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

Case Study: Fleet 2—Lynch Logistics

prepared for

GOVERNOR'S OFFICE OF Policy Innovation and the Future

MaineDOT

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CALSTART

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SUMMARY

Fleet 2, Lynch Logistics is a full-service logistics and transportation provider doing business throughout Maine, the U.S., and Canada. This report assesses their vehicles which domicile on Rice Street (RMC/SOS), as well as the shredding facility on Odlin Road (Lynch Logistics), and the maintenance facility on Lexington Drive (MEMoving/MEDelivery), all located in Bangor.

The medium-duty trucks at the Rice Street facility travel approximately 135 miles a day and are primarily used for commercial moving. Their travel patterns and overnight dwell times are well-suited to electric or hydrogen vehicles, and transitioning to these zero-emission alternatives would result in immediate fuel and maintenance cost savings. Despite that, a zero-emission replacement is not projected to produce lifetime savings due to high upfront capital costs for electric and hydrogen trucks.

The Odlin facility houses both gasoline Ford Transit vans which pick up classified materials, and Class 6/7 trucks which serve as on-site mobile shredding units. Even without incentives, electrification of the vans results in cost savings within the first four years of ownership; with incentives, savings are immediate. With incentives, the electrification of the Class 6 trucks is also immediately lower cost than the internal combustion alternative. Although the zero-emissions transition would result in immediate maintenance and fuel cost savings for the Class 7 trucks, there are not projected to be lifetime savings due to the high upfront capital costs.

The Class 8 trucks operating out of the Lexington Drive facility travel between 250–280 miles per day and are primarily used for moving freight. These vehicles can be away from the domicile location for up to two weeks at a time, and would need to rely on on-route charging for electric alternatives. These trucks could be replaced with hydrogen fuel cell vehicles, where longer ranges are available, though more significant fueling station infrastructure challenges exist. Though fuel and maintenance cost savings are immediate, there are no lifetime savings due to the high upfront costs of Class 8 vehicles.

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

Lynch Logistics operates from three warehouses providing various logistical services. At the Lexington Drive warehouse, 30 vehicles provide freight pickup and delivery services. At Rice Street, six vehicles provide commercial moving services. From the Odlin Road warehouse, fifteen vehicles provide pickup and shredding services for confidential materials. Vehicles at the latter two warehouses domicile overnight at their respective lots, while Lexington Drive vehicles have more irregular schedules and may be on the road for days at a time. Table 1 shows an inventory of the fleet.

TABLE 1 LYNCH LOGISTICS VEHICLE INVENTORY

Vehicle Group	Vehicle Quantity	Vehicle Class	Fuel Type	Manufacturing Year (average)	Average Annual Miles	Owned or Leased Vehicles
Ford Transit Van	2	Class 3–10,001–14,000 lbs.	Gas	2019	25,000	Owned
Chevy 4500 Box Truck	1	Class 4–14,001–16,000	Diesel	2019	35,000	Owned
Freightliner M2106	13	Class 6–19,501–26,000 lbs.	Diesel	2019	35,000	Owned
Freightliner M2106	5	Class 7–26,001–33,000 lbs.	Diesel	2019	35,000	Owned
Freightliner 122SD	2	Class 8–Over 33,000 lbs.	Diesel	2023	65,000	Owned
Freightliner Cascadia	27	Class 8–Over 33,000 lbs.	Diesel	2022	75,000	Owned
Western Star 49X	1	Class 8–Over 33,000 lbs.	Diesel	2024	65,000	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 Fleet 2's duty cycles.

Ford Transit Van

Lynch Logistics operate two Ford Transit vans that drive an average of 96 miles per day and dwell for 13 hours overnight at the RMC/SOS—Bangor facility. These vehicles are used to pick up and transfer confidential materials. All recommendations shown in Table 2 can meet Lynch's current duty cycle.

TABLE 2 FORD TRANSIT VAN ELECTRIC VEHICLE 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					

Chevy 4500 Box Truck

Lynch Logistics operate one Chevy 4500 box trucks that drives an average of 135 miles per day and dwells for 12 hours overnight at the MEMoving/MEDelivery facility. This vehicle is used for commercial moving. Due to their higher available ranges, the Phoenix Motorcars Box Truck and the Bollinger Motors B4 are best suited to meet Lynch's duty cycle on a single charge. Other models may utilize public DC Fast charging to quickly recharge and finish a route. Replacement options are shown in Table 3.

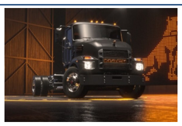
TABLE 3 CHEVY 4500 BOX TRUCK ALTERNATIVES

Make	Motiv	Workhorse	Rizon	Bollinger Motors
Model	Box Truck	W4 CC	E16M	B4
Availability	Now	Now	Now	Now
Class/Size	Class 4	Class 4	Class 4	Class 4
Payload	105 miles	150 miles	110 miles	185 miles
Range	5,000 lbs.	7,000 lbs.	N/A	7,325 lbs.
Fuel Tank Capacity	127 kWh	118 kWh	74 kWh	158 kWh
Charging Time	9 hours	7 hours	6 hours	9 hours
Website	Motiv Box Truck	W4 CC	E16M	B4
Vehicle Photo				

Freightliner M2106—Class 6

Lynch Logistics operate 13 Class 6 Freightliner M2106 trucks that drive an average of 135 miles per day and dwell for 12 hours overnight at the MEMoving/MEDelivery facility. These vehicles are used for last-mile delivery commercial moving. All recommendations shown in Table 4 can meet Lynch's current duty cycle, though DC Fast charging is recommended to allow the vehicles to fully charge within their scheduled dwell time.

TABLE 4 FREIGHTLINER M2106—CLASS 6 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					

Freightliner M2106—Class 7

Lynch Logistics operates five Class 7 Freightliner M2106 trucks that drive an average of 135 miles per day and dwell for 12.5 hours overnight at the RMC-SOS Bangor facility. These vehicles are used as on-site mobile shredding units. Most Class 6 recommendations are also available as a Class 7 build, with the addition of the Kenworth K370E. All recommended models can fulfill Lynch's duty cycle using DC fast charging, which is typically used by Class 7 trucks. Table 5 shows recommended replacement options.

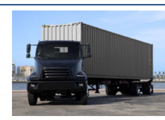
TABLE 5 FREIGHTLINER M2106—CLASS 7 REPLACEMENTS

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

Lynch Logistics operate 30 Class 8 trucks (two Freightliner 122SDs, 27 Freightliner Cascadias, and one Western Star 49X). The Freightliner 122SDs and Western Star 49X drive an average of 250 miles per day, while the Freightliner Cascadias drive an average of 289 miles per day. All 30-vehicle domicile at the Lynch Logistics facility and do not have a set schedule, meaning their daily dwell time varies. All recommended models can either meet Lynch's duty cycle on a single charge or with a quick DC fast charge mid-route, as long as they dwell for at least 1-2.5 hours before restarting travel. Table 6 shows recommended replacement options.

TABLE 6 CLASS 8 ELECTRIC VEHICLE 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						

Alternatively, Fleet 2 can explore the hydrogen fuel cell options listed in Table 7. Hydrogen fuel cells allow for faster refueling and longer ranges in some cases. Fuel cell vehicles require a source of hydrogen for refueling, which could be either privately or publicly owned. The U.S. Department of Energy (DOE) has awarded projects to expand a nationwide hydrogen refueling corridor, however the capital to install and run a hydrogen refueling station is significant, in the million-dollar range. Many fleets could benefit from public hydrogen stations, paying for the fuel but not the infrastructure.

TABLE 7 CLASS 8 HYDROGEN FUEL CELL VEHICLE REPLACEMENTS

Make	Hyundai	Kenworth	Nikola
Model	XCIENT Tractor	T680	Tre FCEV
Availability	Now	Now	Now
Class/Size	Class 8	Class 8	Class 8
Payload	N/A	82,000 lbs.	30,000 lbs.
Range	250 miles	450 miles	500 miles
Fuel Tank Capacity	68 kg	58 kg	70 kg
Charging Time	20 min	20 min	20 min
Website	XCIENT	T680	TRE FCEV
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.

Lynch Logistics could utilize managed charging at their RMC/SOS-Bangor and MEMoving/MEDelivery warehouses, where their vehicles have extended downtime. This could allow them to charge the vehicles using less equipment rather than procuring one charging port per vehicle.

