MAINE
CLEAN TRANSPORTATION ROADMAP FOR MEDIUM- AND HEAVY-DUTY VEHICLES

Case Study: Fleet 1—Pine State Trading

prepared for

GOVERNOR'S OFFICE OF Policy Innovation and the Future

MaineDOT

MAINE GOVERNOR'S Energy Office

prepared by

CAMBRIDGE SYSTEMATICS

CALSTART

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SUMMARY

Fleet 1, Pine State Trading, is a regional beverage distributor whose fleet conducts last-mile delivery operations of beer, wine, liquor, and non-alcoholic beverages throughout the State of Maine. Pine State Trading's fleet domiciles at sites in Bangor and Gardiner. Their fleet consists of three cargo vans, nine Class 6 trucks, two Class 7 trucks, and 57 Class 8 trucks.

Pine State Trading's fleet travels between 55–130 miles per day and returns to either the Bangor or Gardiner site to domicile for 11 hours overnight. This duty cycle is well-suited to electrification, since the range fits what electric models offer and there is ample time to fully charge overnight. Pine State Trading's Class 7 and Class 8 vehicles would require fast charging (Level 3), while the others can be charged using Level 2 charging.

Total cost of ownership analyses were performed for each vehicle class in Pine State Trading's fleet, across an assumed lifespan of 12 years and taking into account available incentives in addition to purchase, infrastructure, and operational costs. Pine State Trading's cargo vans and Class 6 trucks produced favorable total cost of ownership (TCO) projections, making them excellent near-term candidates for electrification. Their Class 7 and 8 trucks did not produce favorable TCO projections, though incentives got them much closer to reaching cost parity to traditional models. These vehicles are still great longer-term candidates for electrification due to their well-suited duty cycle and use case.

INTRODUCTION

The Maine Clean Transportation Roadmap for Medium- and Heavy-Duty Vehicles ("roadmap") charts a path for Maine to decarbonize the trucks and buses moving people and goods within and through the state. As part of the roadmap, the project team has conducted a series of case studies with Maine businesses to identify real world opportunities and challenges for fleet electrification. The case studies are intended to 1) serve the participating fleets by providing customized fleet electrification assessments; and 2) augment the roadmap by evaluating electrification use cases, total cost of ownership, and barriers in the context of actual Maine business operations.

Fleet Information

Pine State Trading has 62 vehicles that are used for last-mile delivery of beer, wine, liquor, and non-alcoholic beverages. Vehicles are housed at two locations: their main warehouse in Gardiner and their cross-docking location in Bangor. Trucks are dispatched for deliveries or product transport from one of these two locations. The vehicles operate beginning at 5:00 a.m. daily and domicile for 11 hours overnight. Table 1 shows an inventory of the fleet.

TABLE 1 FLEET 1 VEHICLE INVENTORY

Vehicle Group	Vehicle Quantity	Vehicle Class	Fuel Type	Manufacturing Year (average)	Average Annual Miles	Owned or Leased Vehicles
Mack Pinnacle gf\Tractor	13	Class 8—Over 33,000 lbs.	Diesel	2016	28,000	Owned
Mack Anthem Tractor	27	Class 8—Over 33,000 lbs.	Diesel	2022	30,500	Owned
Western Star Straight Truck	3	Class 8—Over 33,000 lbs.	Diesel	2018	21,500	Owned
Peterbilt Straight Truck	1	Class 6—19,501—26,000	Diesel	2022	19,000	Owned
GMC Savanna/ Ford Transit Van	3	Class 2—6,001—10,000	Gas	2018	14,000	Owned
Freightliner Straight Truck	1	Class 6—19,501—26000 lbs.	Diesel	2016	11,000	Owned
Western Star Straight Truck	14	Class 8—Over 33,000 lbs.	Diesel	2020	26,000	Owned
Hino/ International Straight Truck	2	Class 7—26,001—33,000 lbs.	Diesel	2018	15,000	Owned
Hino Straight Truck	3	Class 6—19,501—26,000	Diesel	2021	19,000	Owned
Mack MD Straight Truck	4	Class 6—19,501—26,000	Diesel	2022	20,000	Owned

Vehicle Recommendations

To adequately define the needs of a fleet, the vehicles used are categorized into duty cycles. Duty cycles are classifications that describe both the *vehicle*, by type and class, and *how it is operated*, including typical miles traveled, type of use (local versus highway), and fuel consumption.

Vehicle recommendations are not exhaustive of all options that may be on the market; selections are included based on those most likely to meet Pine State Trading's duty cycles.

GMC Savanna/Ford Transit Van

Pine State Trading operate three Ford Transit or GMC Savanna vans that drive an average of 55 miles per day and dwell for 11 hours overnight. One of these vehicles domiciles at their Bangor Cross Dock and the other two domicile at their Primary Warehouse in Gardiner. All recommendations can meet Pine State's current duty cycle, though the Logistar 300 would require Level 3 charging to do so within its scheduled dwell time. Recommended replacement options are shown in Table 2.

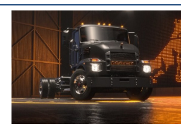
TABLE 2 VAN ELECTRIC REPLACEMENTS

Make	Brightdrop	Rivian	Ram	Mercedes- Benz	Ford
Model	Zevo 600	Delivery 500	Promaster EV	eSprinter	E-Transit
Availability	Now	Now	Now	Now	Now
Class/Size	Class 3	Class 2b	Class 1	Class 2b	Class 2b
Range	250 miles	150 miles	100 miles	248 miles	125 miles
Payload	3,230 lbs.	2,734 lbs.	3,020 lbs.	2,600 lbs.	3,880 lbs.
Energy Capacity	173 kWh	N/A	110 kWh	113 kWh	68 kWh
Level 2 Charging Time	10 hours	N/A	10.5 hours	12 hours	8 hours
Website	Zevo	Delivery 700	Promaster EV	eSprinter	E-Transit
Vehicle Photo					

Class 6 Straight Truck

Pine State Trading operate nine Class 6 straight trucks that drive an average of up to 78 miles per day and dwell for 11 hours overnight. Two of these vehicles domicile at their Bangor Cross Dock and the other seven domicile at their Primary Warehouse in Gardiner. All recommendations can meet Pine State's current duty cycle; even though several recommendations' charging times extend past the 11-hour dwell time, the vehicles can likely charge enough in 11 hours to meet the daily mileage needs using Level 2 charging. Recommended replacement options are shown in Table 3.

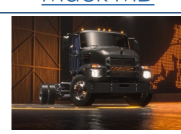
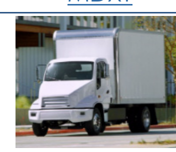
TABLE 3 CLASS 6 STRAIGHT TRUCK ELECTRIC REPLACEMENTS

Make	Freightliner	Lion	Mack	Peterbilt	XOS
Model	eM2	Lion6	MD Truck	220 EV	MDXT
Availability	Now	Now	Now	Now	Now
Class/Size	Class 6	Class 6	Class 6	Class 6	Class 6
Range	180 miles	218 miles	230 miles	200 miles	270 miles
Payload	13,020 lbs.	33,000 lbs.	19,400 lbs.	10,000 lbs.	20,000 lbs.
Energy Capacity	194 kWh	252 kWh	240 kWh	282 kWh	N/A
Level 2 Charging Time	11 hours	14.5 hours	14 hours	15 hours	N/A
Website	eM2	Lion6	Mack MD	220 EV	MDXT
Vehicle Photo					

Class 7 Straight Truck

Pine State Trading operate two Class 7 straight trucks that drive an average of 59 miles per day and dwell for 11 hours overnight at their Primary Warehouse in Gardiner. Most Class 6 recommendations are also available as a Class 7 build, with the addition of the Kenworth K370E. All recommendations can meet Pine State's current duty cycle using DC fast charging, which is typically used by Class 7 trucks. Table 4 shows recommended replacement options.

