,000	Forest River F550 EV	\$350,000
Ford Transit 3500	Assist	1	\$100,000	SV Electric Low Floor Minibus	\$220,000
Freightliner Champion Defender	Link	2	\$225,000	Forest River F550 EV	\$350,000

Research and trends in the alternative fuel vehicle (AFV) market were reviewed to forecast future market conditions and purchase prices for ICE vehicles and BEVs. An annual inflation rate of 3 percent was assumed for all costs, which is consistent with trends in the consumer price index (CPI) as reported by the U.S. Bureau of Labor Statistics. A 5 percent discount rate was then applied to BEV purchase prices until 'price parity', or the point where ICE vehicle and BEV purchase prices are equal, was reached in about six years. This is consistent with BNEF forecasts for battery pack prices, which are expected to drop by up to 10 percent annually before reaching a critical threshold of \$60 per kilowatt-hour (kWh) in that year.<sup>4</sup>

<sup>4</sup>. BloombergNEF: <https://about.bnef.com/blog/the-ev-price-gap-narrows/>



Note that this analysis does not account for any financial incentives or support that CAT may pursue to help fund new vehicle purchases and/or charger installations. Federal funding sources, such as the Federal Transit Administration's (FTA) Low-No Grant Program and Bus and Bus Facilities grants. 80 percent of project funding is provided by the FTA, while the remaining 20 percent is matched locally. The Internal Revenue Service's (IRS) Clean Vehicle Credit can also be leveraged to reduce the capital needs associated with a potential fleet transition. This credit can fund up to \$40,000 per vehicle purchase for vehicles with gross vehicle weight ratings (GVWR) above 14,000 pounds.

### **CHARGING INFRASTRUCTURE**

This analysis considers two BEV charging strategies: overnight depot charging at the Bus Garage Facility using Level 2 equipment and wireless inductive fast charging at key transfer points along CAT's Link service routes. Based on industry standard costs for electric vehicle supply equipment (EVSE), the purchase and installation prices per Level 2 charger were assumed to be \$10,000 each, for a per-charger total of \$15,000. Based on experience with similar projects, the average cost to install a new Level 2 charger is often closer to \$5,000; however, conversations with RMP indicated the potential need for utility upgrades and running of additional conduit. Additionally, CAT would need to install curbs and/or bollards to protect the charging stations in the Bus Garage Facility parking area. An installation cost of \$10,000 is assumed to account for these additional expenses.

Assumed costs for wireless inductive chargers were based on conversations with a charger original equipment manufacturer (OEM), who indicated a per-charger cost of up to \$400,000 for a 250-kilowatt (kW) inductive system, including installation. A per-BEV cost of \$15,000 was also applied to account for the installation of inductive charging equipment on each vehicle in applicable scenarios. All infrastructure costs were grown by the same 3 percent annual inflation rate used to project vehicle purchase prices.

Similar to the assumptions for vehicle purchases, no incentives were included in the analysis of infrastructure costs. Federal funding is available for infrastructure projects that support AFVs and fleet transitions through sources such as the USDOT's RAISE Discretionary Grant program. CAT can leverage available funding opportunities to further reduce its capital expenditures related to fleet electrification.

### **Ongoing Expenditures**

Ongoing expenditures associated with both ICE vehicle and BEV fleets include fuel or electricity costs, respectively, and routine maintenance. This section discusses the methods used to identify the O&M needs of a potential fleet transition to BEVs.

### **FUEL & UTILITY COSTS**

CAT's existing fleet is a mix of gasoline- and diesel-powered transit vehicles. Data provided during a site visit at the City Garage showed that, in 2022, CAT spent an average of \$3.46 per gallon of gasoline fuel and \$4.49 per gallon of diesel fuel. To



forecast future fuel costs, these values were increased or decreased annually based on projections from the Energy Information Administration (EIA) Annual Energy Outlook 2023.<sup>5</sup> Fuel consumption data was provided by City staff.

Based on the energy analysis conducted for a potential BEV fleet in Casper, no charging site would generate a peak load greater than 500 kW, well below the 1-megawatt (MW) threshold set by RMP that would trigger the Large General Service rate structure. Therefore, the General Service rate structure would be applied to the Bus Garage Facility, Downtown Transfer Center, and other transfer stations where charging infrastructure is installed. Under this rate structure, RMP applies an energy charge of 1.468¢ to 1.519¢ per kWh consumed, then a demand charge of \$16.31 to \$16.89 per kW based on the highest-use 15-minute period per month.<sup>6</sup> The high-end rates were applied to any power use related to charging activities to provide a more conservative analysis. The rates do not change based on time of day nor season of use. To forecast future utility costs, these values were also increased or decreased annually based on EIA projections.<sup>7</sup>

#### **ROUTINE MAINTENANCE**

Maintenance expenditures and vehicle usage data provided by City staff were used to determine that, in 2022, CAT's routine maintenance activities incurred a cost of approximately 71.1¢ per mile traveled by the current ICE vehicle fleet, which includes both parts and labor. Argonne National Laboratory has shown that BEV owners can save about 40 percent on routine maintenance costs due to BEVs' mechanical simplicity and less frequent maintenance intervals. BEVs are not equipped with spark plugs, oxygen sensors, and oil filters that require periodic replacement, they do not require oil changes, and their brake replacement intervals can be 50 percent longer than those of their ICE vehicle counterparts due to the reduced wear and tear achieved through regenerative braking.<sup>8</sup> For CAT, a 40 percent savings on current maintenance expenditures would entail a cost of about 57¢ per mile based on the current vehicle usage and maintenance cost data provided by City staff. Note that this level of savings is assumed based on industry averages but may be lower for new BEV types like cutaways. A standard inflation rate of 3 percent per year was then applied to all costs through 2040.

## **ANALYSIS RESULTS**

This financial analysis reflects two full replacement cycles for CAT's fleet vehicles: one from 2024-2029 and one from 2032-2037. Transition costs vary based on which cycle BEVs are introduced during and the type charging technology selected, which can significantly impact the fleet size required to maintain daily operations. The cost of delaying the fleet transition to use Level 2 charging only (\$27.38M) or conducting an on-route charging pilot project (\$29.75M) are similar or lower in cost to maintaining

<sup>5</sup>. Energy Information Administration: <https://www.eia.gov/outlooks/aeo/data/browser> (Table 57)

<sup>6</sup>. Rocky Mountain Power: <https://www.rockymountainpower.net/about/rates-regulation/wyoming-rates-tariffs.html>

<sup>7</sup>. Energy Information Administration: <https://www.eia.gov/outlooks/aeo/data/browser> (Table 8)

<sup>8</sup>. Argonne National Laboratory: <https://www.anl.gov/argonne-scientific-publications/pub/167399>





an ICE vehicle fleet (\$29.83M). Beginning the transition immediately while relying on Level 2 charging, however, would incur a significantly higher cost of \$47.52M as the fleet size would expand from 22 to 50 vehicles, requiring 28 extra vehicle purchases and the installation of 50 charging stations, many of which may not be needed in the future as battery capacities and driving ranges improve. Note that the results for this scenario do not account for additional costs associated with reconstructing the Bus Garage Facility to store and charge 28 additional vehicles.

**Tables 14, 15, and 16** itemize annual expenditures for the Baseline scenario against those for each fleet transition scenario. **Figures 7, 8, 9, and 10** summarize projected annual capital, annual ongoing, annual total, and cumulative expenditures through 2040 under each scenario. Finally, **Table 17** provides a total cost-level summary for each analysis scenario, broken down by total capital and total O&M expenditures through 2040. Both ICE vehicle and BEV costs are shown because the fleet transition would occur over many years, during which ICE vehicles would still be part of CAT's fleet. O&M costs are shown to decrease significantly once all existing ICE vehicles have been replaced with BEVs, at which point all ICE vehicle-related costs reach zero dollars. For example, in the first year with an all-electric fleet under the Delayed Transition scenario (2038), costs are shown to be over \$1.3 M for an ICE fleet versus about \$625,000 for BEVs.

Note that the costs estimated in this analysis are based on fleetwide assumptions regarding vehicle usage and current expenditures rather than a per-vehicle or per-route analysis. Additionally, first year maintenance costs would likely be lower as the vehicles would be under warranty through the OEMs. Moving forward, consistent uptime is important in achieving these projected maintenance costs. If BEVs in the fleet are inoperable for long periods of time, CAT may not experience the full 40 percent savings assumed in this analysis.

The results of this analysis make clear that fleet expansion to support a near-term transition to BEVs is financially infeasible, as it would incur a total cost over \$18M greater than that of maintaining the current ICE vehicle fleet or selecting another transition strategy. To feasibly rely on Level 2 charging, CAT would need to introduce BEVs only when battery technology can enable driving ranges sufficient to complete service routes, relying on only 70 percent of the nameplate battery capacity. Both this strategy and operating an on-route fast charging pilot project appear to be financially feasible, and both show projected total costs similar to, or less than, those for maintaining an ICE vehicle fleet. Large savings in ongoing O&M and continued reductions in BEV purchase prices over the next few years are expected to outweigh the costs associated with installing new charging infrastructure in these scenarios.