On-Route versus Depot Charging

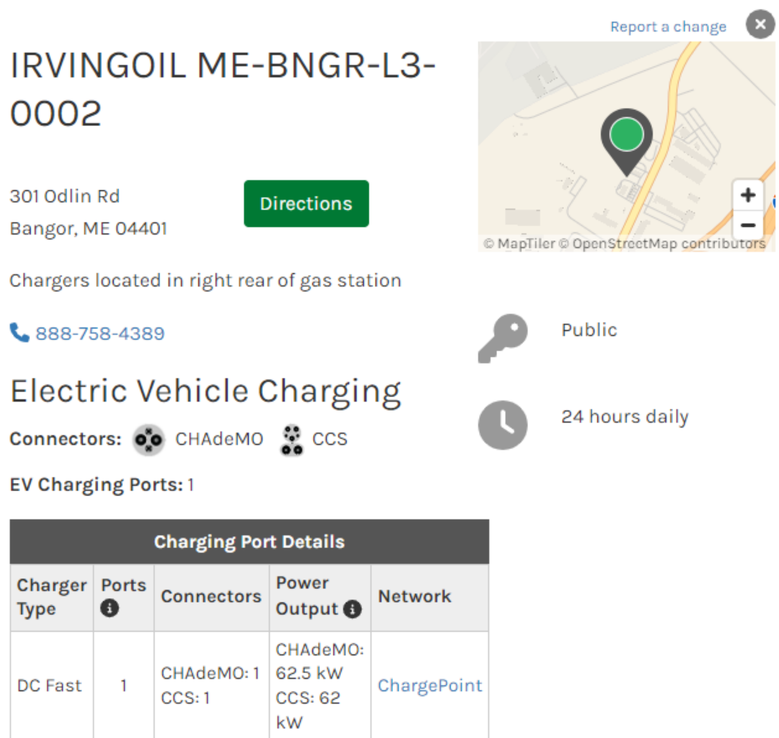
Most commercial EV deployments currently in operation rely solely on depot charging, or a "return-to-base" schedule where a fleet keeps vehicles parked at one location owned/leased by the organization operating those vehicles. While policy efforts and Federal funding are advancing the development of 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 Fleet 2 is shown in Figure 2.

FIGURE 2 ALTERNATIVE FUELS DATABASE DETAILED CHARGER INFORMATION



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 Fleet 2 using CALSTART's Charging Infrastructure Optimization (CHARIOT) Tool. The CHARIOT tool aims to optimize Fleet 2'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. Fleet 2's electricity is provided by Central Maine Power (CMP).

The CHARIOT tool was used twice for each warehouse: once using Versant's high peak time-of-use (TOU) rate ($3.55/kWh) and once using a flat TOU rate ($0.12/kWh). Peak loads were calculated for each of the three sites as follows: RMC/SOS (Odlin)—690 kW; ME Moving/ME Delivery (Rice)—300 kW; Lynch Logistics (Lexington)—3,000 kW.

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.

FIGURE 3 DAILY CHARGING LOAD PROFILES—ALL VEHICLES

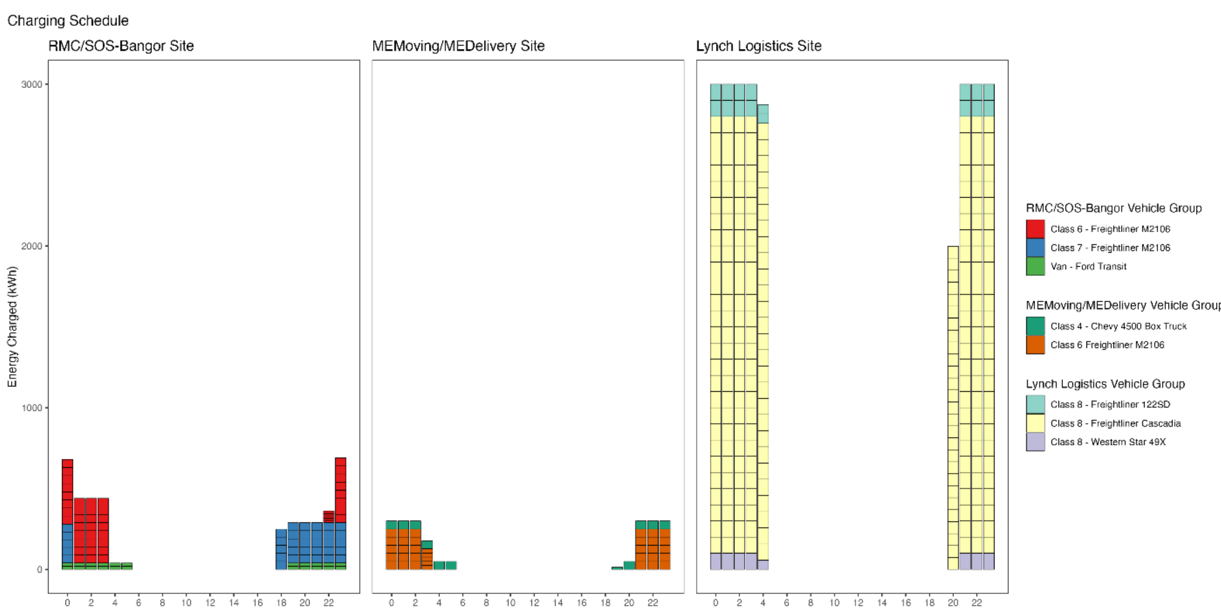
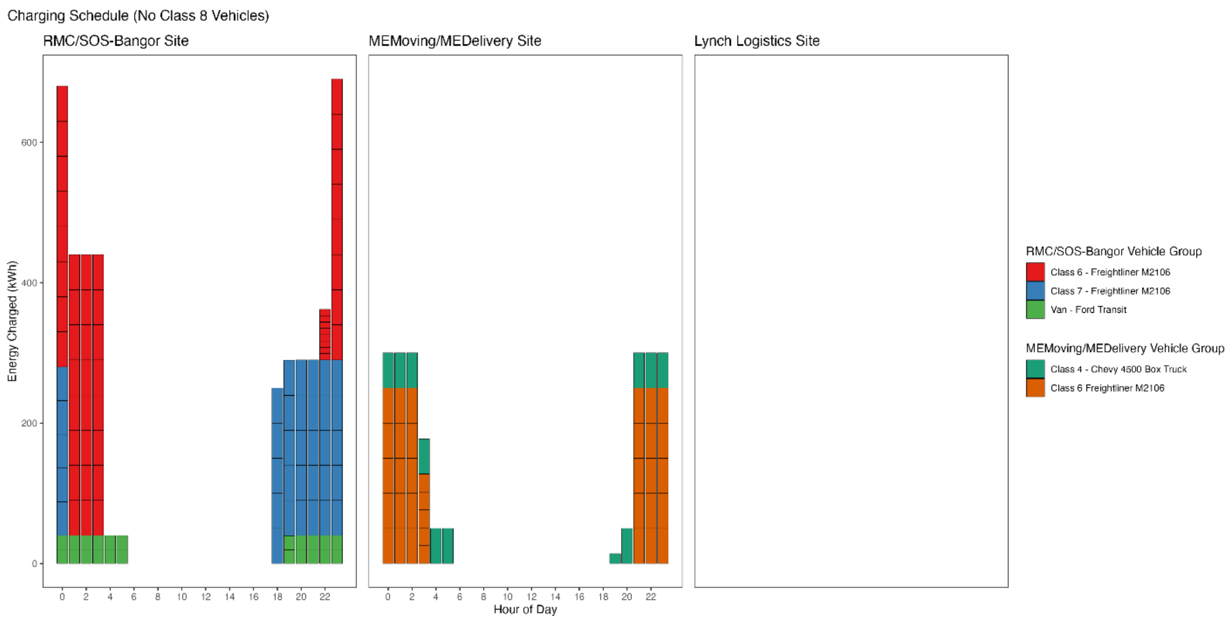


FIGURE 4 DAILY CHARGING LOAD PROFILES—EXCLUDING CLASS 8 VEHICLES



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

The MC/SOS—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 for the vehicles domiciling at the Odlin Street (RMS/SOS) facility. Figure 5 compares the annual energy usage for diesel and electric vehicles, while Figure 6 models the cost per mile for each vehicle type.