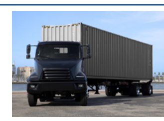
TABLE 4 CLASS 7 ELECTRIC TRUCK REPLACEMENTS

Make	Freightliner	Kenworth	Mack	Peterbilt	XOS
Model	eM2	K370E	MD Truck	220 EV	MDXT
Availability	Now	Now	Now	Now	Now
Class/Size	Class 7	Class 7	Class 7	Class 7	Class 7
Range	180 miles	200 miles	230 miles	200 miles	270 miles
Payload	13,020 lbs.	17,500 lbs.	19,400 lbs.	10,000 lbs.	20,000 lbs.
Energy Capacity	194 kWh	282 kWh	240 kWh	282 kWh	N/A
Level 3 Charging Time (350 kW)	1 hour	1 hour	1 hour	1 hour	N/A
Website	eM2	K370E	Mack MD	220 EV	MDXT
Vehicle Photo					

Class 8 Trucks

Pine State Trading operate 57 Class 8 trucks that drive an average of up to 130 miles per day and domicile for 11 hours overnight. 15 of these trucks domicile at their Cross Dock in Bangor and 42 domicile at their Primary Warehouse in Gardiner. All recommendations can meet Pine State's current duty cycle using DC fast charging, which is typically used by Class 8 trucks. Table 5 shows recommended replacement options.

TABLE 5 CLASS 8 ELECTRIC TRUCK REPLACEMENTS

Make	BYD	Freightliner	Tesla	XOS	Nikola	Volvo
Model	8TT	eCascadia	Semi	HDXT	TRE BEV	VNR Electric
Availability	Now	Now	Coming Soon	Now	Now	Now
Class/Size	Class 8	Class 8	Class 8	Class 8	Class 8	Class 8
Range	200 miles	230 miles	500 miles	230 miles	350 miles	275 miles
Payload	78,765 lbs.	60,000 lbs.	44,000 lbs.	56,000 lbs.	40,000 lbs.	66,000 lbs.
Energy Capacity	422 kWh	438 kWh	1000 kWh	N/A	753 kWh	565 kWh
Level 3 Charging Time (350 kW)	1.5 hours	1.5 hours	1 hour (Using Tesla Semi Charger)	N/A	2.5 hours	2 hours
Website	8TT	eCascadia	Semi	HDXT	TRE BEV	VNR Electric
Vehicle Photo						

CHARGING AND INFRASTRUCTURE

Fleet Electrification Overview

Fleet electrification involves coordination between the fleet and their electric utility, contractors, developers, vehicle original equipment manufacturers, and electric vehicle service providers to determine the power, quantity, and arrangement of electric vehicle supply equipment (EVSE), or vehicle charging, for a particular site. Once vehicle quantity and duty cycles are defined, the quantity and power of EVSE needed can be determined. In most fleet charging configurations, it is typical to install one dedicated charging plug per electric vehicle (EV). This is to support overnight charging, when electricity rates are low and vehicles are ordinarily not in operation; overnight charging typically lends itself to less costly EVSE due to the lower power usage required to charge a vehicle over a long dwell time. For use cases with higher energy needs and/or less available dwell time for charging, higher-power chargers may be required to meet the energy needs of EVs.

Regardless of the quantity or power of charging equipment, it is important to keep in mind the additional space necessary for charging dispensers, transformers, and other considerations which may change a site's traffic pattern or "flow."

It is recommended that any chargers installed are networked, which means they include the capability to communicate over cellular networks. Most businesses choose to install networked chargers, due to access control, ensuring that only the fleet's service vehicles can charge at these chargers. Alternatively, fleets can install "behind the fence" non-networked charging in a secure location only accessible to fleet vehicles, assuring the same charging restrictions and availability. However, networked chargers can provide a bevy of technical information, including duration of charge and charge rate, useful for operational planning and decision- making.

Inductive (wireless) charging equipment, which uses an electromagnetic field to transfer electricity to an EV without a cord, is now commercially available as an aftermarket add-on, and has the potential to support rapid medium- and heavy-duty vehicle (MHDV) charging at depots and in warehouse environments where trucks park for extended periods of time, such as loading bays.

Spreading a charging schedule across as many hours as possible will often lead to the lowest capital and operational cost; thus, it is important to weigh various charging solutions against business needs. The next section describes in greater detail some solutions for how this can be addressed.

Charging Equipment

EV charging equipment is classified by battery charging rates. Time to charge will vary depending on battery state of charge, total energy storage, the type of battery, and the type of charging equipment. Charging time can range from less than 20 minutes to 20 hours or more, depending on these factors.

There are three types of charging: Level 1, Level 2, and Level 3 (direct current or DC fast). Level 1 charging is the slowest method and uses a standard alternating current (AC) wall outlet. It adds 2 to 5 miles of range per hour of charging. Because of its slow rate, Level 1 charging is typically only used at home for personal vehicles or workplaces. Level 2 is another AC method that is significantly faster than Level 1. Level 2 is the most common method of charging as it allows most light- and medium-duty vehicles to charge overnight while also being significantly cheaper and easier to install than Level 3 chargers. Level 2 chargers are most commonly found serving commercial vehicles and in public places like parking garages, shopping centers, and tourist attractions. Level 3 DC fast charging is the fastest method of charging, but also the most expensive for both the charger and infrastructure required. These chargers are typically only recommended for heavy-duty trucks and vehicles that dwell for a few hours or less.

Across the United States, there are four major plug types: J1772 ("J-plug"), Tesla (also known as North American Charging Standard or NACS, or SAE J3400), CHAdeMO, and CCS.

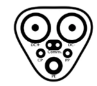
- The J1772 standard is used for Level 1 and 2 AC charging.
- Tesla is used for Level 2 and 3.
- CHAdeMO and CCS are used primarily for Level 3 DC fast charging.

While other proprietary plugs exist for MHDVs, these four represent the majority of those in use. The U.S. Department of Transportation National Electric Vehicle Infrastructure (NEVI) Program has standardized federally funded plugs across Level 2 and Level 3 charging, helping build out a national network of publicly-available charging equipment with predictable plug configurations.

In 2022, Tesla opened its previously proprietary charging standard to other EV manufacturers. In the coming years, its NACS will become the most prevalent charger connection. This connector is also referenced as SAE J3400. All connector types are shown below in Figure 1, but fleets should anticipate a growing share of vehicle options to utilize the NACS standard.

Industry leaders have introduced the concept of the Megawatt Charging Solution, designed to provide higher levels of power needed by MHDVs over a shorter period of charging time. Megawatt chargers require significant infrastructure investment (1–3 million volt-amperes or MVA) and may allow for faster adoption of EVs for long-haul trucking. However, most local and regional delivery businesses can be supported by Level 2 or DC fast chargers.

FIGURE 1 TYPES OF CHARGERS

Type	Level 1 Charging	Level 2 Charging		Level 3 DC Fast Charging			Megawatt
Connector	 J1772	 J1772	 Tesla/ NACS/ SAE J3400	 CHAdeMo	 CCS	 Tesla/ NACS/ SAE J3400	 MCS
Voltage	120 V AC	208–240 V AC		400 V–1000 V DC			1–3 kV A
Power Output	1 kW	7 kW–19 kW		50–350 kW			900 kW+

Managed Charging

Energy management can greatly decrease operational costs associated with fleet electrification. Managed charging, sometimes called "smart charging," entails the purchase and use of EVSE that can actively track and modulate charging, and a subscription for energy management software provided by the EVSE manufacturer or network provider to keep consumption levels within a predetermined range. While there are additional up-front and monthly costs associated with these technologies, their long-term benefits should also be considered from a total cost of ownership perspective.

Depending on the design of local electricity rates, electricity pricing can be based upon the time of day during which electricity is used, where marginal pricing is greater during times of high demand and lower when strain to the grid is at its lowest. Fleets may also be exposed to demand charges, which are increased electricity chargers incurred from large, simultaneous power draws—such as when multiple heavy-duty trucks plug into fast charging at the same location at the same time. However, charging when electricity costs are lowest is not always feasible or operationally convenient for fleets. Managed charging software automates charging to coincide with dwell times while enabling fleets to benefit from lower electric rates and/or mitigating demand charges.

Pine State Trading could utilize managed charging at both of their domicile locations due to their vehicles having extended downtime (11 hours). This could allow them to charge the vehicles using less equipment rather than procuring one charging port per vehicle.

On-Route versus Depot Charging

Most commercial EV deployments currently in operation rely solely on depot charging, or a "return-to-base" schedule where a fleet keeps vehicles parked at one location owned/leased by the organization operating those vehicles. While policy efforts and Federal funding are advancing the development of strategically sited on-route fast charging and public charging hubs, it is recommended that current EV deployments plan for on-site depot charging, where feasible.

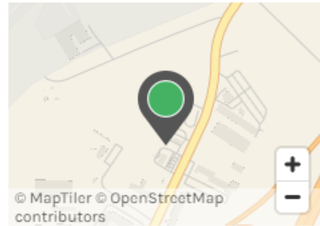
The Alternative Fuels Database, provided by the U.S. DOE, includes a tool to find publicly available charging stations, as does the similar PlugShare tool. Users can also map a route, similar to Google Maps, and see all charging stations along the route. These tools compile data from many networks of charging stations, such as ChargePoint, Electrify America, EVgo, and Tesla. By clicking on a charging station, one can view the number of available charging ports, as well as the type of charging connector.