**Table 14.** Summary of Projected Annual Fleet Transition Expenditures (Expanded Fleet with Depot Charging Only)

Expenditure Type	Annual Expenditures (2023 \$)																		Fleet Total (2023-2040)
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	
MAINTAIN ICE FLEET																			
Capital Expenditures																			
# of Vehicle Purchases	0	5	5	2	9	0	1	0	0	5	5	2	9	0	1	0	0	0	44
\$ per Year (Vehicles)	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,123,130	\$1,243,833	\$506,145	\$2,269,934	\$0	\$155,797	\$0	\$0	\$0	\$9,481,791
Total Capital \$ per Year	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,123,130	\$1,243,833	\$506,145	\$2,269,934	\$0	\$155,797	\$0	\$0	\$0	\$9,481,791
O&M Expenditures																			
\$ per Year (ICE Maintenance)	\$485,242	\$499,799	\$514,793	\$530,237	\$546,144	\$562,528	\$579,404	\$596,786	\$614,690	\$633,131	\$652,124	\$671,688	\$691,839	\$712,594	\$733,972	\$755,991	\$778,671	\$802,031	\$11,361,664
\$ per Year (Fuel)	\$362,536	\$353,878	\$385,334	\$397,369	\$409,972	\$425,092	\$444,044	\$462,352	\$476,131	\$501,170	\$520,255	\$539,703	\$558,138	\$579,330	\$604,224	\$630,819	\$655,951	\$680,070	\$8,986,367
Total O&M \$ per Year	\$847,778	\$853,677	\$900,127	\$927,606	\$956,116	\$987,621	\$1,023,449	\$1,059,138	\$1,090,821	\$1,134,301	\$1,172,379	\$1,211,391	\$1,249,977	\$1,291,924	\$1,338,195	\$1,386,810	\$1,434,621	\$1,482,101	\$20,348,031
Total Baseline Cost per Year	\$847,778	\$1,740,286	\$1,882,020	\$1,327,161	\$2,748,022	\$987,621	\$1,146,436	\$1,059,138	\$1,090,821	\$2,257,431	\$2,416,212	\$1,717,537	\$3,519,911	\$1,291,924	\$1,493,992	\$1,386,810	\$1,434,621	\$1,482,101	\$29,829,821
EXPANDED FLEET WITH DEPOT CHARGING ONLY (BEV CYCLE BEGINS 2024)																			
Capital Expenditures																			
# of Vehicle Purchases	0	11	12	5	20	0	2	0	0	5	5	2	9	0	1	0	0	0	72
# of Level 2 AC Chargers	0	11	12	5	20	0	2	0	0	0	0	6	6	3	10	0	1	0	75
\$ per Year (Vehicles)	\$0	\$3,207,499	\$3,597,607	\$1,494,276	\$5,525,669	\$0	\$377,901	\$0	\$0	\$1,538,298	\$1,708,139	\$738,717	\$3,342,991	\$0	\$303,210	\$0	\$0	\$0	\$21,834,307
\$ per Year (Chargers)	\$0	\$175,049	\$196,691	\$84,413	\$347,782	\$0	\$36,896	\$0	\$0	\$0	\$0	\$39,208	\$44,056	\$18,907	\$77,898	\$0	\$8,264	\$0	\$1,029,165
Total Capital \$ per Year	\$0	\$3,382,547	\$3,794,298	\$1,578,690	\$5,873,451	\$0	\$414,798	\$0	\$0	\$1,538,298	\$1,708,139	\$777,925	\$3,387,047	\$18,907	\$381,109	\$0	\$8,264	\$0	\$22,863,472
O&M Expenditures																			
\$ per Year (Fuel)	\$362,536	\$238,595	\$106,736	\$92,349	\$12,436	\$12,895	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$825,545
\$ per Year (Electricity)	\$0	\$5,811	\$13,880	\$17,838	\$30,621	\$31,443	\$33,108	\$34,230	\$35,358	\$39,566	\$44,844	\$48,004	\$56,927	\$58,834	\$60,662	\$62,345	\$63,878	\$65,449	\$702,799
\$ per Year (ICE Maintenance)	\$485,242	\$358,333	\$167,001	\$147,744	\$25,490	\$26,254	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1,210,063
\$ per Year (EV Maintenance)	\$0	\$173,447	\$416,112	\$534,472	\$967,628	\$996,657	\$1,069,931	\$1,102,029	\$1,135,090	\$1,268,810	\$1,429,830	\$1,500,997	\$1,732,969	\$1,784,958	\$1,865,980	\$1,921,959	\$1,979,618	\$2,039,006	\$21,919,494
Total O&M \$ per Year	\$847,778	\$776,186	\$703,728	\$792,402	\$1,036,175	\$1,067,249	\$1,103,039	\$1,136,259	\$1,170,448	\$1,308,375	\$1,474,675	\$1,549,000	\$1,789,896	\$1,843,793	\$1,926,642	\$1,984,305	\$2,043,496	\$2,104,456	\$24,657,901
Total Transition Cost per Year	\$847,778	\$4,158,733	\$4,498,026	\$2,371,091	\$6,909,626	\$1,067,249	\$1,517,837	\$1,136,259	\$1,170,448	\$2,846,673	\$3,182,814	\$2,326,926	\$5,176,943	\$1,862,700	\$2,307,750	\$1,984,305	\$2,051,761	\$2,104,456	\$47,521,374

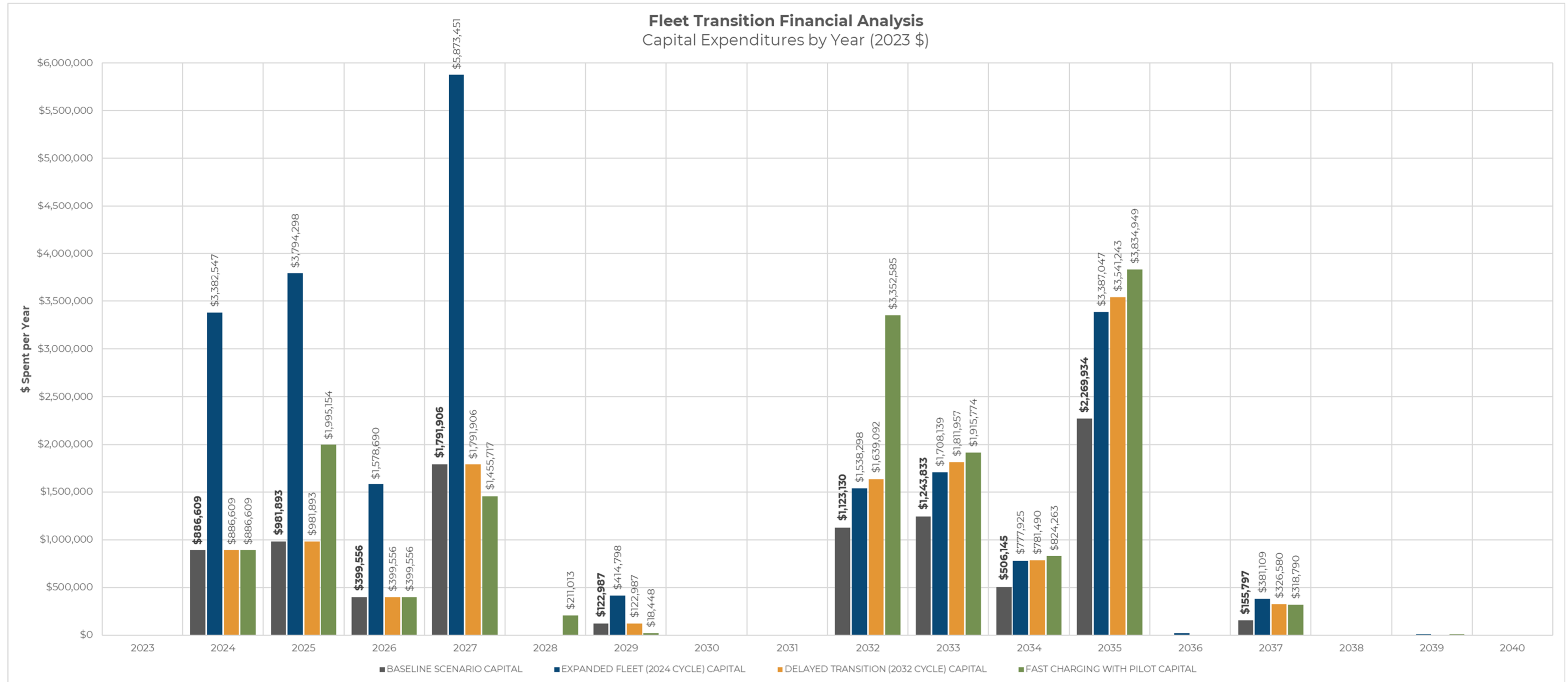
**Table 15.** Summary of Projected Annual Fleet Transition Expenditures (Same Size Fleet with Depot Charging Only)