FIGURE 5 RMC/SOS—FLAT TOU RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

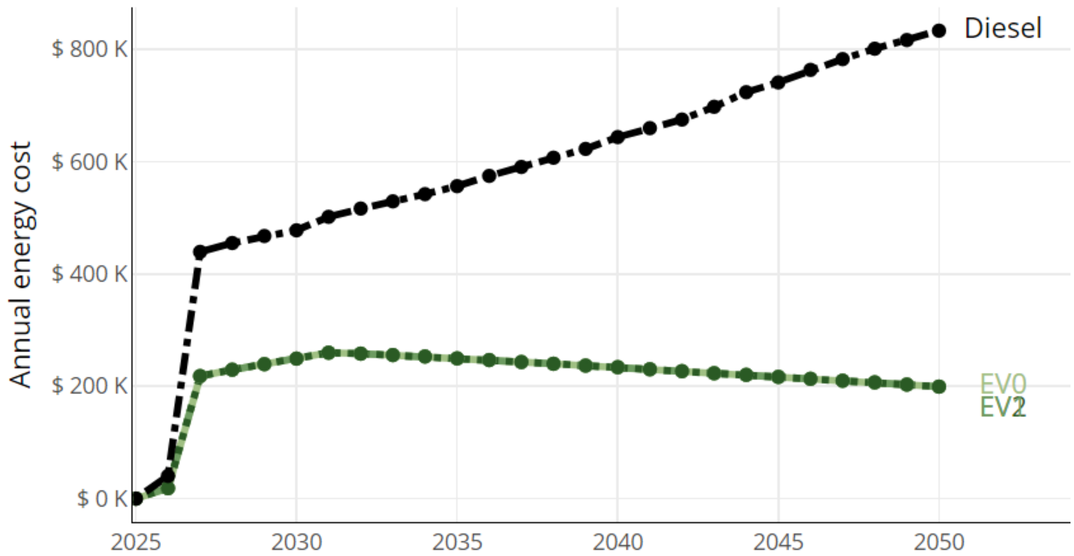
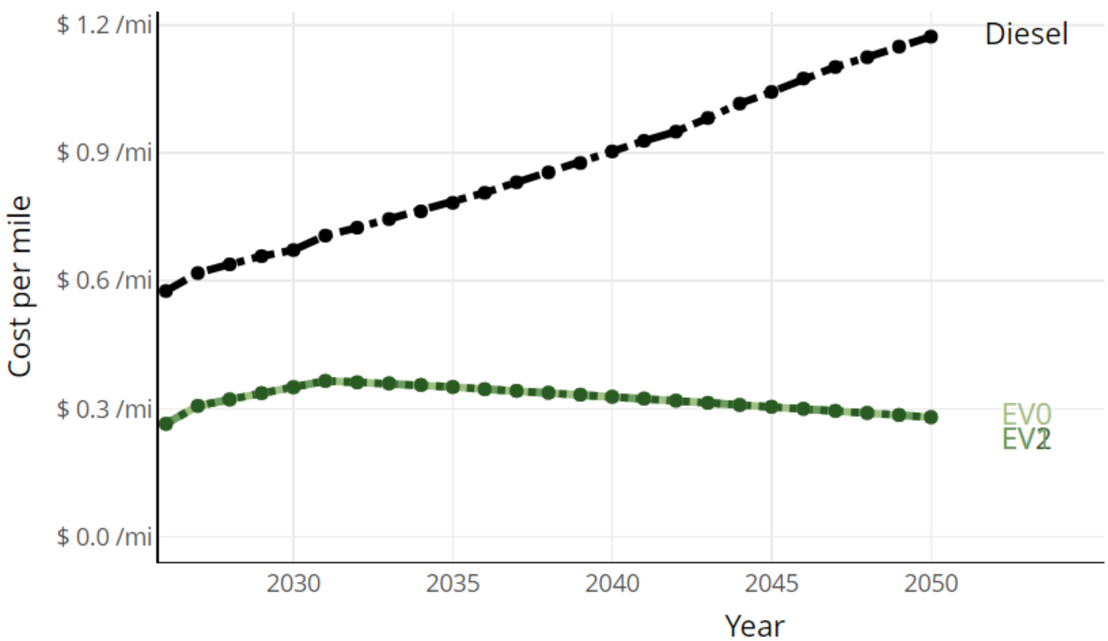


FIGURE 6 RMC/SOS—FLAT TOU RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



The RMC/SOS—high peak rate scenario models a time of use rate of $0.118/kWh (80 percent of charging time) with a $3.55/kWh peak rate (20 percent of charging time) and compares with a $3.70/gallon cost of diesel for the vehicles domiciling at the Odlin Street (RMS/SOS) facility. Figure 7 compares the annual energy usage for diesel and electric vehicles, while Figure 8 models the cost per mile for each vehicle type.

FIGURE 7 RMC/SOS—HIGH PEAK RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

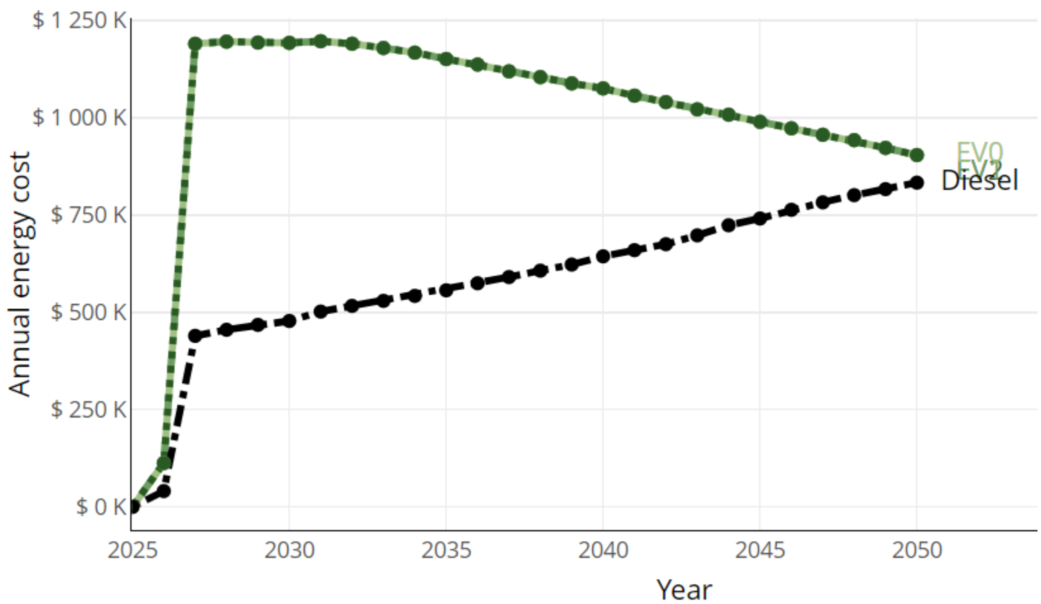
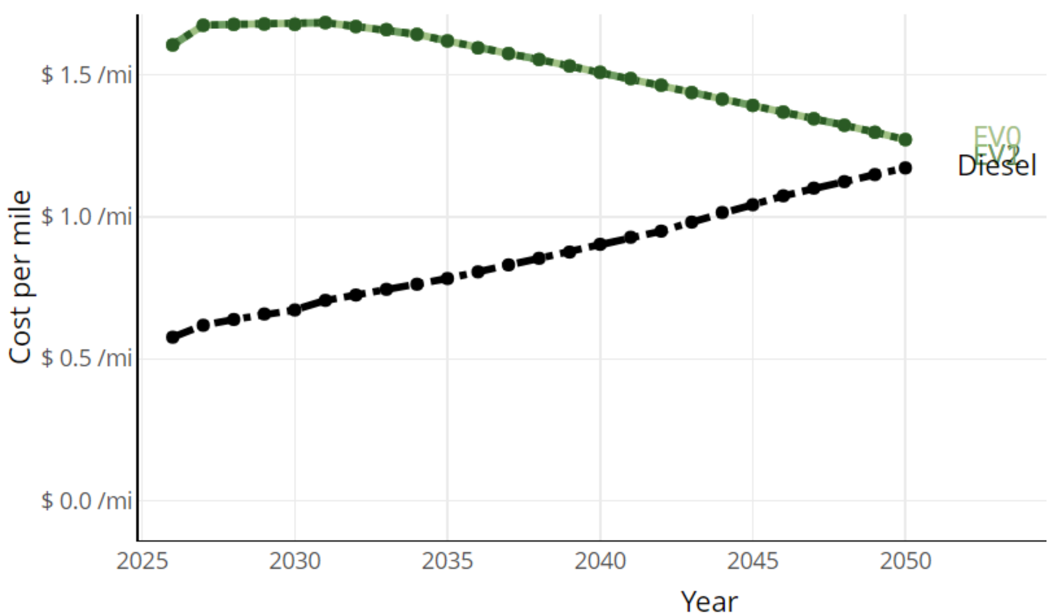


FIGURE 8 RMC/SOS—HIGH PEAK RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



The MEMoving/MEDelivery—flat TOU rate scenario models a time of use rate of $0.118/kWh and compares with a $3.70/gallon cost of diesel for the vehicles domiciling at the Rice St. (MEMoving/MEDelivery) facility. Figure 9 compares the annual energy usage for diesel and electric vehicles, while Figure 10 models the cost per mile for each vehicle type.

FIGURE 9 MEMOVING/MEDELIVERY—FLAT TOU RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