It is important to note that not all charging stations listed on these sites will be appropriate for charging MHDVs. Most Class 2b and Class 3 vehicles will be able to use charging stations designed for light-duty vehicles, but Class 4–8 vehicles are often too large for typical light-duty vehicle parking spaces, and may require higher power levels to recharge quickly. It is anticipated that most public charging stations for medium- and heavy-duty trucks will require power levels of 150–350kW or more per port, paired with pull-through charging stalls and ample clearance. These may not be available at stations that appear in the DOE or PlugShare tools.

Few DC fast chargers are currently available on-route, and those that do exist may not be able to accommodate a Class 8 truck. The network of available chargers will continue to grow, however; active chargers and hours of operation are updated in these tools on a monthly basis. An example charger that would be convenient for Pine State is shown in Figure 2.

FIGURE 2 ALTERNATIVE FUELS DATABASE DETAILED CHARGER INFORMATION

IRVINGOIL ME-BNGR-L3-0002



301 Odlin Rd
Bangor, ME 04401

Directions

Chargers located in right rear of gas station

888-758-4389

Public

24 hours daily

Electric Vehicle Charging

Connectors: CHAdeMO CCS

EV Charging Ports: 1

Charging Port Details				
Charger Type	Ports	Connectors	Power Output	Network
DC Fast	1	CHAdeMO: 1 CCS: 1	CHAdeMO: 62.5 kW CCS: 62 kW	ChargePoint

Public chargers such as ChargePoint or EVgo typically require that drivers use a mobile application to interact with the charger and pay for their charge, either through the app itself, or with a credit card at the charger. In 2023, the NEVI program introduced standards for future EVSE installation including provisions that stations must implement non-proprietary charging ports, accept open-access payments such as pay by phone or contactless credit/debit card, be located along designated FHWA Alternative Fuel Corridors, and be publicly available.

Fueling/Charging Cost Analysis

A charging analysis was performed for electrification scenarios for Pine State Trading using CALSTART's Charging Infrastructure Optimization (CHARIOT) Tool. The CHARIOT tool aims to optimize the fleet's charging schedule, to find a schedule that works well with fleet operations while achieving lowest possible energy cost. It also provides a projected energy flow of a fleet's energy consumption and, when applicable, potential for on-site energy generation (e.g., solar power with battery storage) to get a sense of a site's energy independence and grid reliance. Pine State Trading's electricity is provided by Central Maine Power (CMP) at their Gardiner and Augusta sites and by Versant at their Bangor site.

The CHARIOT tool was used twice for Pine State Trading's Gardiner and Bangor sites: once using CMP and Versant's high peak time-of-use (TOU) rate ($3.55/kWh) and once using a flat TOU rate ($0.12/kWh).

Daily Charging Load Profiles

Figure 3 and Figure 4 show what daily charging profiles (energy demand by hour) might look like for this fleet, for all vehicles and excluding Class 8 vehicles, respectively. Class 8 vehicles are excluded in the second example due to their significant impact on load; Pine State could consider starting electrification with their Class 2b and Class 6 vehicles only. The peak loads calculated with all vehicles are 810 kW for the Bangor site and 2,320 kW for the Gardiner site. The peak loads calculated excluding Class 8 vehicles are 60 kW for the Bangor site and 220 kW for the Gardiner site.

FIGURE 3 DAILY CHARGING LOAD PROFILES—ALL VEHICLES

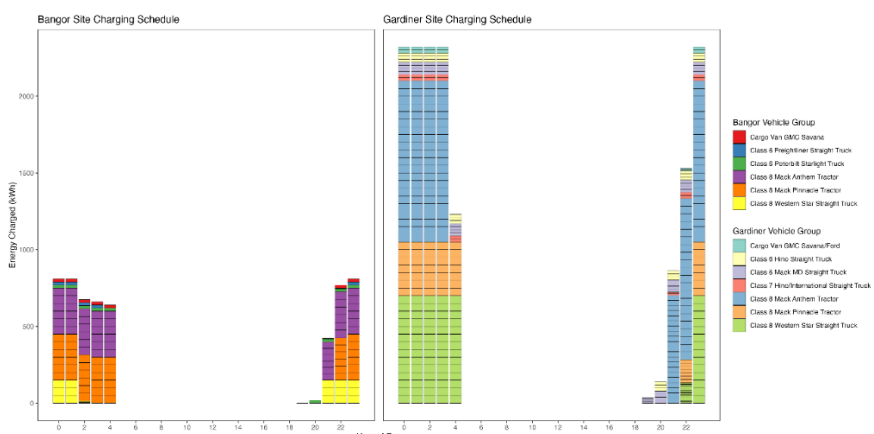
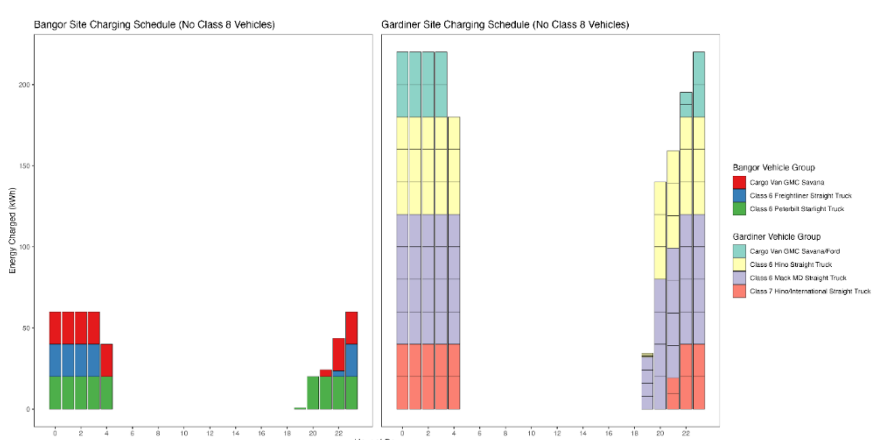


FIGURE 4 DAILY CHARGING LOAD PROFILES—EXCLUDING CLASS 8 VEHICLES



The following figures show total annual energy costs for the base vs. replacement electric vehicle, at each location and under the two electricity pricing scenarios.

The Bangor site—flat TOU rate scenario models a flat time of use rate of $0.118/kWh and compares with a $3.70/gallon cost of diesel. Figure 5 compares the annual energy usage for diesel and electric vehicles, while Figure 6 models the cost per mile for each vehicle type. Based on the anticipated energy needs of 18 electric vehicles at the Bangor site compared to 18 gasoline/diesel vehicles, Pine State Trading is estimated to achieve significant reductions to their annual energy costs and cost per mile of operation.