Expenditure Type	Annual Expenditures (2023 \$)																		Fleet Total (2023-2040)
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	
MAINTAIN ICE FLEET																			
Capital Expenditures																			
# of Vehicle Purchases	0	5	5	2	9	0	1	0	0	5	5	2	9	0	1	0	0	0	44
\$ per Year (Vehicles)	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,123,130	\$1,243,833	\$506,145	\$2,269,934	\$0	\$155,797	\$0	\$0	\$0	\$9,481,791
Total Capital \$ per Year	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,123,130	\$1,243,833	\$506,145	\$2,269,934	\$0	\$155,797	\$0	\$0	\$0	\$9,481,791
O&M Expenditures																			
\$ per Year (ICE Maintenance)	\$485,242	\$499,799	\$514,793	\$530,237	\$546,144	\$562,528	\$579,404	\$596,786	\$614,690	\$633,131	\$652,124	\$671,688	\$691,839	\$712,594	\$733,972	\$755,991	\$778,671	\$802,031	\$11,361,664
\$ per Year (Fuel)	\$362,536	\$353,878	\$385,334	\$397,369	\$409,972	\$425,092	\$444,044	\$462,352	\$476,131	\$501,170	\$520,255	\$539,703	\$558,138	\$579,330	\$604,224	\$630,819	\$655,951	\$680,070	\$8,986,367
Total O&M \$ per Year	\$847,778	\$853,677	\$900,127	\$927,606	\$956,116	\$987,621	\$1,023,449	\$1,059,138	\$1,090,821	\$1,134,301	\$1,172,379	\$1,211,391	\$1,249,977	\$1,291,924	\$1,338,195	\$1,386,810	\$1,434,621	\$1,482,101	\$20,348,031
Total Baseline Cost per Year	\$847,778	\$1,740,286	\$1,882,020	\$1,327,161	\$2,748,022	\$987,621	\$1,146,436	\$1,059,138	\$1,090,821	\$2,257,431	\$2,416,212	\$1,717,537	\$3,519,911	\$1,291,924	\$1,493,992	\$1,386,810	\$1,434,621	\$1,482,101	\$29,829,821
DELAYED TRANSITION WITH DEPOT CHARGING (BEV CYCLE BEGINS 2032)																			
Capital Expenditures																			
# of Vehicle Purchases	0	5	5	2	9	0	1	0	0	5	5	2	9	0	1	0	0	0	44
# of Level 2 AC Chargers	0	0	0	0	0	0	0	0	0	5	5	2	9	0	1	0	0	0	22
\$ per Year (Vehicles)	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,538,298	\$1,708,139	\$738,717	\$3,342,991	\$0	\$303,210	\$0	\$0	\$0	\$11,814,307
\$ per Year (Chargers)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$100,794	\$103,818	\$42,773	\$198,252	\$0	\$23,370	\$0	\$0	\$0	\$469,006
Total Capital \$ per Year	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,639,092	\$1,811,957	\$781,490	\$3,541,243	\$0	\$326,580	\$0	\$0	\$0	\$12,283,313
O&M Expenditures																			
\$ per Year (Fuel)	\$362,536	\$353,878	\$385,334	\$397,369	\$409,972	\$425,092	\$444,044	\$462,352	\$476,131	\$377,135	\$272,178	\$228,082	\$16,930	\$17,573	\$0	\$0	\$0	\$0	\$4,628,607
\$ per Year (Electricity)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$3,093	\$7,153	\$9,113	\$16,648	\$17,206	\$18,040	\$18,541	\$18,997	\$19,464	\$128,256
\$ per Year (ICE Maintenance)	\$485,242	\$499,799	\$514,793	\$530,237	\$546,144	\$562,528	\$579,404	\$596,786	\$614,690	\$508,854	\$370,804	\$315,935	\$32,290	\$33,258	\$0	\$0	\$0	\$0	\$6,190,766
\$ per Year (EV Maintenance)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$99,667	\$225,613	\$285,307	\$528,945	\$544,814	\$588,631	\$606,290	\$624,479	\$643,213	\$4,146,958
Total O&M \$ per Year	\$847,778	\$853,677	\$900,127	\$927,606	\$956,116	\$987,621	\$1,023,449	\$1,059,138	\$1,090,821	\$988,750	\$875,749	\$838,437	\$594,813	\$612,851	\$606,671	\$624,831	\$643,476	\$662,677	\$15,094,587
Total Transition Cost per Year	\$847,778	\$1,740,286	\$1,882,020	\$1,327,161	\$2,748,022	\$987,621	\$1,146,436	\$1,059,138	\$1,090,821	\$2,627,842	\$2,687,706	\$1,619,927	\$4,136,056	\$612,851	\$933,251	\$624,831	\$643,476	\$662,677	\$27,377,900

Table 16. Summary of Projected Annual Fleet Transition Expenditures (Fast Charging with Near-Term Pilot Project)

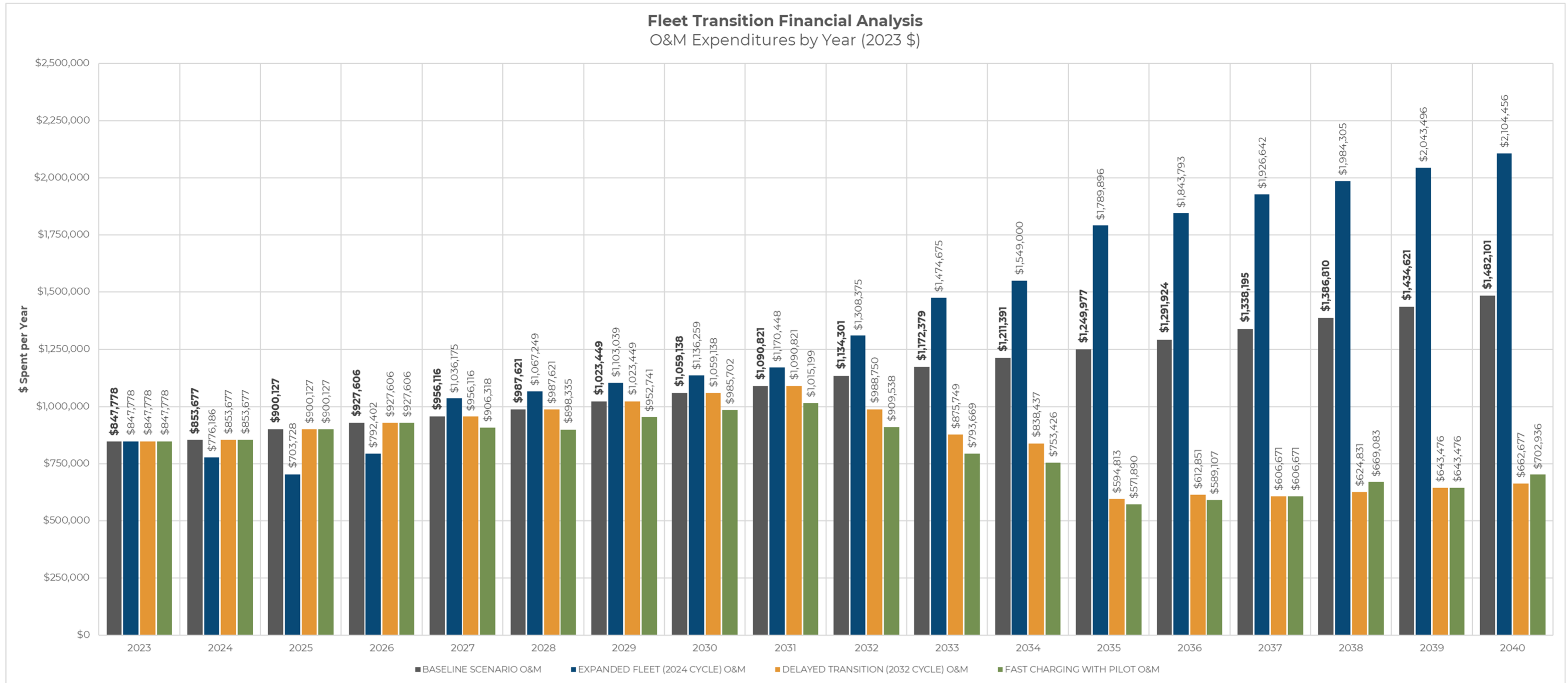