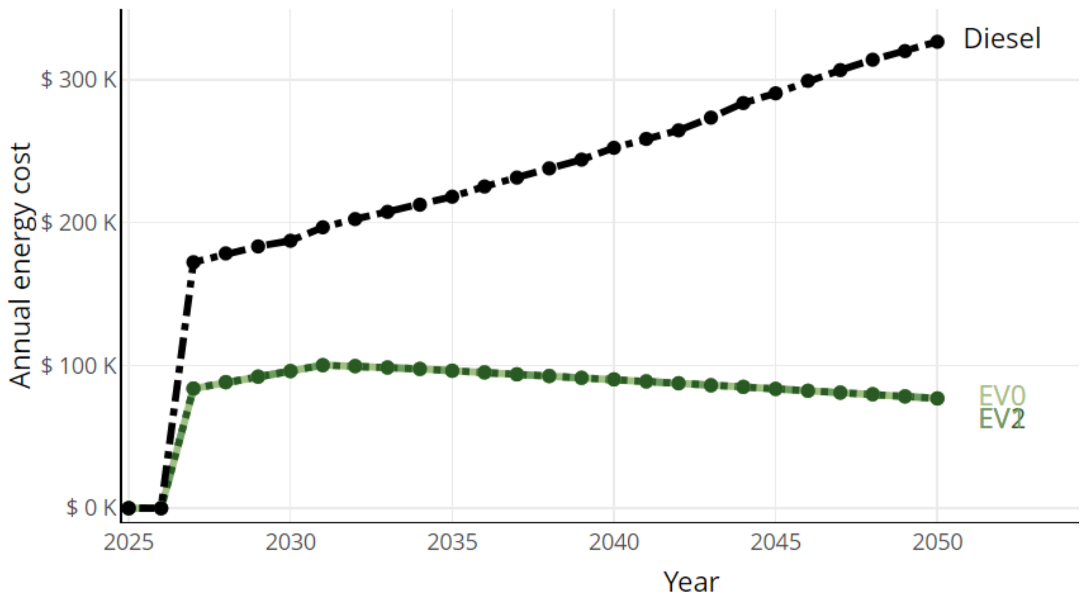
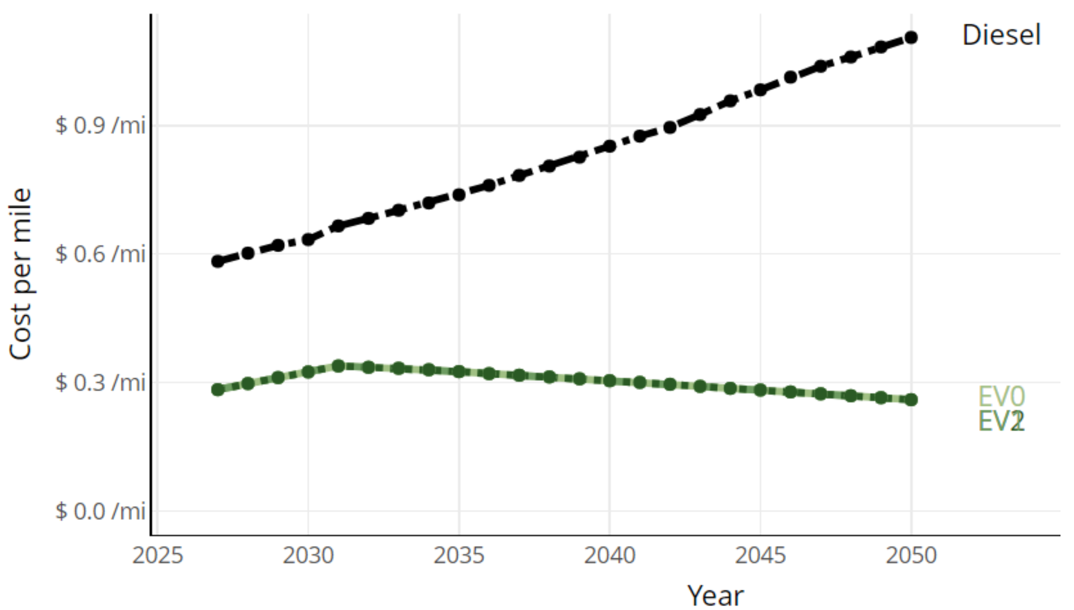


FIGURE 10 MEMOVING/MEDELIVERY—FLAT TOU RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



The MEMoving/MEDelivery—high peak rate scenario models a time of use rate of $0.118/kWh (80 percent of charging time) with a $3.55/kWh peak rate (20 percent of charging time) and compares with a $3.70/gallon cost of diesel for the vehicles domiciling at the Rice St. (MEMoving/MEDelivery) facility. Figure 11 compares the annual energy usage for diesel and electric vehicles, while Figure 12 models the cost per mile for each vehicle type.

FIGURE 11 MEMOVING/MEDELIVERY—HIGH PEAK RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

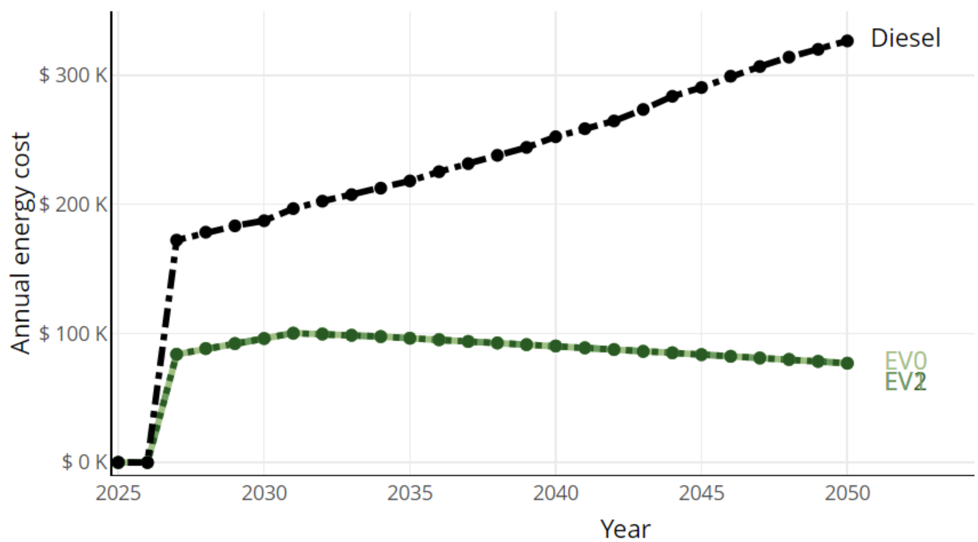
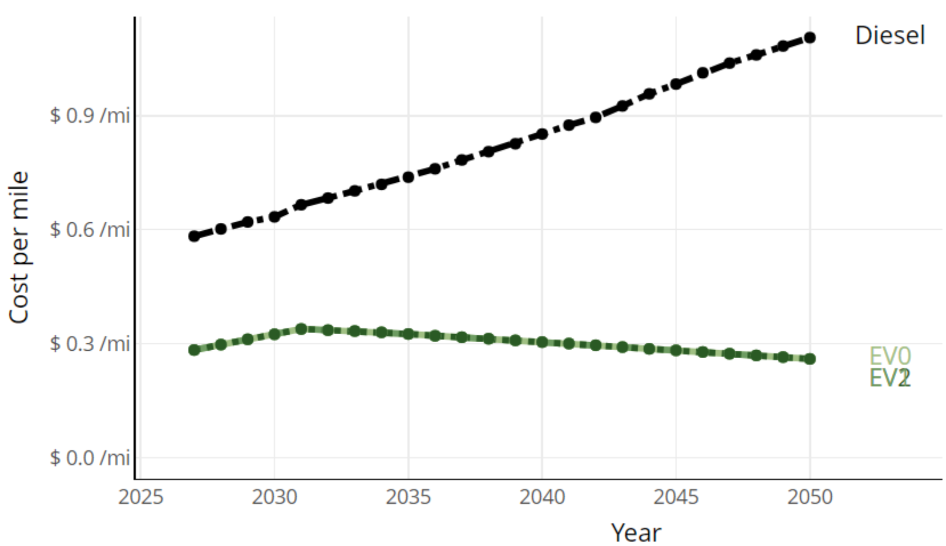


FIGURE 12 MEMOVING/MEDELIVERY—HIGH PEAK RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



The Lynch Logistics (Lexington Drive)—flat TOU rate scenario models a time of use rate of $0.118/kWh and compares with a $3.70/gallon cost of diesel for the vehicles domiciling at the

Rice St. (MEMoving/MEDelivery) facility. Figure 13 compares the annual energy usage for diesel and electric vehicles, while Figure 14 models the cost per mile for each vehicle type.