FIGURE 5 BANGOR—FLAT TOU RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

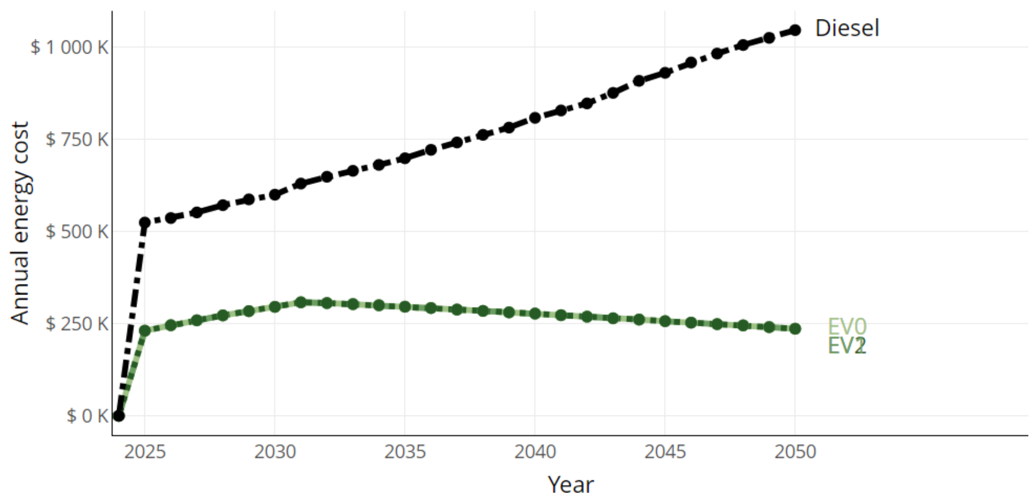
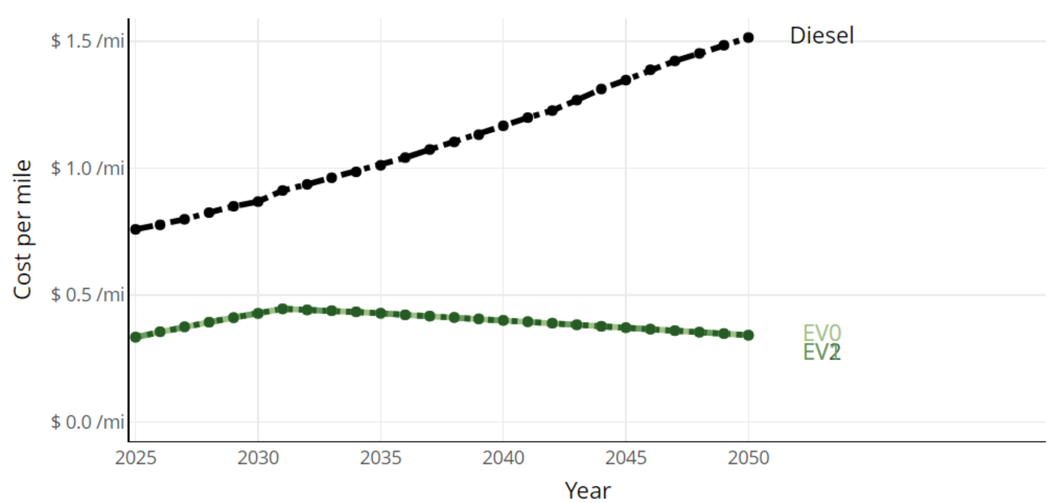


FIGURE 6 BANGOR—FLAT TOU RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



The Gardiner site—flat TOU rate scenario models a flat time of use rate of $0.118/kWh and compares with a $3.70/gallon cost of diesel. Figure 7 compares the annual energy usage for diesel and electric vehicles, while Figure 8 models the cost per mile for each vehicle type. Based on the anticipated energy needs of 53 electric vehicles at the Bangor site compared to 53 gasoline and diesel vehicles, Pine State Trading is estimated to achieve significant reductions to their annual energy costs and cost per mile of operation.

FIGURE 7 GARDINER—FLAT TOU RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

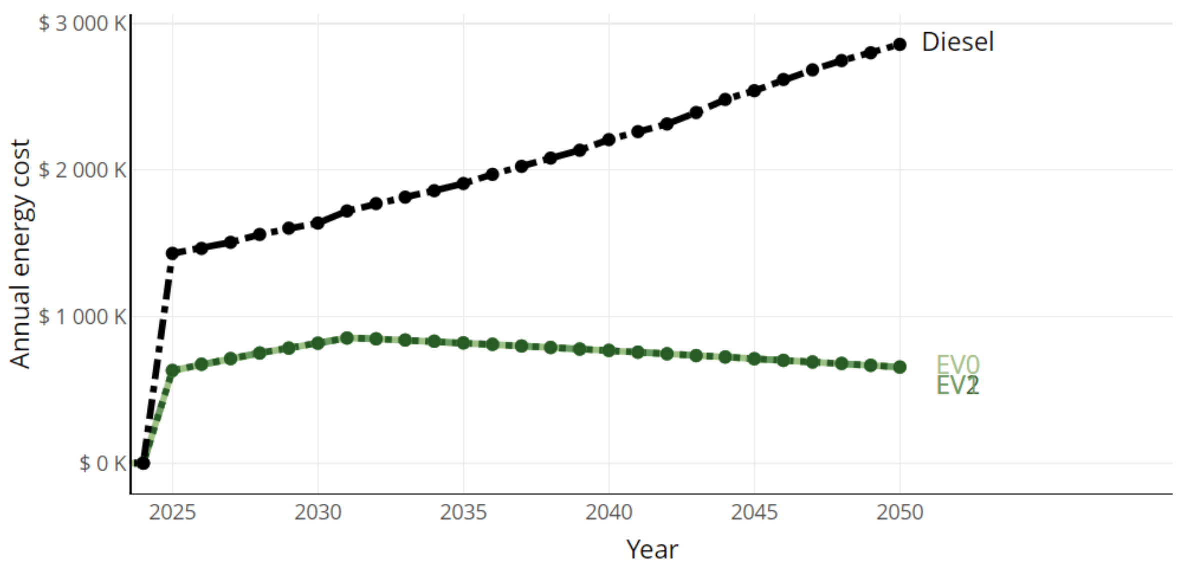
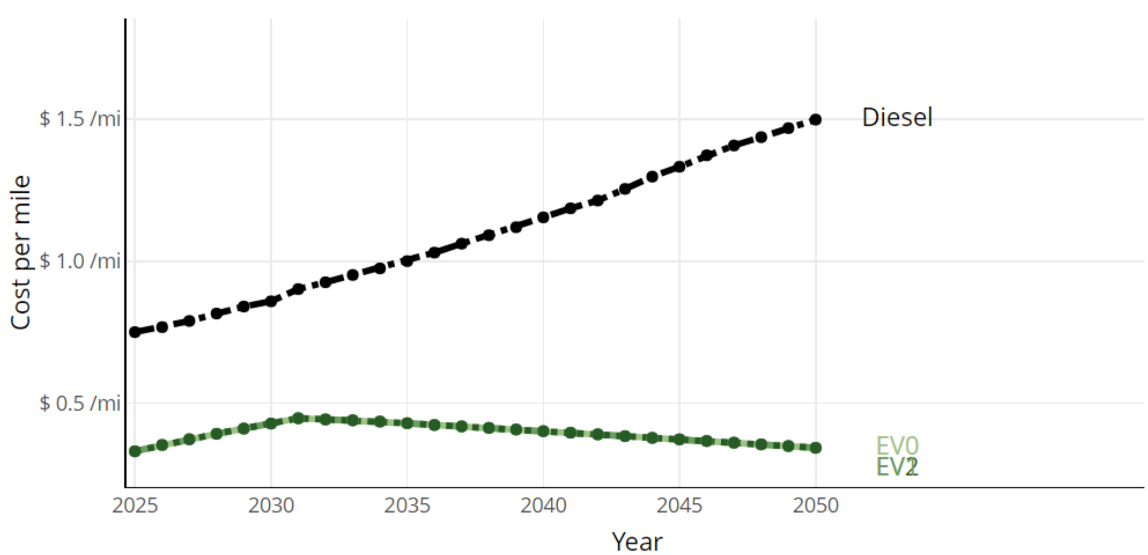


FIGURE 8 GARDINER—FLAT TOU RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



EVSE FINANCING

Federal Incentives

Commercial Clean Vehicle Tax Credit

The Federal Government's adoption of the Infrastructure Reduction Act (IRA) enacted new Federal tax credits (IRC Section 45W) for commercial clean (electric or hydrogen fuel cell) vehicles in 2022. Eligible entities include businesses and tax-exempt organizations that purchase commercial clean vehicles between January 1, 2023, and before January 1, 2033. Heavy-duty vehicles with a gross vehicle weight rating of 14,000 lbs. or greater are eligible for a tax credit up to $40,000, or 30 percent of the incremental cost of the vehicle as compared to a gasoline or diesel vehicle, whichever is lower. Applicable electric vehicles must have a battery with at least 15 kWh of capacity and be made by a qualified manufacturer (see the IRS's list for examples). For tax exempt entities, such as schools, governments, or non-profit organizations, the tax credit is available through a mechanism commonly known as direct, or elective, pay.

Alternative Fuel Infrastructure Tax Credit

Beginning on January 1, 2023, installation of EV charging equipment is eligible for a tax credit of 30 percent of the installation costs (or 6 percent in the case of property subject to depreciation), not to exceed $100,000. Permitting and inspection fees are not included in covered expenses. As above, tax-exempt entities are eligible to claim these credits through direct or elective pay.

These tax credits are only available to business locations and tax-exempt entities with the following census tract requirements:

» A population census tract where the poverty rate is at least 20 percent.

» Metropolitan and non-metropolitan area census tract where the median family income is less than 80 percent of the State median family income level.

Fleets should work with their charging infrastructure installers to determine eligibility by identifying their census tract using this tool and determining if it is included in the IRS's list. If eligible, tax form 8911 should be completed.