Expenditure Type	Annual Expenditures (2023 \$)																		Fleet Total (2023-2040)
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	
MAINTAIN ICE FLEET																			
Capital Expenditures																			
# of Vehicle Purchases	0	5	5	2	9	0	1	0	0	5	5	2	9	0	1	0	0	0	44
\$ per Year (Vehicles)	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,123,130	\$1,243,833	\$506,145	\$2,269,934	\$0	\$155,797	\$0	\$0	\$0	\$9,481,791
Total Capital \$ per Year	\$0	\$886,609	\$981,893	\$399,556	\$1,791,906	\$0	\$122,987	\$0	\$0	\$1,123,130	\$1,243,833	\$506,145	\$2,269,934	\$0	\$155,797	\$0	\$0	\$0	\$9,481,791
O&M Expenditures																			
\$ per Year (ICE Maintenance)	\$485,242	\$499,799	\$514,793	\$530,237	\$546,144	\$562,528	\$579,404	\$596,786	\$614,690	\$633,131	\$652,124	\$671,688	\$691,839	\$712,594	\$733,972	\$755,991	\$778,671	\$802,031	\$11,361,664
\$ per Year (Fuel)	\$362,536	\$353,878	\$385,334	\$397,369	\$409,972	\$425,092	\$444,044	\$462,352	\$476,131	\$501,170	\$520,255	\$539,703	\$558,138	\$579,330	\$604,224	\$630,819	\$655,951	\$680,070	\$8,986,367
Total O&M \$ per Year	\$847,778	\$853,677	\$900,127	\$927,606	\$956,116	\$987,621	\$1,023,449	\$1,059,138	\$1,090,821	\$1,134,301	\$1,172,379	\$1,211,391	\$1,249,977	\$1,291,924	\$1,338,195	\$1,386,810	\$1,434,621	\$1,482,101	\$20,348,031
Total Baseline Cost per Year	\$847,778	\$1,740,286	\$1,882,020	\$1,327,161	\$2,748,022	\$987,621	\$1,146,436	\$1,059,138	\$1,090,821	\$2,257,431	\$2,416,212	\$1,717,537	\$3,519,911	\$1,291,924	\$1,493,992	\$1,386,810	\$1,434,621	\$1,482,101	\$29,829,821
FAST CHARGING WITH NEAR-TERM PILOT PROJECT																			
Capital Expenditures																			
# of Vehicle Purchases	0	5	7	2	7	1	0	0	0	5	5	2	9	0	1	0	0	0	44
# of Level 2 AC Chargers	0	0	0	0	2	0	1	0	0	5	5	2	7	0	2	0	1	0	25
# of Wireless Fast Chargers	0	0	1	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	5
\$ per Year (Vehicles)	\$0	\$886,609	\$1,525,282	\$399,556	\$1,420,939	\$193,102	\$0	\$0	\$0	\$1,538,298	\$1,708,139	\$738,717	\$3,342,991	\$0	\$303,210	\$0	\$0	\$0	\$12,056,843
\$ per Year (Chargers)	\$0	\$0	\$469,873	\$0	\$34,778	\$17,911	\$18,448	\$0	\$0	\$1,814,287	\$207,635	\$85,546	\$491,959	\$0	\$15,580	\$0	\$8,264	\$0	\$3,164,280
Total Capital \$ per Year	\$0	\$886,609	\$1,995,154	\$399,556	\$1,455,717	\$211,013	\$18,448	\$0	\$0	\$3,352,585	\$1,915,774	\$824,263	\$3,834,949	\$0	\$318,790	\$0	\$8,264	\$0	\$15,221,123
O&M Expenditures																			
\$ per Year (Fuel)	\$362,536	\$353,878	\$385,334	\$397,369	\$371,959	\$372,783	\$389,403	\$405,457	\$417,541	\$315,464	\$208,159	\$161,669	\$0	\$0	\$0	\$0	\$0	\$0	\$4,141,550
\$ per Year (Electricity)	\$0	\$0	\$0	\$0	\$1,289	\$1,324	\$1,696	\$1,753	\$1,811	\$4,961	\$9,084	\$11,105	\$17,049	\$17,620	\$18,040	\$18,541	\$18,997	\$19,464	\$142,736
\$ per Year (ICE Maintenance)	\$485,242	\$499,799	\$514,793	\$530,237	\$487,087	\$475,445	\$489,708	\$504,400	\$519,532	\$410,841	\$269,851	\$211,954	\$0	\$0	\$0	\$0	\$0	\$0	\$5,398,889
\$ per Year (EV Maintenance)	\$0	\$0	\$0	\$0	\$45,983	\$48,783	\$71,934	\$74,092	\$76,315	\$178,271	\$306,576	\$368,698	\$554,841	\$571,486	\$588,631	\$650,541	\$624,479	\$683,472	\$4,844,103
Total O&M \$ per Year	\$847,778	\$853,677	\$900,127	\$927,606	\$906,318	\$898,335	\$952,741	\$985,702	\$1,015,199	\$909,538	\$793,669	\$753,426	\$571,890	\$589,107	\$606,671	\$669,083	\$643,476	\$702,936	\$14,527,278
Total Transition Cost per Year	\$847,778	\$1,740,286	\$2,895,281	\$1,327,161	\$2,362,035	\$1,109,349	\$971,189	\$985,702	\$1,015,199	\$4,262,123	\$2,709,443	\$1,577,688	\$4,406,839	\$589,107	\$925,461	\$669,083	\$651,740	\$702,936	\$29,748,401