FIGURE 13 LYNCH LOGISTICS (LEXINGTON DRIVE)—FLAT TOU RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

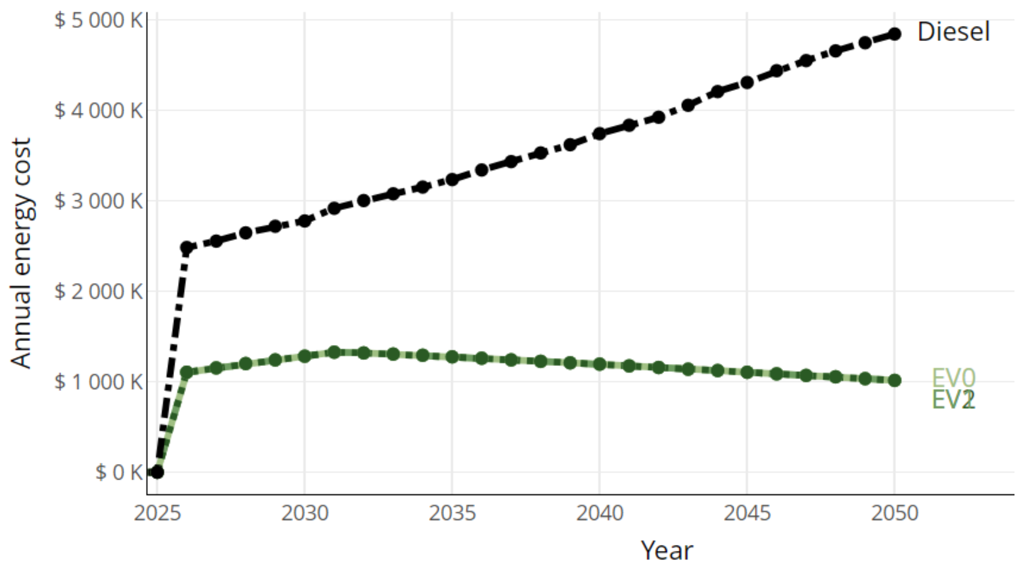
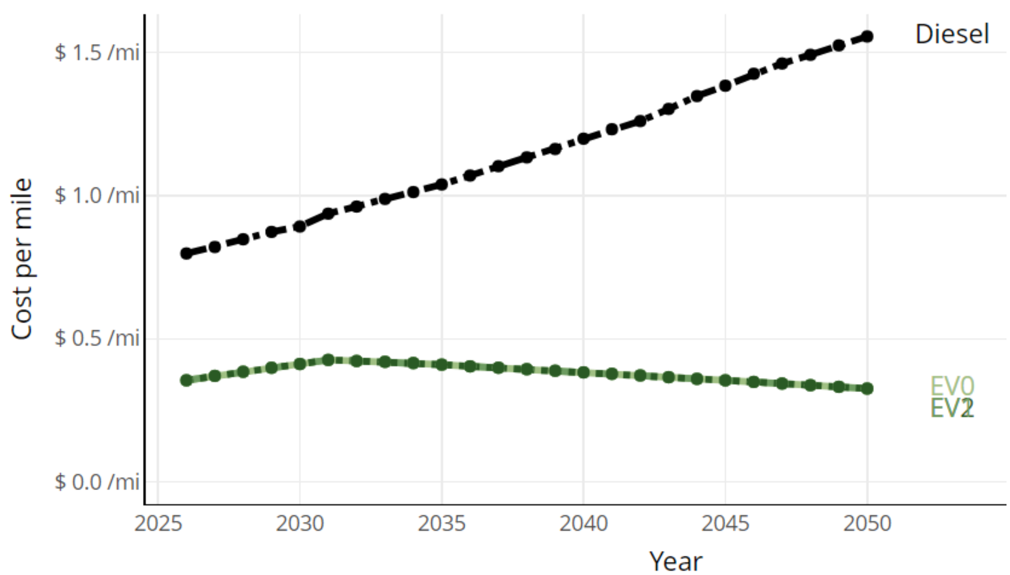


FIGURE 14 LYNCH LOGISTICS (LEXINGTON DRIVE)—FLAT TOU RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



The Lynch Logistics (Lexington Drive)—high peak rate scenario models a time of use rate of $0.118/kWh (80 percent of charging time) with a $3.55/kWh peak rate (20 percent of charging time) and compares with a $3.70/gallon cost of diesel for the vehicles domiciling at the Lexington Drive (Lynch Logistics) facility. Figure 15 compares the annual energy usage for diesel and electric vehicles, while Figure 16 models the cost per mile for each vehicle type.

FIGURE 15 LYNCH LOGISTICS (LEXINGTON DRIVE)—HIGH PEAK RATE SCENARIO ANNUAL ENERGY COST FOR DIESEL VERSUS EV

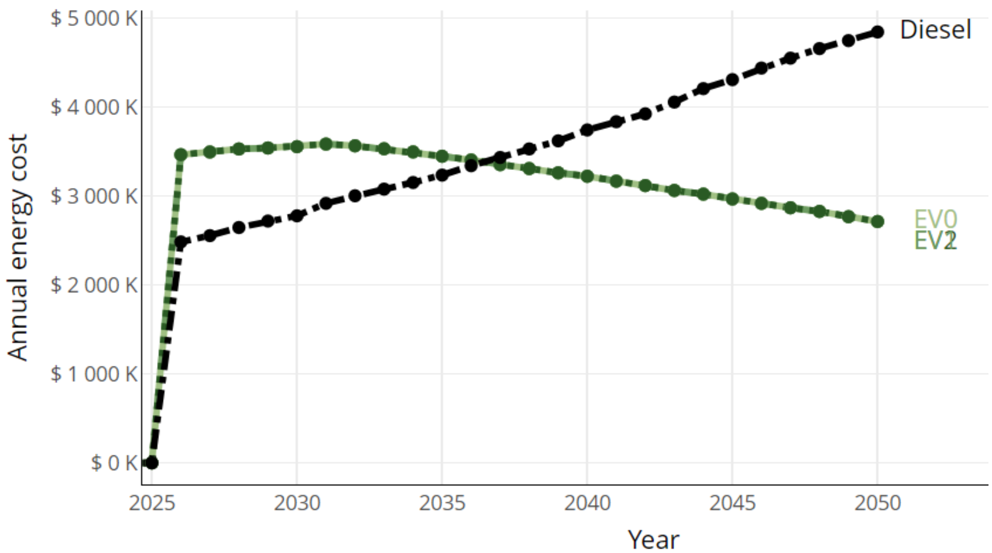
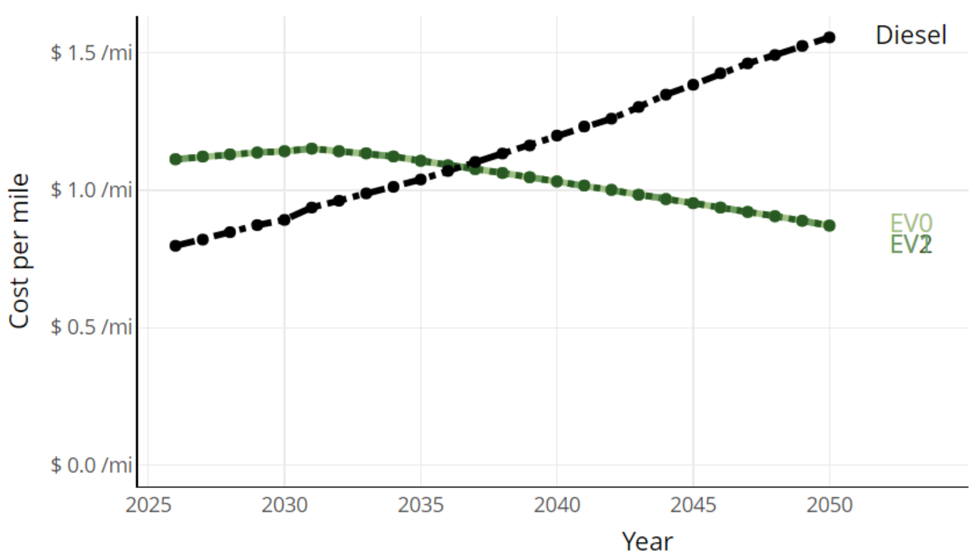


FIGURE 16 LYNCH LOGISTICS (LEXINGTON DRIVE)—HIGH PEAK RATE SCENARIO COST PER MILE FOR DIESEL VERSUS EV



Based on the anticipated energy needs of 51 medium- and heavy-duty vehicles across three warehouses, Lynch Logistics would be estimated to achieve significant reductions in their annual energy costs. The only exception is a high peak rate scenario at the RMC/SOS-Bangor warehouse, where medium and heavy-duty vehicle charging would be more expensive than diesel fueling. Due to the reduced cost of charging compared to diesel fuel, Lynch Logistics could expect a significantly decreased cost per mile of operation, particularly in the flat rate scenario.

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 8.

TABLE 8 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 (TCO) 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 Lynch Logistics' Ford Transit vans, Class 4 box trucks, and Class 6 straight trucks. Level 3 DC fast charging was assumed for their Class 7 and Class 8 trucks.

Ford Transit Van

Lynch Logistics' two Ford Transit vans have an average annual mileage of up to 25,000 miles and operate 260 days per year, meaning their daily driving distance is up to about 96 miles. Figure 17 shows cumulative costs over time and Figure 18 shows itemized total costs.