State Incentives

Efficiency Maine Medium- and Heavy-Duty Vehicle Incentive Pilot

In October 2024, the quasi-state agency Efficiency Maine Trust launched a pilot program to demonstrate potential use cases and performance of zero-emission MHDVs in Maine. Awards will be issued in three rounds, with applications open through the end of February 2025, with the possibility of further rounds of funding in the future. In order to be eligible, applicants must be based in Maine and already own a Class 3 to 7 vehicle in their fleet. The maximum award for different vehicle classes is shown in Table 6.

TABLE 6 EFFICIENCY MAINE INCENTIVE LEVELS

Vehicle Class	Maximum Award
Class 3	40% of purchase price up to $40,000
Class 4	40% of purchase price up to $60,000
Class 5	50% of purchase price up to $80,000
Class 6	50% of purchase price up to $100,000
Class 7	50% of purchase price up to $120,000

Along with awards for vehicle purchases, the program also offers incentives for Level 2 charging and professional services such as consulting. For further information, and to apply, fleets should visit the program website.

RESULTS

Total Cost of Ownership

Calculating the total cost of ownership for a vehicle offers fleet owners information to evaluate direct and indirect costs of EV purchases, as well as potential savings over the life cycle of purchased vehicles. The transition to EVs involves a shift in perspective regarding TCO components. Traditional internal combustion engine (ICE) vehicle costs are usually presented as capital cost for vehicles and dollar per gallon ($/gal) costs for fuel, as well as lifetime maintenance expenses. An analysis of TCO for EVs must consider power output, $ per kilowatt, grants and incentive programs, and planning and installing EVSE. While EVs are typically more expensive upfront, they are often less expensive to operate and maintain than comparable ICE vehicles; in many cases, these operational savings can offset higher upfront costs across the lifespan of the vehicle, resulting in a positive TCO.

TCO is calculated by combining the vehicle capital and operating costs over a set period of operations. For this analysis, the vehicle price points came from industry averages. Calculations assume a purchase in 2025 and a 12-year vehicle life, which is average across Maine trucks in this class. The results represent one vehicle in each duty cycle. Calculations accounted for the Efficiency Maine Trust vehicle incentives and the Federal Commercial Clean Vehicle tax credit. The results are estimates and actual cost differences may vary.

Each TCO scenario is modeled with a capital procurement cost for the diesel versus electric model and does not include any vehicle resale or residual values. The Federal tax credit is detailed in the Federal Incentives section and, along with Maine state incentives, is taken into consideration when modeling cumulative costs over time. For simplicity, the TCO calculation includes procurement of EVSE and infrastructure upgrades based on the cost of a single port. Infrastructure upgrade costs are calculated per location, not per vehicle. Those costs are modeled in the Fueling/Charging Cost Analysis section. The included costs are vehicle procurement, sales tax, Federal excise tax, maintenance, fuel, and insurance costs. Level 2 charging was assumed for Pine State Trading's GMC Savanna vans, Ford Transit vans, and Class 6 straight trucks. Level 3 DC fast charging was assumed for their Class 7 and Class 8 trucks.

Ford Transit/GMC Savanna Van

Pine State Trading's three Ford Transit/GMC Savanna vans have an average annual mileage of up to 16,000 miles and operate 255 days per year, meaning their daily driving distance is up to about 63 miles. Figure 9 shows cumulative costs over time and Figure 10 shows itemized total costs.

FIGURE 9 FORD TRANSIT/GMC SAVANNA VAN—FLEET COSTS OVER TIME

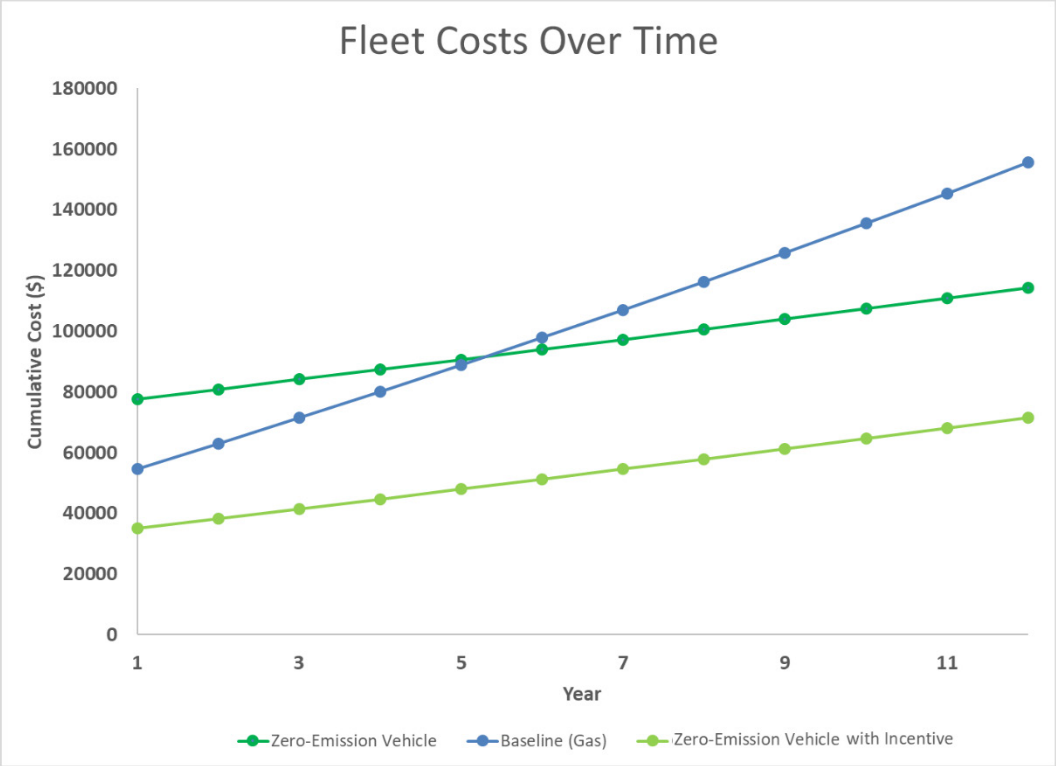
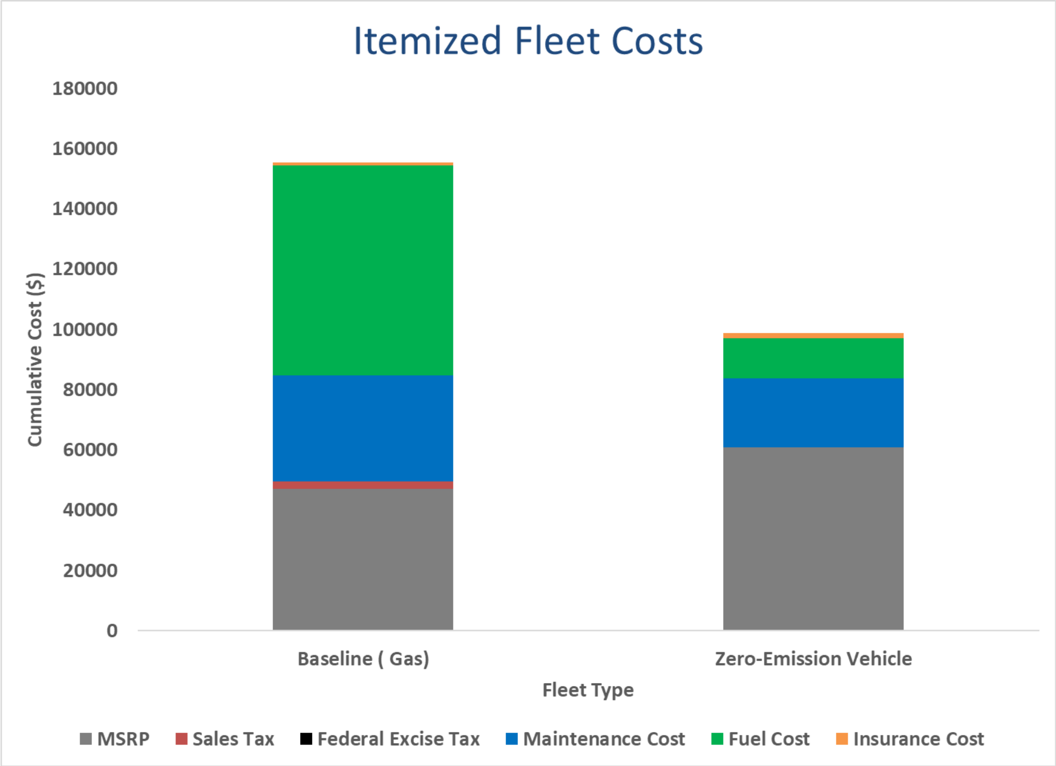


FIGURE 10 FORD TRANSIT/GMC SAVANNA VAN—ITEMIZED FLEET COSTS



This TCO analysis compares a gasoline-powered cargo van priced at $47,000 with an electric cargo van priced at $61,000. It assumes a $3.50/gallon price of gasoline and an $0.18/kWh price of charging. The infrastructure cost is priced at $12,200 for the costs of one Level 2 charging port hardware, installation and local infrastructure, and utility-side make-ready costs. This cost is included in the upfront capital costs of the vehicle purchase.