**Figure 7.** Projected Annual Capital Expenditures by Analysis Scenario

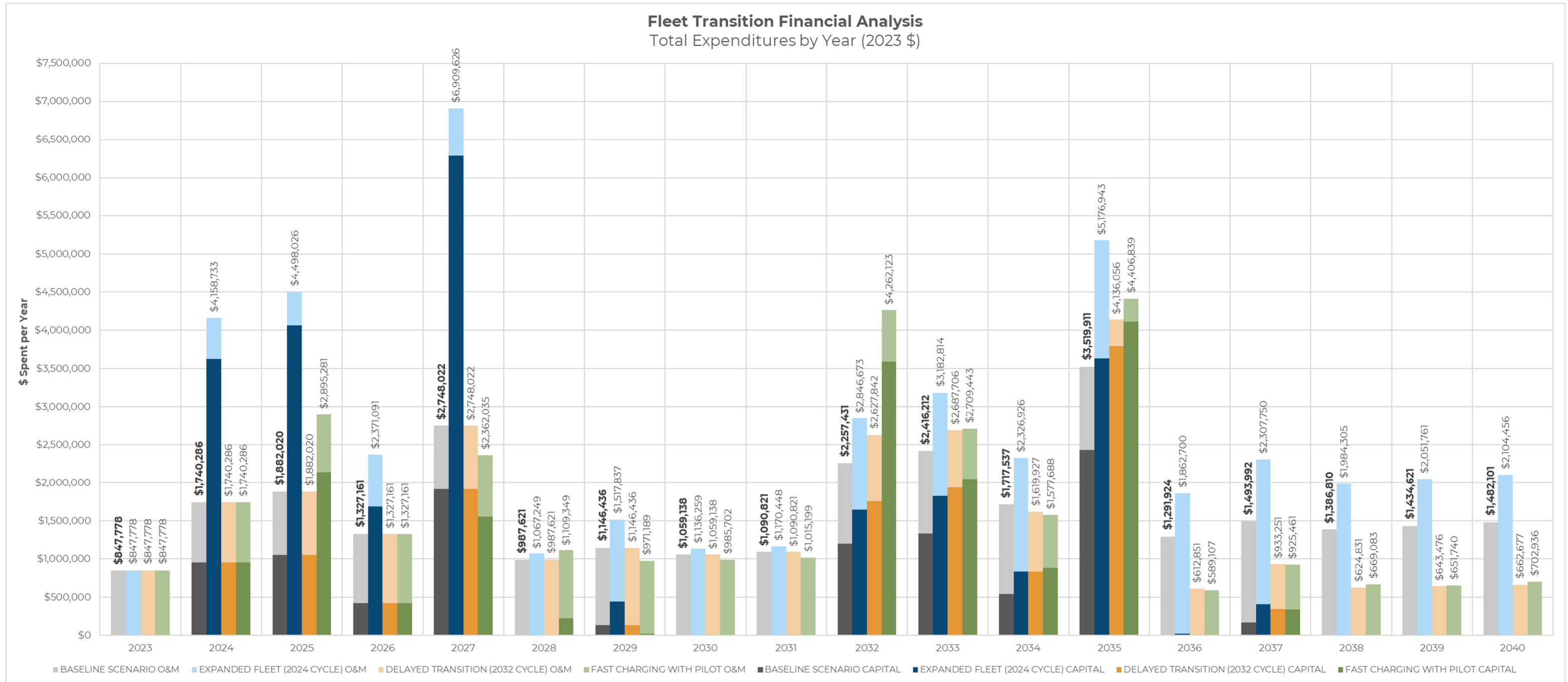




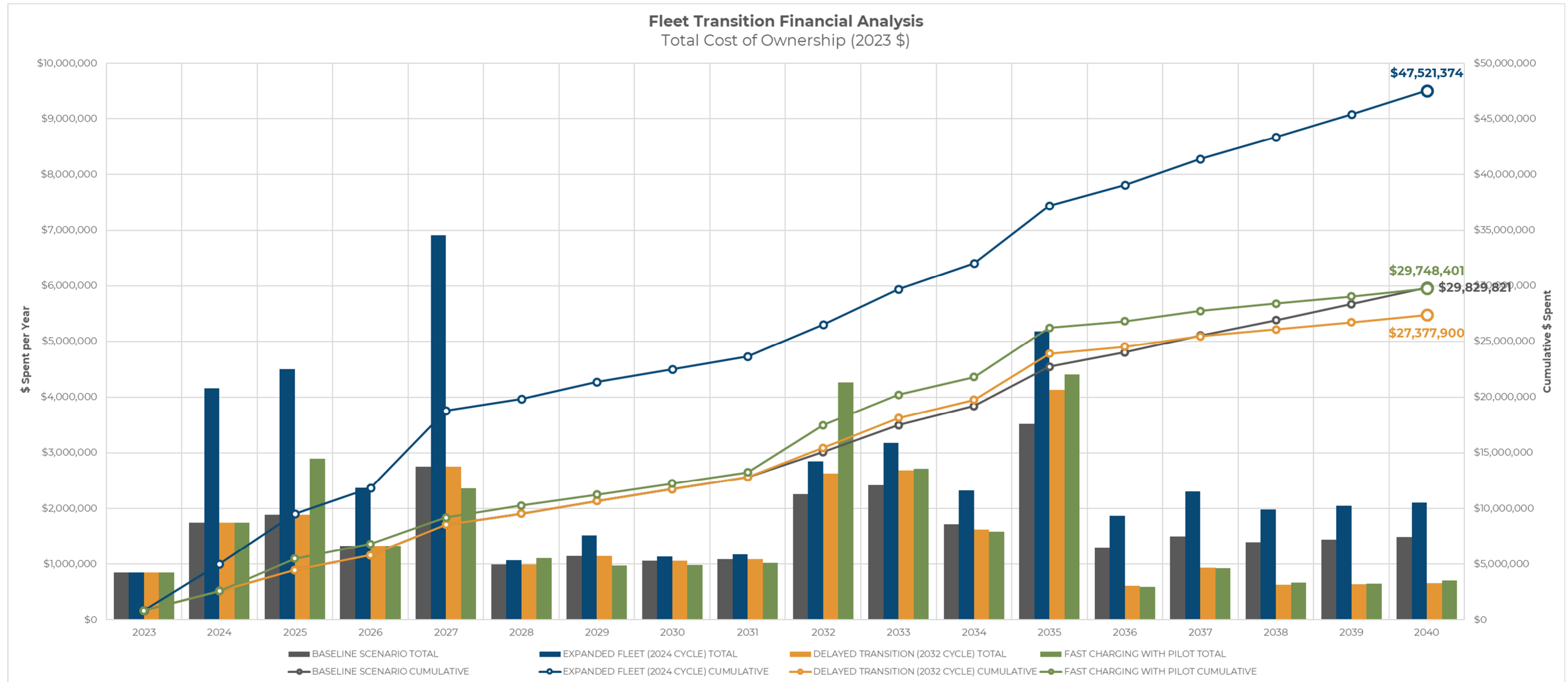
**Figure 8.** Projected Annual Ongoing Expenditures by Analysis Scenario



**Figure 9.** Projected Total Annual Expenditures by Analysis Scenario



**Figure 10.** Projected Cumulative Cost of Ownership by Analysis Scenario





**Table 17.** Summary of Projected Total Baseline and Fleet Transition Expenditures

Analysis Scenario	Total Cost of Ownership (2023 \$)		
	Capital	O&M	Total
<b>Maintain ICE Fleet</b>	\$9,481,791	\$20,348,031	<b>\$29,829,821</b>
<b>Expanded Fleet with Depot Charging Only</b> (BEV Cycle Begins in 2024)	\$22,863,472	\$24,657,901	<b>\$47,521,374</b>
<b>Delayed Transition with Depot Charging Only</b> (BEV Cycle Begins in 2032)	\$12,283,313	\$15,094,587	<b>\$27,377,900</b>
<b>Fast Charging with Near-Term Pilot Project</b>	\$15,221,123	\$14,527,278	<b>\$29,748,401</b>

## ANALYSIS CONCLUSIONS

This financial analysis evaluated four scenarios to compare the financial impacts of a BEV fleet in terms of both capital and ongoing O&M expenditures through 2040. The findings build upon those from the energy analysis to show that an expanded fleet is infeasible. However, a delayed transition or a near-term on-route fast charging pilot project are viable options with total costs of ownership that are not expected to significantly exceed those of maintaining an ICE vehicle fleet. Note that the Delayed Transition scenario relies on assumptions related to advancements in battery technology, so CAT would need to be sure an all-electric fleet is technologically feasible before committing to a full transition based on the technology available at that time. Also note that the Fast Charging Pilot Project scenario, although feasible, is the most dependent on upfront capital funds of the three viable options.

The Transition Roadmap section of this study identifies benchmarks at which CAT might feasibly operate a same-size BEV fleet relying entirely on depot charging, then describes in more detail the logistics of a potential on-route charging pilot project using a small number of BEVs and a single charger at the Downtown Transfer Center. If CAT wishes to pursue a BEV pilot project and leverage available funding in the near term, this is likely a more valid option than a complete fleet transition.



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# WORKFORCE DEVELOPMENT





## WORKFORCE DEVELOPMENT

Proper training on vehicle systems and subcomponents is crucial when introducing any AFV, proper training on vehicle systems and subcomponents is crucial to ensure the safe and efficient operation and maintenance of the new vehicles. CAT should encourage coordination between its operations department, vehicle OEMs, and the City Maintenance Department to ensure staff are acclimated to the new technology and prevent any displacement of the existing workforce. This section outlines steps to evaluate the skills of the current workforce, identify skill gaps at an individual level, and develop a plan to train both bus operators and maintenance personnel on BEVs and/or HEVs.

### CURRENT PRACTICES

#### Training

CAT has an in-house training program called Entry Level Driver Training (ELDT) for new bus operators, which focuses on obtaining a commercial driver's license (CDL) with passenger endorsement. Due to limitations in personnel and vehicle availability and taxing requirements, ELDT is not conducted regularly at present. CAT relies on the Transportation Safety Institute's (TSI) passenger theory training, developed by the FTA under the supervision of the USDOT, when developing new curricula. Approval for adopting a new curriculum must be obtained from the City of Casper Risk Management and CAT Management. No in-house training program for bus maintenance exists today, but there is interest in establishing one if it makes sense for servicing new equipment.

As CAT considers the purchase of training from OEMs for new zero-emission rolling stock, several factors related to the agency's current training practices and staff base need to be considered. CAT and/or the City may need to purchase training materials unique to the new vehicle technologies from the OEM as part of the rolling stock procurement. Currently, CAT provides training for maintenance staff during normal work hours.

In terms of training and certifications of the City's current maintenance personnel, there are several elements to consider. While all transit-specific mechanics are trained to work on the existing fleet, there are no individuals on the CAT staff who are certified for high voltage work, and there are no current plans to develop this capability in-house. The City Maintenance Department typically contracts out any high-voltage work. Although CDL training is not required for City mechanics or management, it is preferred by operations and maintenance management. All maintenance technicians on the City's staff hold Automotive Service Excellence (ASE) certifications, and the agency traditionally participates in hydraulic training programs offered by Construction Equipment and Solutions and training clinics conducted by Ford for emissions and transmission.

CAT also actively coordinates with local first responding agencies, like Fire and emergency management services, to the best of their ability in terms of emergency



readiness plans. It would be important to coordinate emergency response for any issues with the BEVs or on-route chargers (e.g., breakdowns, fires, crashes, or other emergencies). The Mayor of the City of Casper is responsible for declaring and managing disasters or emergencies and, in the case of an emergency declaration, works with CAT via the City Manager to direct any actions of the agency. If CAT's services are required, they will make every effort to fulfill any given assignment in the safest manner possible.

## **Staffing**

This section outlines the workplace hierarchy and authorized responsibilities of individuals based on qualifications, the skill level requirements for the work needing to be performed, and initial, refresher, and proficiency guidelines and requirements for training and associated qualifications. Generally, operational staff can be grouped into four categories:

1. **Bus Operations Support:** Staff include those critical to bus operations but not directly interacting with the buses. Minimal training is required and typically only covers a high-level overview of the bus technology and its capabilities. For example, it is important for dispatchers and schedulers to understand the operational range of the vehicles to avoid assigning them to routes for which they are not suited.
2. **Bus Operations:** Staff include those who directly interact with the buses but do not perform any maintenance. Bus Operations staff require more training than the Bus Operations Support staff given their direct interaction with CAT's vehicles. For example, bus operators must be familiar with all dash indicator lights, door operations, wheelchair accommodations, and safety procedures. Staff would also need to be knowledgeable regarding charging protocols and basic charger system elements.
3. **Bus Maintenance Support:** Staff include operations specialists who directly interact with the buses, support or lead bus maintenance training, or are responsible for the assignment and oversight of maintenance functions. Bus Maintenance Support staff receive the same training as Bus Maintenance staff as their roles require full familiarity with all vehicle systems and mechanical components.
4. **Bus Maintenance:** Staff include operations specialists who directly interact with the buses and perform routine and unplanned maintenance functions. Bus Maintenance staff require the most training as they have the most frequent and in-depth interaction with CAT's vehicles. Staff are individually assessed on current skills and assigned to training modules as necessary, ensuring that all staff receive all required training without duplicating efforts. For example, maintenance staff who can demonstrate proficient multiplexing skills are not assigned to multiplexing courses.



**Table 18** shows the composition of CAT's existing operations and maintenance staff, including the number of full-time equivalents (FTE), number of authorized positions, union affiliation, and role categorization with respect to fleet electrification in Casper.