FIGURE 17 FORD TRANSIT VAN—FLEET COSTS OVER TIME

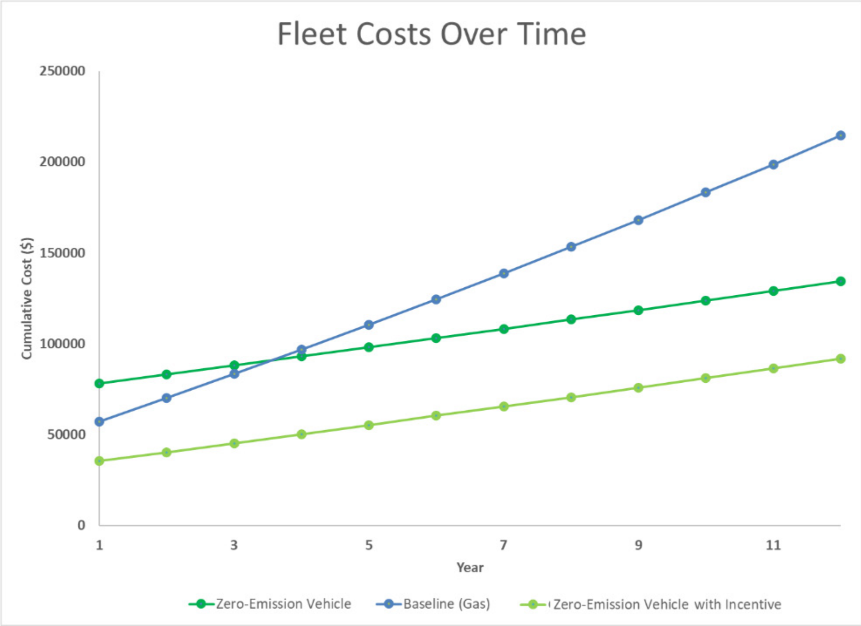
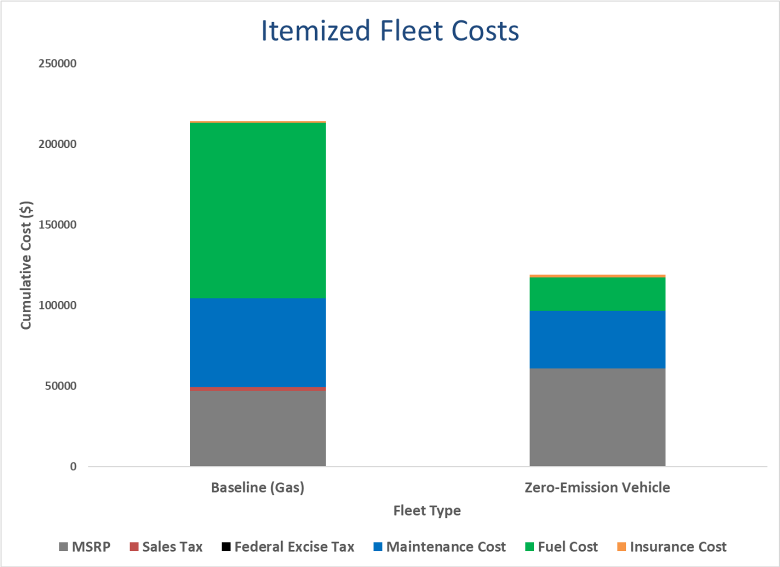


FIGURE 18 FORD TRANSIT VAN—ITEMIZED FLEET COSTS



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 manufacturer's 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 9.

TABLE 9 FORD TRANSIT VAN ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
Manufacturer's Suggested Retail Price	$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

Chevy 4500 Box Truck

Lynch Logistics' Chevy 4500 box truck has an average annual mileage of up to 35,000 miles and operates 260 days per year, meaning its daily driving distance is up to about 135 miles. Figure 19 shows cumulative costs over time and Figure 20 shows itemized total costs.

FIGURE 19 CHEVY 4500 BOX TRUCK—FLEET COSTS OVER TIME

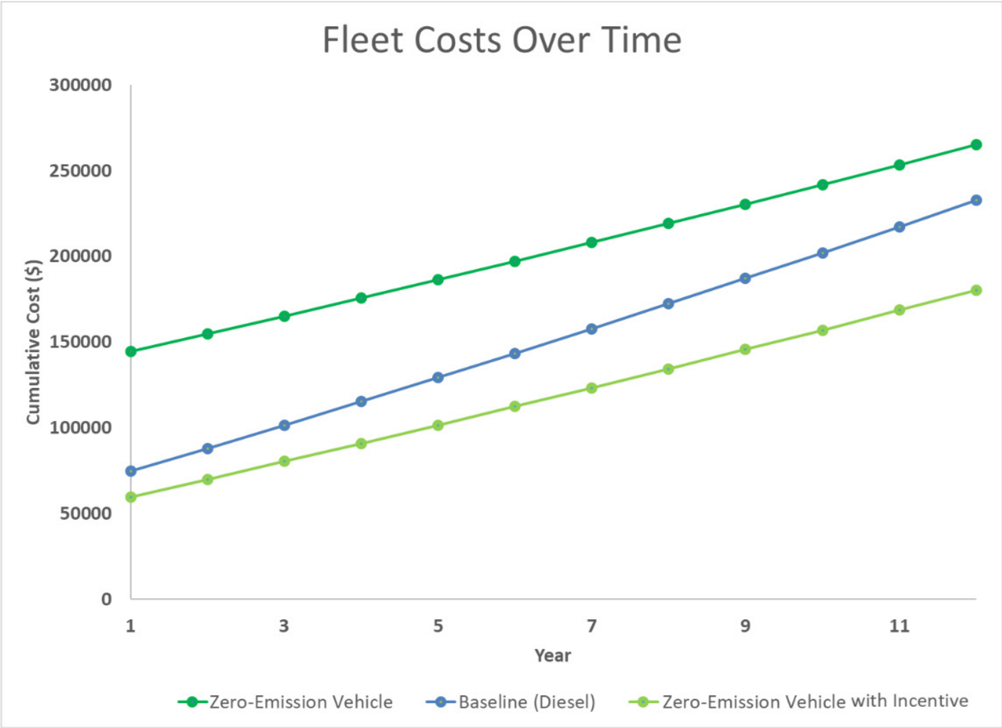
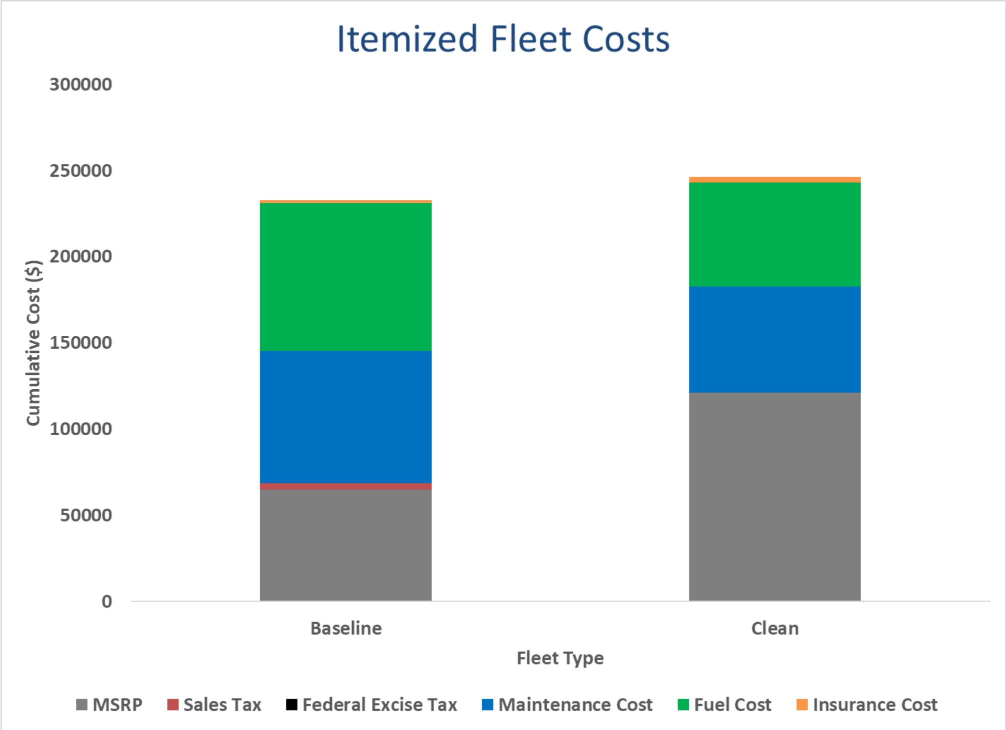


FIGURE 20 CHEVY 4500 BOX TRUCK—ITEMIZED FLEET COSTS



This TCO analysis compares a diesel-powered box truck priced at $65,000 with an electric box truck priced at $121,000. 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 $48,400 off the purchase vehicle price. The Commercial Clean Vehicle tax credit removes $36,300 more (30 percent of the vehicle MSRP), reducing the procurement cost further to $36,300.

The results indicate that the box truck does not reach cost parity without the incentive but that the electric vehicle produces savings at the point of purchase with the incentive. The electric box truck produces estimated annual fuel costs savings of 34 percent ($1,788) and estimated annual maintenance costs savings of 22 percent ($1,400), 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 CHEVY 4500 BOX TRUCK ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
MSRP	$65,000	$121,000
Sales Tax	$3,575	$6,655
Federal Excise Tax	$0	$0
Maintenance Cost	$7,000	$5,600
Fuel Cost	$6,163	$4,375
Insurance Cost	$195	$363
Infrastructure Costs	$0	$12,200

Class 6 Truck

Lynch Logistics' 13 Class 6 Freightliner M2106 have an average annual mileage of up to 35,000 miles and operate 260 days per year, meaning their daily driving distance is up to about 135 miles. Figure 21 shows cumulative costs over time and Figure 22 shows itemized total costs.