The modeled Maine incentive is $24,400 off the purchase vehicle price. The Commercial Clean Vehicle Tax Credit removes $18,300 more (30 percent of the vehicle manufacturers' suggested retail price, or MSRP), reducing the procurement cost further to $34,729.

The results indicate that the cargo van's payback period is five years without the incentive and that the electric vehicle produces savings at the point of purchase with the incentive. The electric cargo van produce estimated annual fuel costs savings of 136 percent ($6,321) and estimated annual maintenance costs savings of 42 percent ($1,750), primarily due to savings on items like oil and filter changes, and reduction in parts failure (fewer moving parts) Itemized costs are shown in Table 7.

TABLE 7 FORD TRANSIT VAN ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
MSRP	$47,000	$61,000
Sales Tax	$2,585	$3,355
Federal Excise Tax	$0	$0
Maintenance Cost	$26,400	$17,160
Fuel Cost	$52,150	$9,936
Insurance Cost	$1,227	1,592
Infrastructure Costs	$0	$12,200

Class 6 Truck

Pine State Trading's nine Class 6 trucks have an average annual mileage of up to 20,000 miles and operate 255 days per year, meaning their daily driving distance is up to about 79 miles. Figure 11 shows cumulative costs over time and Figure 12 shows itemized total costs.

FIGURE 11 CLASS 6—FLEET COSTS OVER TIME

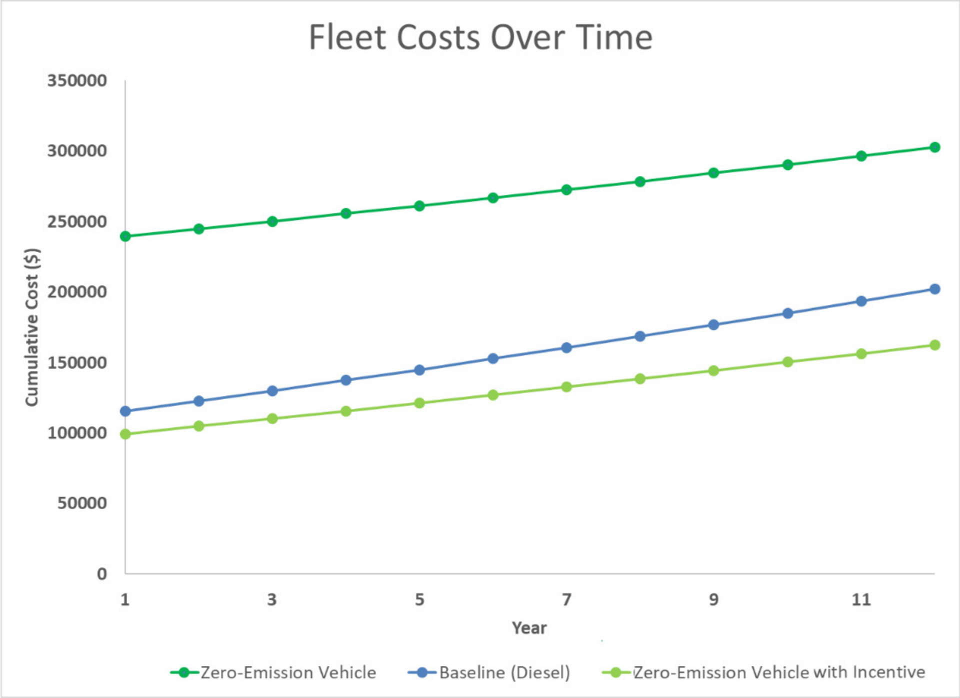
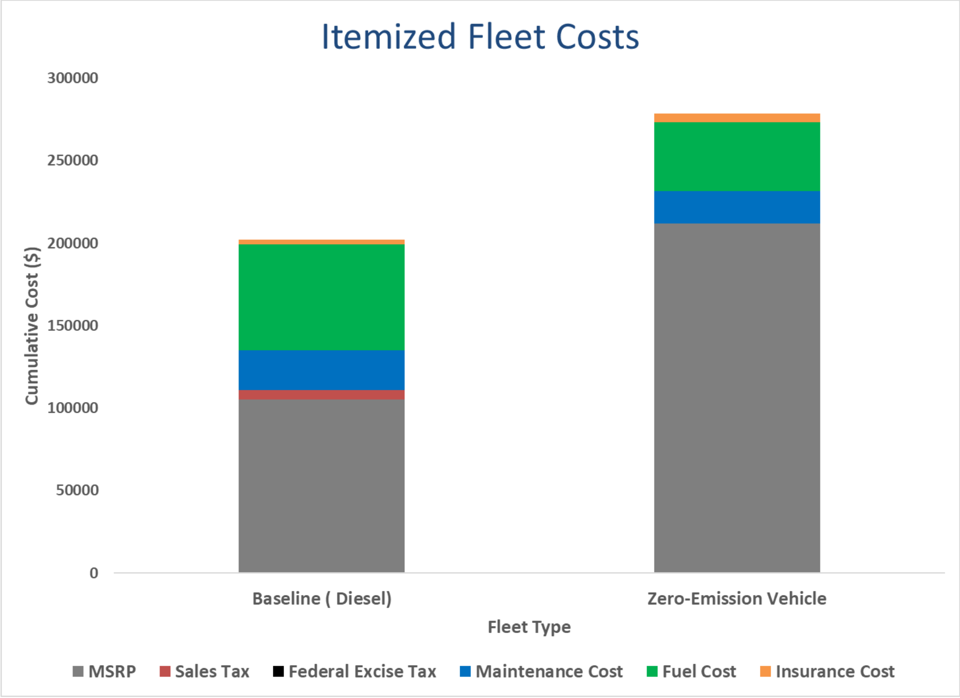


FIGURE 12 CLASS 6—ITEMIZED FLEET COSTS



This TCO analysis compares a diesel-powered truck priced at $105,000 with an electric truck priced at $212,000. It assumes a $4.00/gallon price of diesel and an $0.18/kWh price of charging. The infrastructure cost is priced at $12,200 for the costs of one Level 2 charging port hardware, installation and local infrastructure, and utility-side make-ready costs. This cost is included in the upfront capital costs of the vehicle purchase.

The modeled Maine incentive is $100,000 off the purchase vehicle price, reducing the capital procurement cost to $141,512. The Commercial Clean Vehicle tax credit removes $40,000 more, reducing the procurement cost further to $101,512.

The results indicate that the Class 6 truck's payback period exceeds its expected life without the incentive but produces savings immediately with the incentives included. The electric Class 6 truck also produces an estimated 43% reduction in annual fuel costs ($2,742) and an estimated 22 percent reduction in annual maintenance costs ($760), primarily due to savings on items like oil and filter changes, and reduction in parts failure (fewer moving parts). Itemized costs are shown in Table 8.

TABLE 8 CLASS 6 ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
MSRP	$105,000	$212,000
Sales Tax	$5,775	$11,660
Federal Excise Tax	$0	$0
Maintenance Cost	$41,800	$33,440
Fuel Cost	$111,368	$72,105
Insurance Cost	$2,741	$5,533
Infrastructure Costs	$0	$12,200

Class 7 Truck

Pine State Trading's two Class 7 trucks have an average annual mileage of 15,000 miles and operate 255 days per year, meaning their daily driving distance about 59 miles. Figure 13 shows cumulative costs over time and Figure 14 shows itemized total costs.