**Table 18.** CAT Operations and Maintenance Staff (Q1 2023)

Job Title	Role Category	Full Time (FT) or Part Time (PT)	# of Employees	# of Authorized Positions	CDL Required?
Dispatcher	Bus Operations Support	FT	3	3	No
Management	Bus Operations Support	FT	2	3	Preferred
Vehicle Operator	Bus Operations	FT / PT	14 / 12	26	Yes
Maintenance Supervisor	Bus Maintenance Support	FT	1	1	No
Mechanic	Bus Maintenance	FT	6	7	No

### Recruitment

CAT employs various strategies for recruiting its workforce that encompass many different approaches and methods. The agency would appreciate obtaining younger drivers through sponsoring internships or apprenticeships, but CDL certification requirements include an age minimum of 21 years. Budget also limits the agency from performing outreach for options like this. Today, CAT does not partner with any local technical, trade schools, or community colleges. The agency has worked with Disadvantaged Business Enterprises (DBE) as defined through the FTA; one of their most recent vehicle procurements was through a DBE.

When evaluating potential recruits for vehicle operator and mechanic positions, CAT considers various minimum qualifications in their hiring criteria. While a CDL is not mandatory for mechanics, having one is preferred. It is a requirement for mechanics to possess ASE certification. Obtaining a passenger endorsement on a driver's license in Wyoming necessitates converting a Class A, C, or D license to include the endorsement. CAT is only able to provide the training needed for Class C licenses to obtain passenger endorsement.

When examining CAT's hiring practices and recruitment methods, it is important to consider various factors, especially when comparing approaches for internal versus external hires. CAT tends to promote from within for part-time or full-time positions. For certain roles, positions are posted internally for a period before being posted externally. Part-time positions for bus operators are publicly posted from the start, but full-time positions are generally posted internally first before being opened to public applications if the position is not filled; this occurs very infrequently. CAT also partners with NeoGov and State workforce to post new open positions on the City's website, which are spread through 'word of mouth' among City staff.



Overall, CAT does not have plans to hire additional staff to support a fleet transition, but may be open to doing so based on the requirements and recommendations identified in this plan. If CAT's fleet size grows, it may be necessary for the staff base to expand to adequately maintain the vehicles and infrastructure and support the capabilities of the agency.

## **TRAINING NEEDS**

BEVs have systems that differ from the existing gasoline- and diesel-powered fleet, so additional training would be needed for staff working with the new technology. It is anticipated that Bus Operations Support staff, Bus Operations staff, and Bus Maintenance staff would take part in various training modules, as BEVs require some additional knowledge and skills to be operated and maintained efficiently and safely. CAT's Bus Operations Support staff would complete vehicle familiarization training to obtain an understanding of the BEVs. These trainings are typically offered by the vehicle OEM and completing these trainings is standard practice when new vehicles are introduced. It is generally recommended to purchase additional training from the OEM, and it would be advantageous for CAT to utilize a 'train the trainer' model when receiving the training. This would enable better knowledge transfer within the agency and reduce costs associated with sending staff to OEM trainings.

Bus Operations staff would need to complete driver trainings to learn to efficiently drive the BEVs, familiarize themselves with the sub-systems within them, and understand high voltage safety. Like with Bus Operations Support staff, it would be advantageous to utilize a 'train the trainer' model that enables CAT to conduct their own operator trainings in the future. Operators would need to be trained to drive BEVs differently than they do ICE vehicles to leverage the regenerative braking system in a way that maximizes battery efficiency and driving range. Operators should also be trained on the procedures for pulling the BEVs into the stalls where they would be charged. Operators would need to be familiarized with the camera, window, door, fire suppression, and fire detection sub-systems within the BEVs to provide efficient and safe operations. Finally, if the operators are tasked with charging the BEVs at a garage facility or pulling onto on-route charging spots, additional training should be conducted to ensure safety near high voltage systems.

Bus Maintenance staff would also need vehicle familiarization trainings. They would need to understand drive train theory, the on-board energy storage system, regular maintenance procedures, system diagnostics, troubleshooting, and repairs. Once this understanding is in place, Bus Maintenance staff would need to become high voltage certified. CAT's existing relationships with high voltage mechanics in the area might also be utilized for work specific to high voltage, while in-house staff are utilized for all other maintenance activities. Finally, mechanics would need to learn procedures for the proper use and inspection of personal protective equipment (PPE) and Lock-Out-Tag-Out (LOTO) procedures for BEVs. CAT should also consider the maintenance of any EVSE used to support the BEVs. Bus Maintenance staff may be tasked with maintaining the EVSE or coordinating repairs with the OEM(s).



If Casper Area Transit were to fully adopt BEVs and transition the fleet using Level 2 depot charging only, additional maintenance staff would be needed to support the 28 additional fleet vehicles. More drivers would also need to be hired to operate the additional vehicles and perform midday vehicle swaps. It is anticipated that at least 4 additional maintenance staff and 1 additional bus operator will be needed to support the expanded fleet in this scenario.

## **CASPER BEV TRAINING PROGRAM**

### **Training Practices**

When first adding any AFV to a fleet, it is often best practice to utilize OEM support, apply 'train the trainer' formats, and focus on training a subset of staff to work with the new vehicles. OEMs offer many resources (typically included with the vehicle purchase, while additional resources are available at an extra cost) to ensure that their vehicles are successful, and CAT should explore these options when purchasing a new vehicle. Training for vehicle and charging infrastructure maintenance should also be considered. It is typical for an agency to retain the vehicle maintenance in-house while another entity, such as the OEMs or local electricians, maintain the charging infrastructure. If it pursues a BEV fleet, CAT should consider purchasing extended warranties and preventative maintenance packages through the OEMs to ensure working order of equipment and minimize maintenance complexity for City Maintenance Department staff.

It is also helpful to focus initial training efforts on a subset of staff rather than all operations and maintenance staff. Transit agencies will typically add AFVs to their fleets over long periods of time, and it is not always necessary for all staff to become immediately specialized to work on the vehicles. Initial training efforts should focus on a subset of staff and use a 'train the trainer' format, where staff already trained can assist with training additional staff in the future.

Over time, CAT might work to develop a training program that integrates a BEV curriculum with its existing internal training program, including bus maintenance technical training and behind-the-wheel training. Technical training would need to include system familiarization and operations, safety, troubleshooting, diagnostics, rebuilding and repairs, and preventative maintenance.

Potential resources that might assist CAT in developing new training programs or revising existing ones include:

- Vehicle and charger OEM training curricula purchased as part of new rolling stock procurements,
- Vehicle sub-system and sub-component OEM training curricula,
- Partnerships with local first responding agencies,
- Memberships through training consortiums like the National Transit Institute (NTI), and





- Participation in transit associations like the American Public Transportation Association (APTA), Center for Transportation and the Environment (CTE), and Zero Emissions Bus Resource Alliance (ZEBRA).

If it chooses to begin an electric fleet transition, CAT should coordinate its training with local first responders. While a transit agency is not responsible for training local first responders, it is best practice to provide them training materials and work with them on-site to establish an emergency response plan. This ensures that, in case of emergency, the first responders are familiar with the facilities and vehicles.

### **Sample Training Program**

A sample training program related to BEVs that CAT could adopt is shown in **Table 19**. Note this is not an exhaustive list; additional coordination between CAT and the vehicle OEMs would be needed to confirm real-world training needs. If the training module is marked with an 'X', the training is required for the respective fuel type. Shown at the bottom are the total estimated hours of training required for each fuel type. BEVs are shown to require the lowest number of training hours (284 hours), followed by diesel vehicles (324 hours) and HEVs (364 hours). Most trainings are similar regardless of fuel type, but there are a few specialized trainings for each. BEVs will require high voltage training and training on the propulsion system, while diesel buses require trainings around transmissions and engine tune-ups that BEVs do not. HEVs require all the diesel vehicle trainings, but also require high voltage training similar to BEVs. Overall, the total number of training hours required for each fuel type are comparable.



**Table 19.** Sample BEV Training Program Hours

Role	Training Module	Time to Train (hours)	Applicable to Fuel Type?		
			Diesel	Battery Electric	Hybrid Electric
<b>Ops. Support</b>	Vehicle Familiarization and Systems Overview	8	x	x	x
	Advance Communication System	16	x	x	x
<b>Bus Ops.</b>	New Vehicle Bus Operator Orientation	4	x	x	x
	Sub-Systems Overview	32	x	x	x
	High Voltage Safety	16		x	x
<b>Bus Maint.</b>	Shop Safety and Procedures	16	x	x	x
	Fundamentals of Troubleshooting	16	x	x	x
	Basic Repair Skills	16	x	x	x
	HVAC Systems	16	x	x	x
	Air Brake Systems	24	x	x	x
	Hydraulic Brake Systems	8	x	x	x
	Steering and Suspension Systems	16	x	x	x
	Basic Electrical	24	x	x	x
	Multiplex Systems	24	x	x	x
	Low Voltage Systems Troubleshooting and Repair	16	x	x	x
	High Voltage Systems Troubleshooting and Repair	24	x	x	x
	Automatic Transmissions	24	x		x
	Diesel Engine Tune-Up and Troubleshooting	24	x		x
	Diesel Engine Electronic Control Systems	16	x		x
	Diesel Hybrid Propulsion Systems	24			x
	BEV Propulsion Systems	24		x	
<b>Total Training Hours</b>		<b>388</b>	<b>324</b>	<b>300</b>	<b>364</b>

### Staffing and Recruitment

Training for existing staff on BEV operations and maintenance for newly acquired vehicles will help avoid displacement of the current CAT workforce. If new vehicles require new skills, it is CAT's intention to train and/or promote existing staff before considering external labor. After training existing staff, there could be a need for additional staff to support BEV maintenance. If BEVs are introduced to the fleet, the



agency would reevaluate staffing needs on a rolling basis based on overall fleet growth. CAT may also need to approve additional mechanic positions if the City Maintenance Department determines they are necessary, with the goal of filling these positions internally before looking to external candidates or contracted labor.