FIGURE 21 CLASS 6—FLEET COSTS OVER TIME

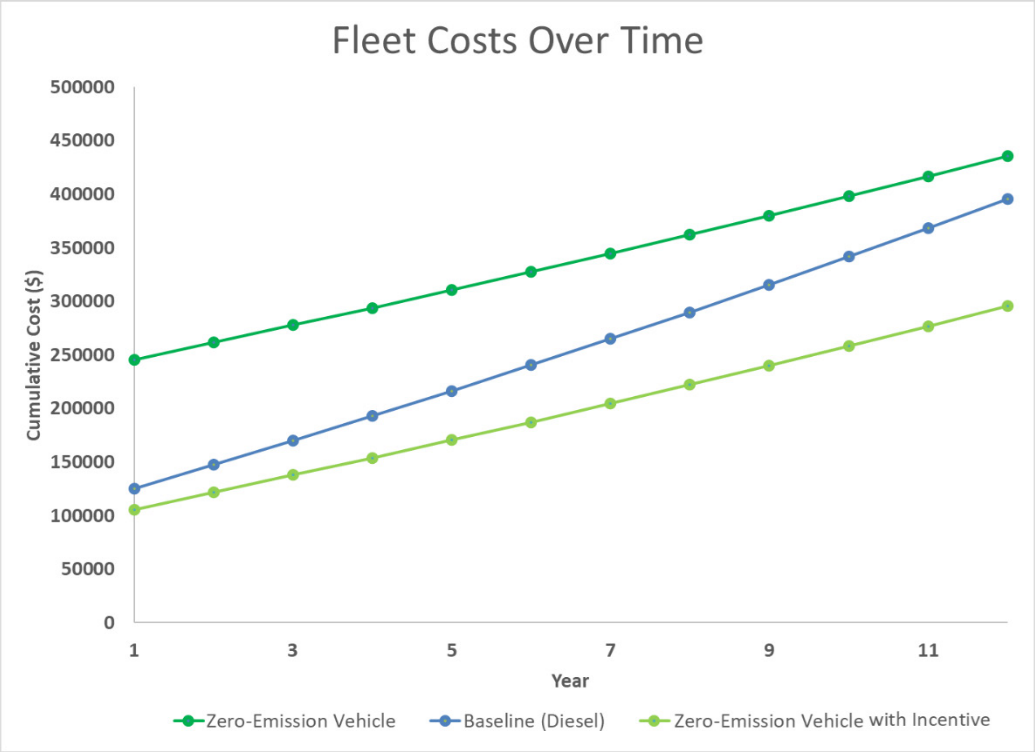
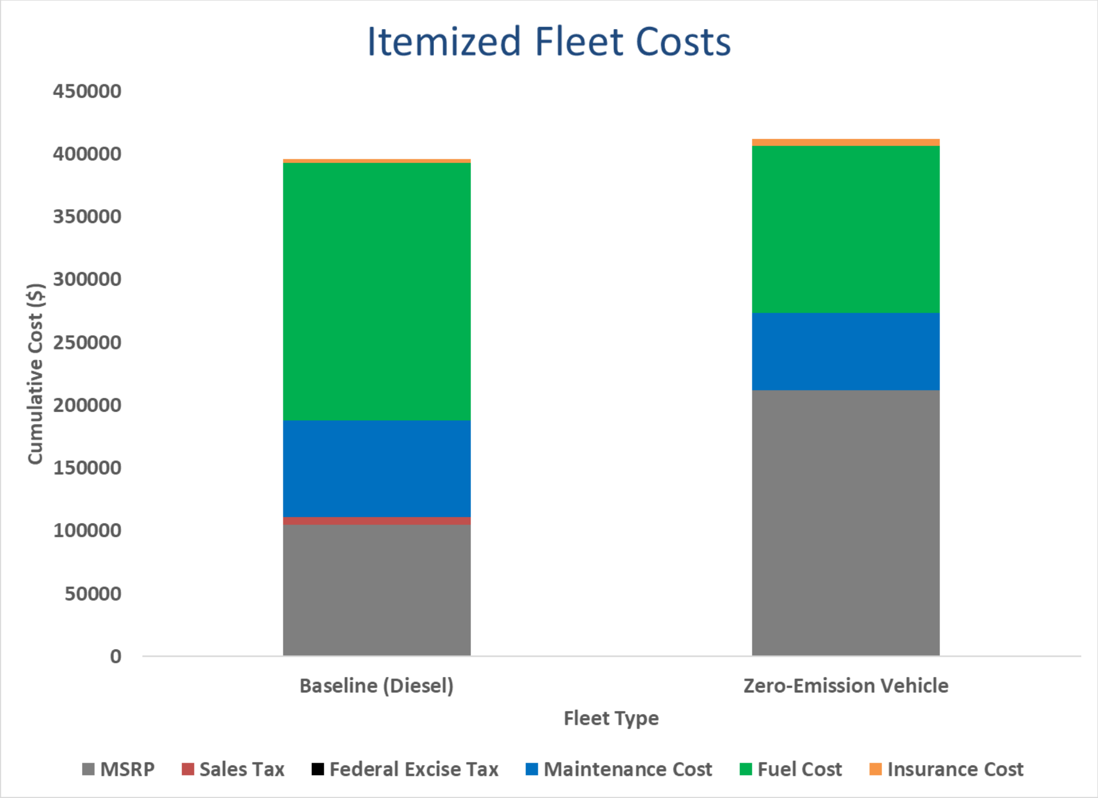


FIGURE 22 CLASS 6—ITEMIZED FLEET COSTS



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. The Commercial Clean Vehicle tax credit removes $40,000 more, reducing the procurement cost further to $72,000.

The results indicate that the Class 6 truck does not reach cost parity without the incentive but that the electric vehicle produces savings at the point of purchase with the incentive. The electric truck produces estimated annual fuel costs savings of 42 percent ($5,140) and estimated annual maintenance costs savings of 22 percent ($1,400), 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 11.

TABLE 11 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	$7,000	$5,600
Fuel Cost	$24,766	$9,625
Insurance Cost	$300	$604
Infrastructure Costs	$0	$12,200

Class 7 Truck

Lynch Logistics' five Class 7 Freightliner M2106 have an average annual mileage of up to 35,000 miles and operate 260 days per year, meaning their daily driving distance is up to about 135 miles. Figure 23 shows cumulative costs over time and Figure 24 shows itemized total costs.

FIGURE 23 CLASS 7—FLEET COSTS OVER TIME

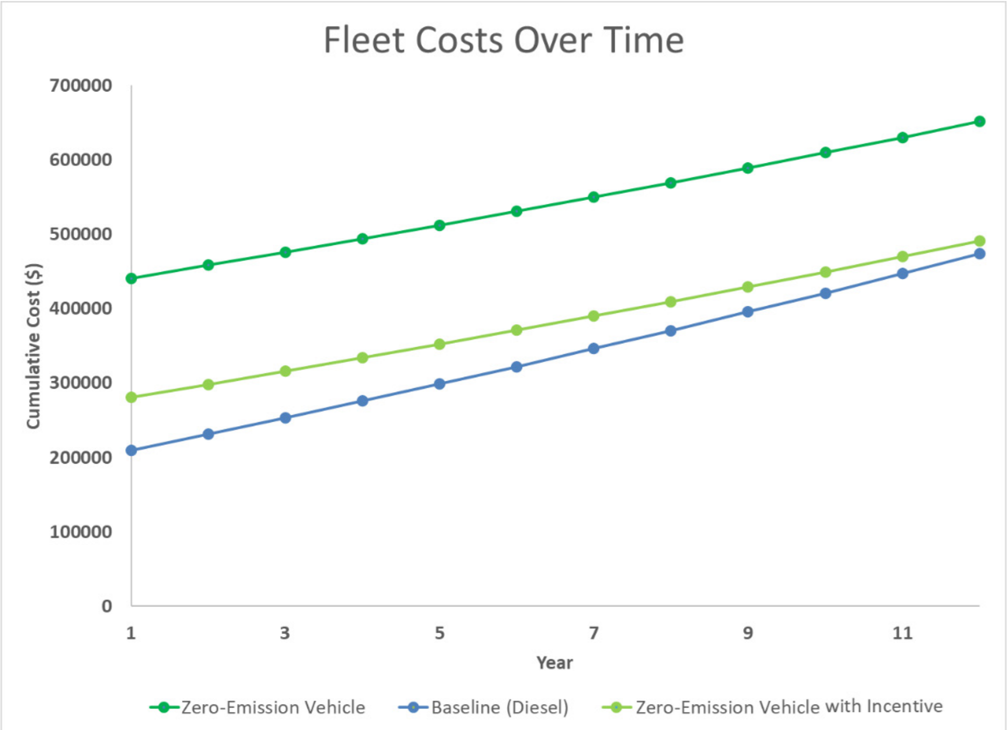
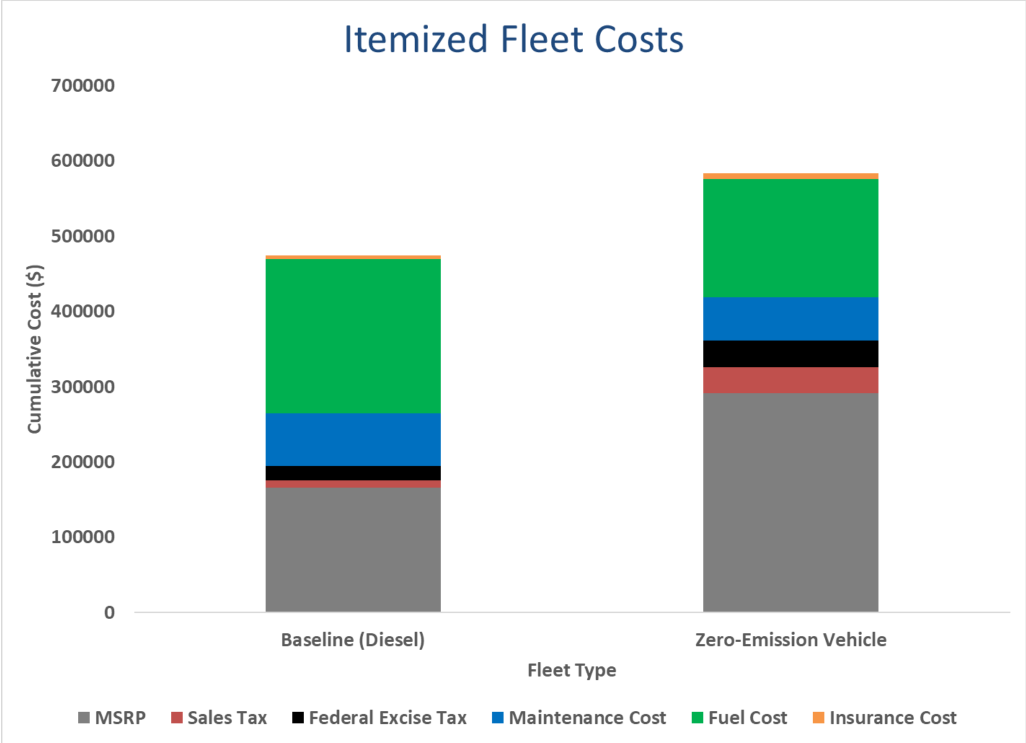