FIGURE 13 CLASS 7—FLEET COSTS OVER TIME

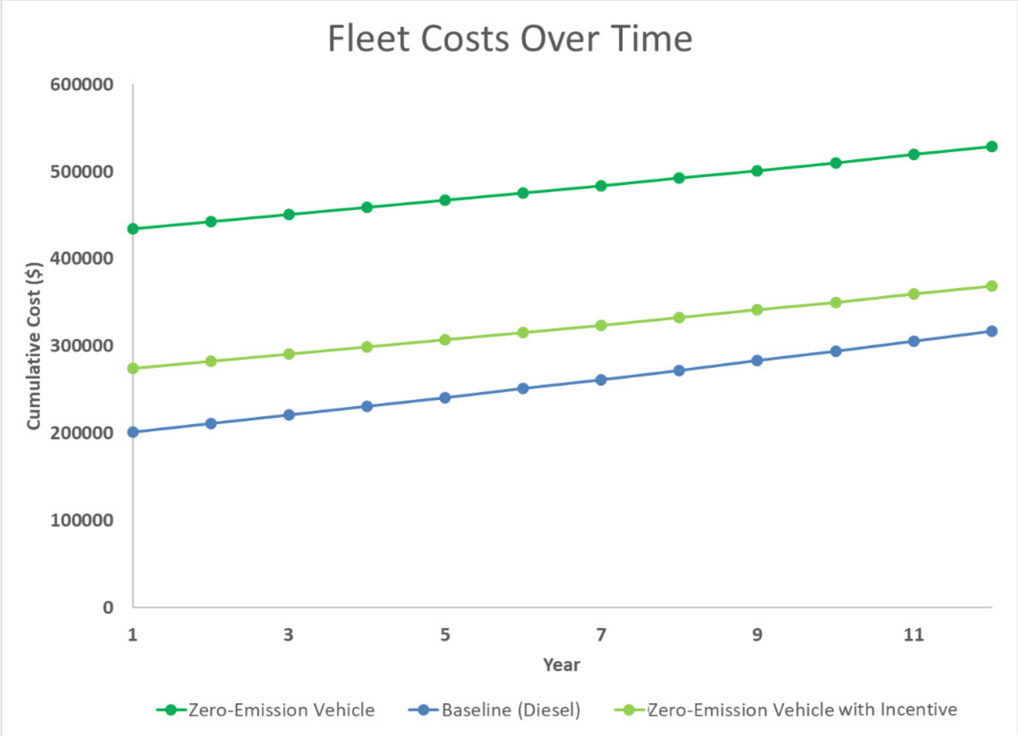
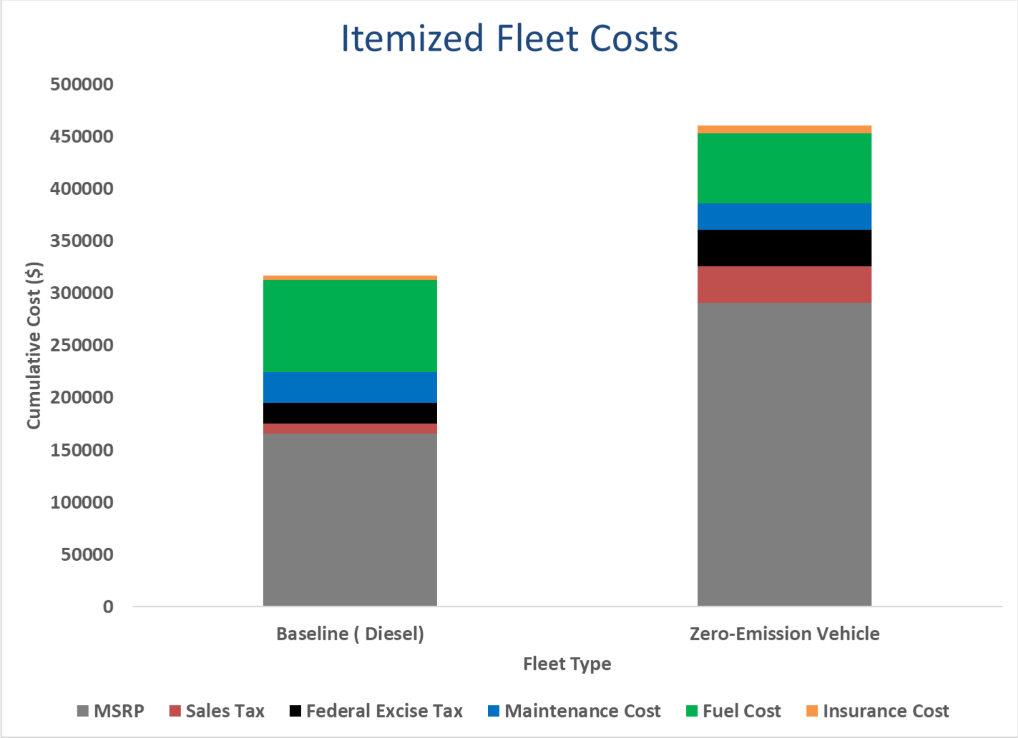


FIGURE 14 CLASS 7—ITEMIZED FLEET COSTS



This TCO analysis compares a diesel-powered truck priced at $166,000 with an electric truck priced at $291,000. It assumes a $4.00/gallon price of diesel and an $0.18/kWh price of charging. The infrastructure cost is priced at $87,450 for the costs of one Level 3 charging port hardware, installation and local infrastructure, and utility-side make-ready costs. This cost is included in the upfront capital costs of the vehicle purchase.

The modeled Maine incentive is $120,000 off the purchase vehicle price, reducing the capital procurement cost to $141,512. The Commercial Clean Vehicle tax credit removes $40,000 more, reducing the procurement cost further to $101,512.

The results indicate that the Class 7 truck's payback period exceeds its expected life but with and without the incentives included due to higher upfront capital costs. The electric Class 7 truck still produces an estimated 27 percent reduction in annual fuel costs ($1,445) and an estimated 18 percent reduction in annual maintenance costs ($450), primarily due to savings on items like oil and filter changes, and reduction in parts failure (fewer moving parts). Itemized costs are shown in Table 9Table 8.

TABLE 9 CLASS 7 ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
MSRP	$105,000	$212,000
Sales Tax	$5,775	$11,660
Federal Excise Tax	$0	$0
Maintenance Cost	$41,800	$33,440
Fuel Cost	$111,368	$72,105
Insurance Cost	$2,741	$5,533
Infrastructure Costs	$0	$87,450

Class 8 Truck

Pine State Trading's 57 Class 8 trucks have an average annual mileage of up to 33,000 miles and operate 255 days per year, meaning their daily driving distance is up to about 129 miles. Figure 15 shows cumulative costs over time and Figure 16 shows itemized total costs.