## **FUNDING OPPORTUNITIES**

Training costs will likely fluctuate in response to the adoption of BEVs in CAT's fleet. Funding for workforce development can come from many sources, including vehicle procurement, where the cost of training can be included in the budgeted cost of the vehicle or infrastructure purchase; existing funding sources used for training; and/or federal or local funding shares, such as:

- The FTA Bus and Bus Facilities Grant Program – 5339(b)
- The FTA Low- or No-Emission Grant Program – 5339(c)
- The Congestion Mitigation and Air Quality (CMAQ) Infrastructure Law

The labor cost to train bus maintenance personnel is anticipated to be high, but the cost of training is only one aspect of total costs related to workforce development. As highlighted by the International Transportation Learning Center, budgeting should include costs related to classroom training hours, instructor hours, wages, and benefits, instructor costs per class and trainee, mentor hours, wages, and benefits, on-the-job training hours, facilities, and training materials, software, and simulations.



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# TRANSITION ROADMAP



## TRANSITION ROADMAP

Based on the energy modeling and financial analysis, it is not currently feasible to transition CAT's entire fleet to BEVs without risking service reliability and incurring significant capital costs. Rather than begin a complete conversion right away, there are strategies that CAT might consider to introduce a small number of BEVs into the fleet and gain real-world experience before committing to a full fleet transition. Two strategies are presented for consideration by the MPO and CAT as feasible—but not required—paths toward fleet electrification in Casper.

### FAST CHARGING WITH NEAR-TERM PILOT PROJECT

#### Pilot Project Overview

A pilot project to test on-route inductive fast charging technology in local conditions may be feasible in the near-term if the MPO leverages available Federal funding. The pilot project would build CAT experience operating BEVs and using wireless fast chargers that could be applied later to a larger electric transition. The pilot project would also build City maintenance staff expertise with BEV- and charging station-specialized maintenance practices.

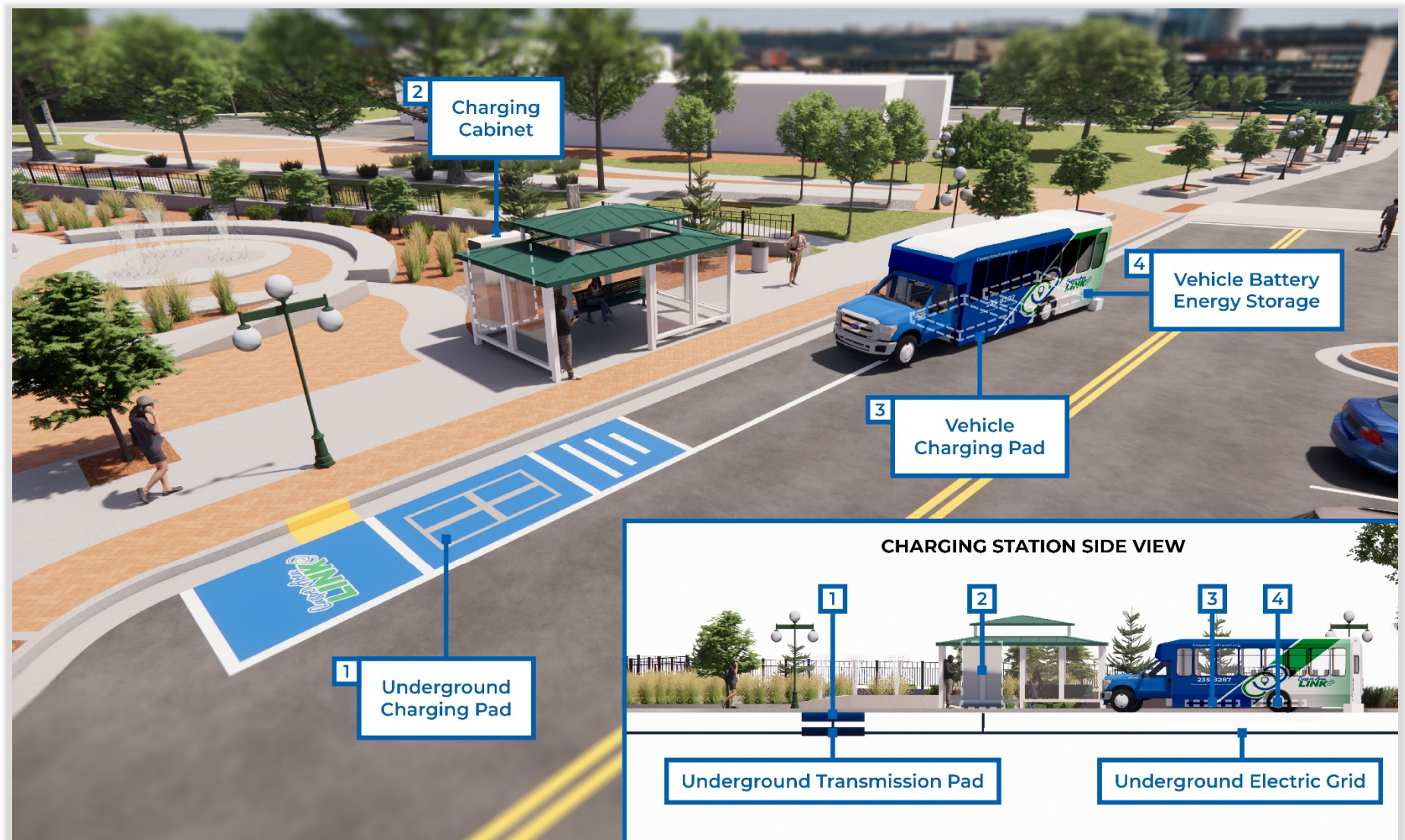
In the potential pilot program, CAT would replace two Ford E450s assigned to the Link service and one Ford Transit 3500 assigned to the Assist service with BEVs. One inductive fast charger would be installed at the Downtown Transfer Center for on-route fast charging and three Level 2 chargers would be installed at the Bus Garage Facility, either inside or under covered parking, for overnight charging. Multiple short top-offs or one extended (i.e., 30-minute) midday layover at the Downtown Transfer Center would need to be scheduled for the Assist vehicle so that it could complete its service day. This layover would need to be scheduled while the Link vehicles are completing a trip to avoid blocking the charger.

**Figure 11** illustrates above- and below-ground views of a potential fast charger at the Downtown Transfer Center, showing nearly no aesthetic impacts as most electrical infrastructure near Downtown Casper is located below the surface. Other than one charging cabinet, no above-ground infrastructure would be needed to support the pilot project. The charging cabinet would be strategically placed to avoid impacts to aesthetics and pedestrian flow, such as behind the existing bus shelter. **Table 20** summarizes the planning and implementation timeline for a potential pilot project. If the pilot project is successful, CAT may consider a full transition supported by fast charging during the day and Level 2 charging overnight. This would entail the installation of 3 more on-route fast chargers and 19 more Level 2 chargers to support a fleet of 22 BEVs. Discussions with RMP indicated there is ample power at all four proposed charging locations to support the associated power demand. CAT would need to coordinate with RMP throughout the pilot project to measure actual power requirements, ensure they are met, and confirm that optimal rates are applied.





**Figure 11.** Rendering of Potential Wireless Fast Charger at Downtown Transfer Center





**Table 20.** Potential Pilot Project Timeline

<b>2024</b>	<ul style="list-style-type: none"> <li>• Begin planning for pilot project</li> <li>• Obtain buy-in and approvals to execute pilot project</li> <li>• Determine exact vehicles to replace with BEVs <ul style="list-style-type: none"> <li>◦ Consider 2 Ford E450s on Link service in 2027</li> <li>◦ Consider 1 Ford Transit 3500 on Assist service in 2029</li> </ul> </li> <li>• Determine BEV make(s) and model(s)</li> <li>• Determine charger make(s) and model(s) <ul style="list-style-type: none"> <li>◦ Identifying OEM partners in grant applications can allow agencies to bypass the RFP process when applying for Federal funding</li> </ul> </li> <li>• Determine placement for on-route fast charger</li> <li>• Create budget for pilot project</li> </ul>
<b>2025</b>	<ul style="list-style-type: none"> <li>• Work with WYDOT to submit grant application(s) for FTA Low-No Program and/or FTA Bus and Bus Facilities grants <ul style="list-style-type: none"> <li>◦ More than \$1 billion in annual funding has been allocated to these programs through 2026</li> <li>◦ Based on previous funding cycles, it is anticipated applications would be submitted in Spring or Summer 2025; awards would be announced toward the end of that year</li> <li>◦ If the application is not successful, the MPO can apply again in 2026 before formula changes occur in 2027 under a new administration</li> </ul> </li> <li>• Order two vehicles and chargers after award to plan for up to two-year lead times for vehicles and one-year lead times for chargers</li> <li>• Begin coordinating with RMP to install a new transformer at the Downtown Transfer Center</li> </ul>
<b>2026</b>	<ul style="list-style-type: none"> <li>• Begin planning, design, utility coordination, permitting, construction, installation, and testing for charging infrastructure and transformers <ul style="list-style-type: none"> <li>◦ One wireless fast charger at the Downtown Transfer Center</li> <li>◦ Two Level 2 chargers (one per Link vehicle) at the Bus Garage Facility</li> <li>◦ Two new transformers (one at each facility)</li> </ul> </li> <li>• Conduct route planning to ensure BEVs operate on same or complementary service routes</li> </ul>
<b>2027</b>	<ul style="list-style-type: none"> <li>• Finish installing charging infrastructure</li> <li>• Receive vehicles from OEMs</li> <li>• Conduct standard testing and commissioning of all vehicles and chargers</li> <li>• Begin workforce development activities</li> <li>• Initiate transit service with pilot BEVs</li> </ul>