FIGURE 24 CLASS 7—ITEMIZED FLEET COSTS



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 $87,050 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. The Commercial Clean Vehicle tax credit removes $40,000 more, reducing the procurement cost further to $130,000.

The results indicate that the Class 7 truck does not reach cost parity with or without the incentive, but there are still fuel and maintenance cost savings. The electric truck produces estimated annual fuel costs savings of 26 percent ($3,390) and estimated annual maintenance costs savings of 18 percent ($1,050), 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 12.

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

Cost Components	Baseline	ZEV
MSRP	$166,000	$291,000
Sales Tax	$9,130	$16,005
Federal Excise Tax	$19,920	$34,920
Maintenance Cost	$6,300	$5,250
Fuel Cost	$14,766	$11,375
Insurance Cost	$473	$829
Infrastructure Costs	$0	$87,050

Class 8 Truck

Lynch Logistics' 30 Class 8 trucks—Freightliner 122SD, Freightliner Cascadia, and Western Star 49X—have an average annual mileage of up to 74,000 miles and operate 260 days per year, meaning their daily driving distance is up to about 285 miles. Figure 25 shows cumulative costs over time and Figure 26 shows itemized total costs.

FIGURE 25 CLASS 8—FLEET COSTS OVER TIME

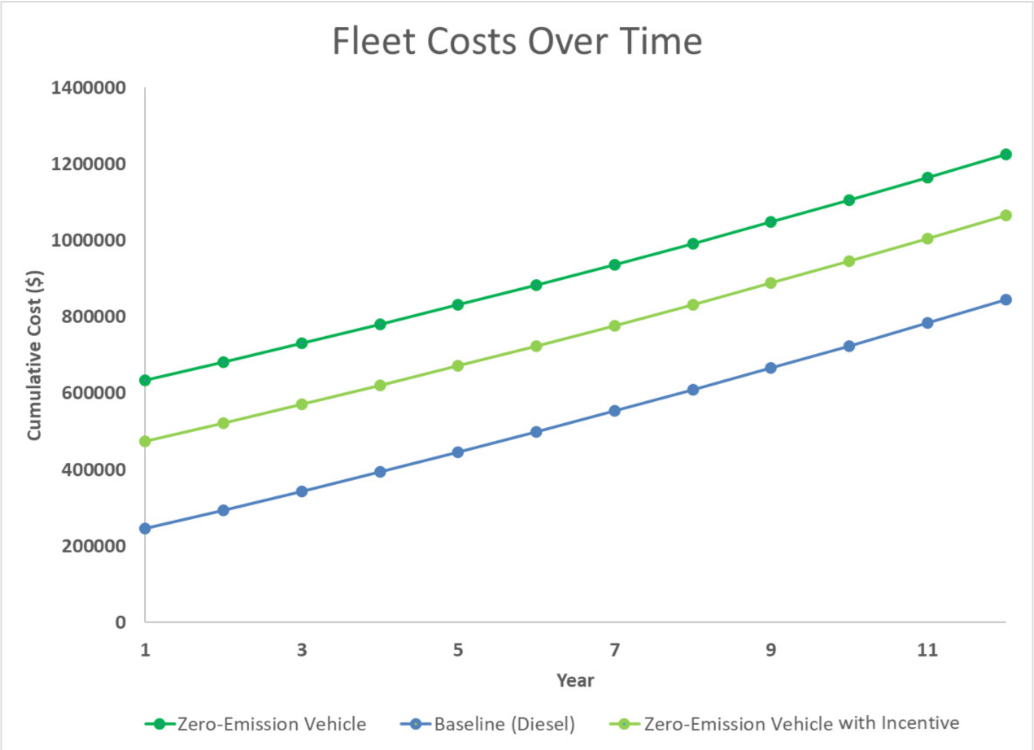
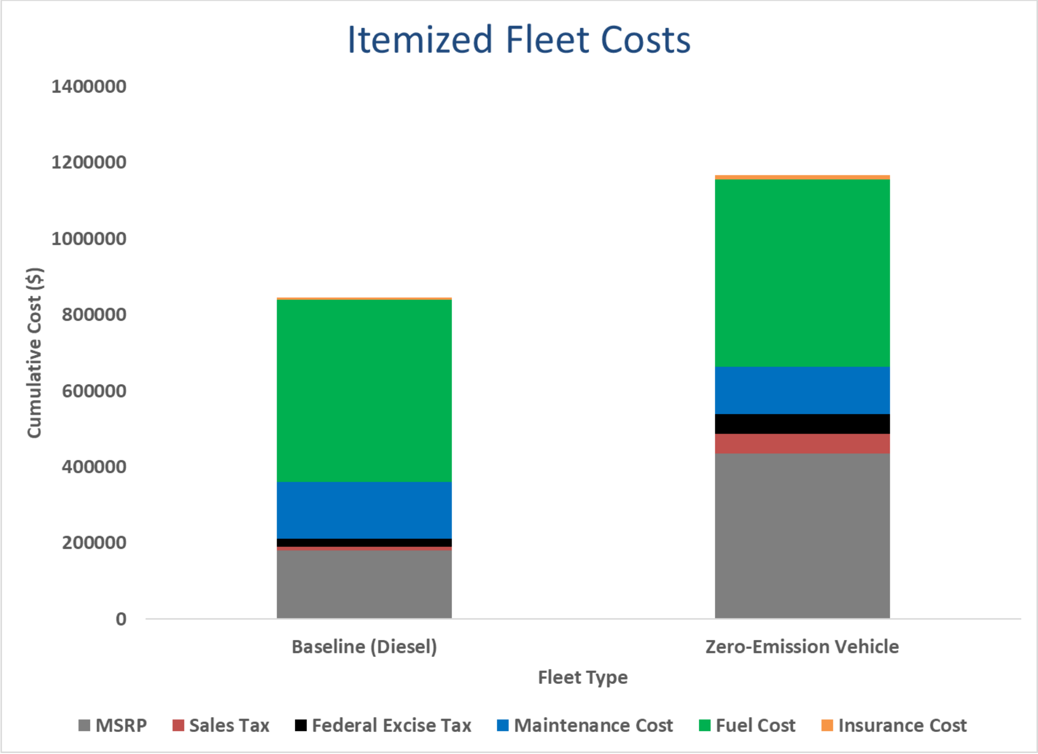


FIGURE 26 CLASS 8—ITEMIZED FLEET COSTS



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 $87,050 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. The Commercial Clean Vehicle tax credit removes $40,000 more, reducing the procurement cost further to $130,000.

The results indicate that the Class 8 truck does not reach cost parity with or without the incentive, but there are still fuel and maintenance cost savings. The electric truck produces estimated annual fuel costs savings of 26 percent ($3,390) and estimated annual maintenance costs savings of 18 percent ($1,050), 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 12.

TABLE 13 CLASS 8 TRUCK ITEMIZED CUMULATIVE COSTS OVER 12 YEAR VEHICLE LIFE

Cost Components	Baseline	ZEV
MSRP	$170,299	$435,000
Sales Tax	$10,644	$27,188
Federal Excise Tax	$20,435	$52,200
Maintenance Cost	$108,900	$90,750
Fuel Cost	$358,937	$236,973
Insurance Cost	$4,445	$11,354
Infrastructure Costs	$0	$87,050

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 Fleet 2's 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 97 vehicles in the fleet. Converting Fleet 2's vehicles to ZEVs would eliminate all of these direct emissions.

TABLE 14 INTERNAL COMBUSTION ENGINE FLEET EMISSIONS

Pollutant	Annual Emissions (Short Tons/Year)
Carbon Monoxide (CO)	13.06
Nitrogen Oxides (NO_x)	19.285
Particulate Matter (PM)	0.034
Carbon Dioxide (CO_2)	5,909

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 bidirectional charging, and Ford supports claims that the truck can provide up to 100 kWh of

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

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.