FIGURE 15 CLASS 8—FLEET COSTS OVER TIME

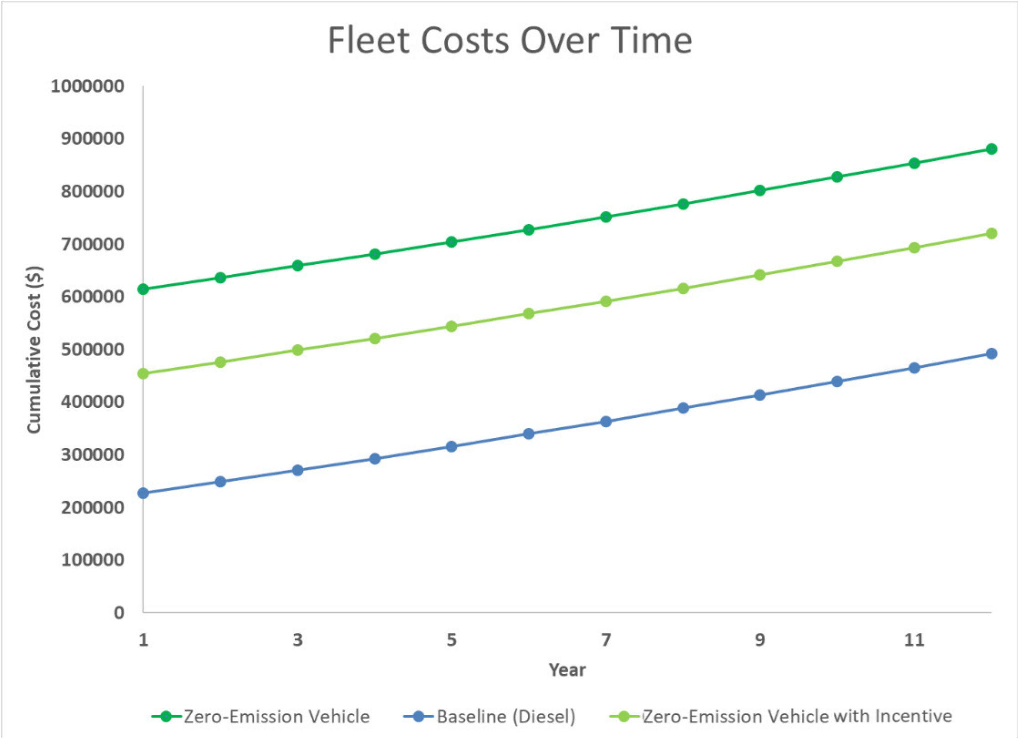
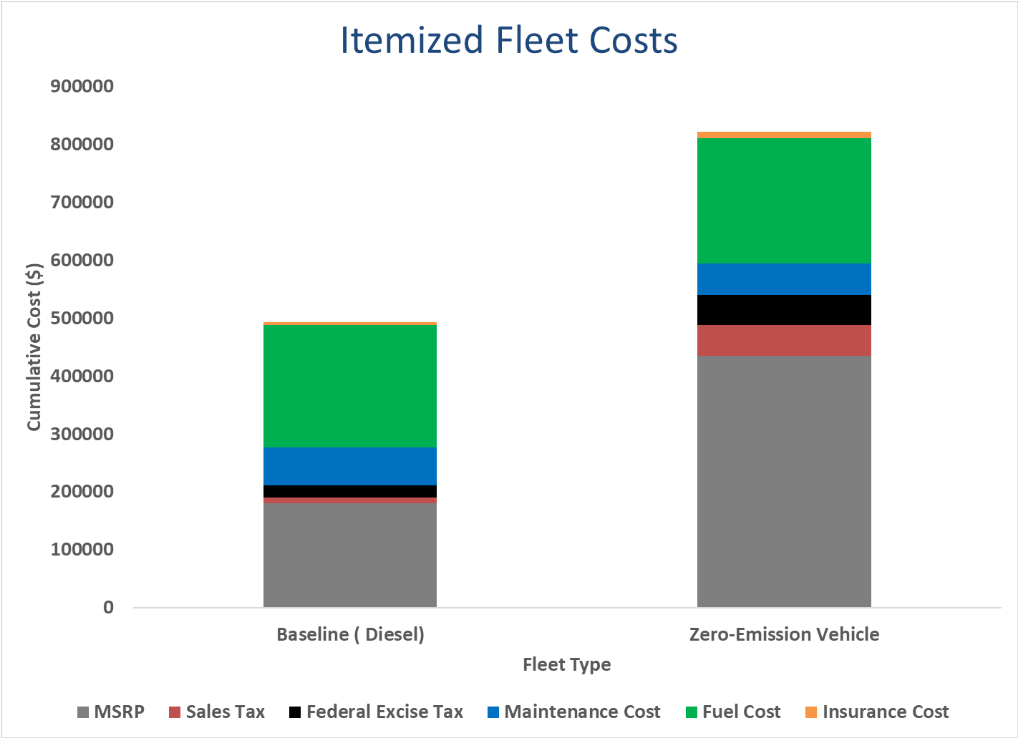


FIGURE 16 CLASS 8—ITEMIZED FLEET COSTS



This TCO analysis compares a diesel-powered truck priced at $180,000 with an electric truck priced at $435,000. It assumes a $4.00/gallon price of diesel and an $0.18/kWh price of charging. The infrastructure cost is priced at $87,050 for the costs of one Level 3 charging port hardware, installation and local infrastructure, and utility-side make-ready costs. This cost is included in the upfront capital costs of the vehicle purchase.

The modeled Maine incentive is $120,000 off the purchase vehicle price, reducing the capital procurement cost to $494,528. The Commercial Clean Vehicle tax credit removes $40,000 more, reducing the procurement cost further to $454,528.

The results indicate that the Class 8 truck's payback period exceeds its expected life but with and without the incentives included due to higher upfront capital costs. The electric truck produces estimated annual maintenance costs savings of 18 percent ($990), primarily due to savings on items like oil and filter changes, and reduction in parts failure (fewer moving parts). Itemized costs are shown in Table 10.

TABLE 10 CLASS 8 ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
MSRP	$105,000	$212,000
Sales Tax	$5,775	$11,660
Federal Excise Tax	$0	$0
Maintenance Cost	$41,800	$33,440
Fuel Cost	$111,368	$72,105
Insurance Cost	$2,741	$5,533
Infrastructure Costs	$0	$87,450

Fleet Emissions

Maine's transportation sector is the largest source of greenhouse emissions in the State, and medium- and heavy-duty trucks account for 27 percent of these emissions.[1] Providing power to vehicles via electricity is significantly less polluting than diesel fuel, especially in areas served by low-carbon sources of electricity generation. Renewable resources powered

1 Rocky Mountain Institute. "RMI Analysis: With Smart Policy, Truck Electrification Is Within Reach." Accessed October 2024.

64 percent of Maine's total electricity net generation, and wind provided the largest share at 23 percent of the State's total net generation, in 2022.[2]

An analysis of Pine State Trading' direct exhaust emissions was performed using the U.S. Environmental Protection Agency's Diesel Emission Quantifier tool. The analysis combines the average annual mileage traveled by all diesel vehicles in the fleet. Converting Fleet 1's vehicles to ZEVs would eliminate all of these direct emissions.

TABLE 11 INTERNAL COMBUSTION ENGINE FLEET EMISSIONS

Pollutant	Annual Emissions (Short Tons/Year)	10-Year Emissions (Short Tons)
Carbon Monoxide (CO)	3.726	37.26
Nitrogen Oxides (NO_x)	5.277	52.77
Particulate Matter (PM)	0.009	0.09
Carbon Dioxide (CO_2)	3,376	33,764

IMPLEMENTATION CONSIDERATIONS

Energy Storage and Resiliency

Power outages are always a possibility at fleet depots, regardless of grid advancements and fidelity. Fleets should consider contingencies for maintaining operations of electric trucks in the event of a long-term power outage. Today's electric vehicles do not necessarily require electricity from the grid to be available to properly fuel. There are means of fueling battery-electric vehicles using energy storage solutions, most commonly batteries, which are safer than storing flammable fossil fuels on site. Critical vehicle operations may consider other forms of backup power to ensure charging access, including generators.

Many consumers have asked whether EVs can be used in an emergency to provide backup power to homes, offices, and other facilities. For a vehicle to provide backup power, there are several additional considerations: whether the vehicle is designed for 'bidirectional charging', meaning that the vehicle can output power, and whether the facility has appropriate two-way charging equipment. The Ford F-150 Lightning is equipped to support

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[2] U.S. Energy Information Administration. State Profile and Energy Estimates. Accessed October 2024.

bidirectional charging, and Ford supports claims that the truck can provide up to 100 kWh of power on a single charge, which is enough to power an average house for three days (30 kWh per day).

Preheat/Precool

One consideration often overlooked in commercial EV operation is the energy use associated with climate control, either for the operator or for the goods themselves. Idle time spent bringing a cab to a comfortable riding temperature uses energy otherwise intended for moving the vehicle along its intended route. The energy used to heat or cool the vehicle cabin may consume a significant amount of the vehicle's battery capacity. Preconditioning while vehicles are connected to chargers at the depot is a simple approach to providing comfortable conditions and extending driving range during winter and summer. These types of considerations are important to factor in, and experiment with, during a fleet's initial deployment.

"Vampire" Energy

Vehicles of all kinds are meant to be driven; they benefit from regular usage by foregoing the potential negative impacts of remaining idle for extended periods. One such impact to commercial EVs is what is known as "vampire" energy, where a vehicle's battery will slowly deplete while it remains unplugged and idle. This is normal behavior and not an indication that anything is malfunctioning. Rather, this is an expected effect resulting from a combination of onboard electronics that remain on or in stand-by, as well as the natural chemical reactions occurring in a vehicle's battery.

Best practices for long-term battery health include keeping a vehicle's battery charged to 80 percent when possible and taking measures to ensure its state of charge does not regularly fall below 20 percent while idle. Managed and networked charging infrastructure can help fleets keep battery state of charge within this optimal range. For smaller EV deployments and fleets involving just a few vehicles, this also may be achievable through effective training and communication with staff on-site.

REFERENCES

CALSTART's Zero-Emission Technology Inventory (ZETI) is a public online interactive dashboard containing the status and anticipated timing of commercial availability for zero-emission MHDVs across a range of vehicle platforms and key global regions. ZETI was the primary tool used to find equivalent medium and heavy-duty electric vehicle models that could replace the current fleet inventory.