### Opportunities and Risks

There are several opportunities presented by the pilot project. It would offer CAT the ability to gain experience operating BEVs without committing to a full transition in the near term and enable CAT to test wireless charging technologies against its specific service profiles and local conditions, such as cold weather and terrain. The environmental benefits of BEVs are significant. They reduce emissions of harmful pollutants and GHGs that contribute to climate change and poor health—even when



considering the emissions produced during the battery manufacturing process—and use their stored energy more efficiently than traditional gasoline- and diesel-powered engines.

There are a few potential risks of operating a BEV pilot program specific to CAT and the vehicles it operates. The electric cutaway market is not as developed as the full-size electric transit bus market, but technological advancements are expected in the coming years. Battery technology for cutaway vehicles could advance rapidly, potentially making Level 2 depot charging feasible and negating the need for on-route inductive charging. However, it is impossible to predict the exact nature and timeline of these technological advancements.

Piloting a relatively new and unproven technology may result in operational and maintenance concerns based on CAT's current staffing levels and capabilities. There is also a risk associated with timely OEM support in remote areas like Casper. BEV and charger OEMs typically offer service agreements and warranties that help agencies maintain their vehicles and charging stations. Many OEMs have employees located nationwide, but they are largely concentrated in major urban areas. When a vehicle or charging station experiences an issue that requires OEM support, it could take longer for the OEM employee to travel to Casper. CAT may consider more robust training for in-house staff to mitigate the risk of longer repairs and down times, or wait to begin a pilot project until OEMs can offer timely support in the country's remote areas.

## **DELAYED TRANSITION WITH DEPOT CHARGING**

CAT may consider BEVs to be a more feasible option as prices fall and technologies continue to improve in a way that makes relying entirely on Level 2 depot charging feasible and negates the need for on-route midday fast charging. Conversations with RMP indicate that there is ample energy available to support the electrification of CAT's fleet, but the energy analysis showed the fleet size would need to more than double to maintain current service levels. While energy is not a barrier, extreme cold weather conditions and long routes present unique challenges that limit current opportunities for electrification in Casper.

In response to the limitations of today's battery electric cutaways, CAT may consider several market indicators to assess the state of the industry and determine the correct time to reevaluate BEVs for its fleet moving forward. It is important to note that these indicators are not intended to prompt the immediate pursuit of BEVs; rather, they should be used as indicators to revisit this plan with new information.

## **Financial Indicators**

BEV purchase prices similar to those of their ICE equivalents can help make full BEV fleet transitions more feasible for local transit agencies. According to BloombergNEF, 'price parity', or the point at which electric and ICE vehicles can be sold at the same price while maintaining the same margins for the OEMs, is anticipated to be reached





when battery pack prices fall to about \$60 per kWh.<sup>9</sup> BloombergNEF expects this inflection point to be reached in 2029.

Until BEV and ICE vehicle purchase prices are equal, government programs, such as federal grants or tax credits, can help reduce the financial burden associated with an electric fleet transition. With adequate grant funding, the cost of purchasing a BEV could be made comparable to an ICE vehicle today. However, it is often the charging infrastructure that creates additional upfront costs. CAT might reevaluate the feasibility of BEVs when purchase prices are similar to those of ICE vehicles or when available funding programs can adequately mitigate or negate the cost differential.

### Technology Indicators

Increases in the charge speeds and/or battery storage capacities of battery electric cutaways, both likely to occur over the next decade, could make relying entirely on Level 2 charging more feasible for CAT's fleet. Moderate improvements in both indicators, or significant improvement in just one indicator, could trigger the MPO and CAT to reconsider a full transition to BEVs. For example, increased charge speeds may enable more routes to be electrified using on-route fast charging during the service day. Alternatively, if battery storage capacity significantly increases and market-available vehicles have enough range to complete a service day, Level 2 depot charging may adequately support CAT's service levels. A mixed scenario, where charge speeds and battery storage capacity both moderately increase, might also trigger a reevaluation of BEVs and the magnitude of charging infrastructure needed to support them.

#### BEV Technology Improvement Indicators

**250** kW Charge Speed  
kWh of Battery Storage  
Miles of Range

The benchmarks provided below assume one indicator is met while the other stays consistent with today's technology. Meeting either (or both) indicators may prompt CAT's reevaluation of BEVs.

- **Charge Speed Improvements**

CAT might reevaluate BEVs for its fleet once market-available battery electric cutaways can accept a 250-kW fast charge, at which point the energy analysis showed all routes could be operated interchangeably using BEVs. Changes to service routes could change this threshold; but, based on existing service profiles, a fast charge speed of 250 kW can be used as a benchmark to indicate that technology has developed enough for CAT to revisit a full transition with a BEV fleet that relies primarily on on-route fast charging.

- **Battery Storage Capacity and Driving Range**

CAT might also reevaluate BEVs for its fleet once battery storage capacities approach 250 kWh and/or driving ranges approach 250 miles. Today's 40-foot

<sup>9</sup>. BloombergNEF: <https://about.bnef.com/blog/the-ev-price-gap-narrows/>



battery electric transit buses have battery capacities of 250 kWh to 650 kWh, but the battery capacities of battery electric cutaways on the market range from just 75 kWh to about 160 kWh. Increased battery capacities and driving ranges are likely to make BEVs more feasible for CAT service. Assuming BEVs continue to operate with the same energy efficiency, a battery capacity of 250 kWh would likely yield a range of about 250 miles, which would be adequate based on CAT's current service profiles. These values can serve as benchmarks indicating technology has developed enough such that a BEV fleet could rely entirely on Level 2 depot charging.





## CONCLUSION

In response to the growing market for BEVs and continued allocation of State and Federal funds for fleet electrification projects, the Casper MPO in conjunction with CAT have developed a plan for a potential transition to BEVs. The incorporation of BEVs in public transit fleets reflects a national trend to modernize fleets, reduce harmful GHG emissions, and promote a cleaner, more environmentally friendly service to local communities. Developing this plan prepares the MPO to pursue Federal funding opportunities, such as those allocated by the FTA, when it is ready. Leveraging funding opportunities like this can greatly reduce the financial burden being placed on many local agencies electrifying their fleets.

Stakeholder engagement and an understanding of local conditions in Casper were integral in developing this plan, which identifies feasible approaches to fleet electrification that are specific to Casper's priorities and challenges. The extreme cold experienced in Casper, for example, can significantly impact the driving range of today's BEVs. These challenges were incorporated in an analysis of the energy requirements of an electric fleet, which identified that today's BEVs would be unable to complete a full day of CAT service. CAT's fleet would need to more than double in size to begin a fleet transition immediately, incurring logistical concerns, operational impacts, staffing increases, and significant costs related to a combination of vehicle purchases, charger installations, and facility reconfigurations.

Rather than recommend an immediate transition to BEVs, this plan identifies two potential strategies that could be adopted to introduce them to the CAT fleet over a longer period of time. The first strategy involves a near-term pilot project that would replace two Link vehicles and one Assist vehicle with electric alternatives by the end of 2027. One wireless inductive fast charger would be installed at the Downtown Transfer Center for on-route top-offs, and three Level 2 chargers would be installed at the Bus Garage Facility for overnight charging. Conducting a pilot project would allow CAT to gain experience operating BEVs and test new charging technologies against specific local conditions and operational constraints. However, while this pilot may be feasible, it presents some operational risks and incurs higher up-front costs. The pilot would utilize relatively new technology in extreme weather, and Casper's rural location could present challenges if support is needed from the vehicle and/or charger OEMs. CAT would also need to consider adjusting service, which may require additional operator hours and detailed planning. Lastly, funding the pilot may require significant grant funding to be financially viable for CAT.

The second strategy involves delaying the start of a potential fleet transition until certain market indicators have been met that indicate technology has improved such that an all-electric fleet is feasible in Casper. These indicators are not meant to prompt the immediate pursuit of BEVs, but rather serve as a guide to reevaluate their use with new information. The final decision must consider stakeholder and public input, financial considerations, and workforce development needs such that CAT's fleet can be modernized without leaving anyone behind.