Champlain Water District

EV Fleet Study Report

May 2022

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List of Acronyms

AFLEET - Alternative Fuel Lifecycle Environmental and Economic Transportation Tool developed by Argonne National Lab

AWD – All-Wheel Drive

AEV - All Electric Vehicle (*also commonly known as Battery Electric Vehicles (BEVs)*)

CWD – Champlain Water District

EV – Plug-in Electric Vehicle, including both AEV and PHEV models

EVSE – Electric Vehicle Supply Equipment, often referred to as EV charging equipment

MSRP – Manufacturer's Suggested Retail Price

PHEV - Plug-In Hybrid Electric Vehicle

SUV – Sport Utility Vehicle

TCO – Total Cost of Ownership

Executive Summary

The Champlain Water District (CWD) contacted VEIC to request assistance examining potential electrification of their fleet vehicles to achieve sustainability goals and reduce long-term costs. VEIC completed the analysis documented in this report with support from the Chittenden County Regional Planning Commission. As described below, VEIC recommends CWD replace their entire fleet of pickup trucks and SUVs with All-Electric Vehicles (AEVs[1]) in two phases over the next eight years.

Phase One (2022-2025)

- Replace all Chevrolet Silverado 1500 and Colorado pickups with AEV light-duty pickup trucks and the Chevrolet Equinox SUV with a PHEV or AEV SUV. These replacements can occur within the next 4 years (2022-2025) due to availability of comparable EVs and projected lifetime cost savings.
    - AEV Light-Duty Pickup: the all-electric Ford F-150 Lightning Pro is the most cost-effective option for replacement of CWD's existing Chevy Silverado 1500 and Colorado full-size pickup trucks with a 4-wheel drive AEV pickup truck. Its 230-mile range will easily meet the roughly 50-mile maximum daily mileage of CWD's existing full-size trucks.
    - PHEV or AEV SUV: The Hyundai Tucson PHEV offers all-wheel drive and an electric range of 33 miles, which should enable it to cover most of CWD's current SUV travel on electric miles only. However, due to relatively low annual miles traveled and higher upfront purchase costs, its lifetime projected ownership cost is roughly $5,000 higher than CWD's existing compact gasoline SUV. An equivalent AEV compact SUV (such as the VW ID.4 Pro AWD) would have a projected lifetime cost about $11,000 higher. If CWD chooses to make this replacement in the near term it may need to seek additional subsidies.
    - AEV Compact SUV or Cargo Van: Base MSRP pricing for AEV Compact SUVs and Cargo Vans are higher than the base Ford F-150 Lightning pickup truck without offering dramatic additional operating cost savings. Consequently, AEV SUVs or Cargo vans are not recommended as a cost-effective alternative to an AEV light-duty pickup truck.
- These vehicles represent CWD's best opportunity for cost-effective, near-term electrification because their short, predictable daily range needs and moderate to high

[1] All-Electric Vehicles (AEVs) are powered solely by electric energy stored in their battery. Plug-In Hybrid Electric Vehicles (PHEVs) may operate solely from battery power over moderate distances but use a gasoline engine. Electric Vehicles (EVs) include both AEVs and PHEVs. See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for details.

annual mileage can be easily met by existing AEVs. The recommended PHEV compact SUV is an excellent match for CWDs operations, though not currently projected to offer lifetime savings compared to a gasoline version.

- Based on known data, each of these vehicles are good candidates for replacement with EVs and should achieve sufficient lifetime operating savings (at least $3,477 per vehicle) to justify the higher initial capital investment for vehicle purchasing and charging station costs, after taking incentives into account (Figure ES-1, below).
- CWD could save $19,400 in net lifetime costs relative to conventional gasoline-powered vehicles and reduce lifetime carbon emissions by 126 short tons.

Phase Two (2025-2030)

- Replace all Chevrolet Silverado 2500 and 3500 pickup trucks with medium-duty AEV or PHEV pickup trucks.
- These AEV medium-duty pickup trucks represent vehicle types that are currently projected to be more expensive over their lifetime compared to conventional gasoline or diesel vehicles, based on CWD's annual mileage. Medium-duty AEV pickup trucks are also not currently widely available but some options are expected to be on the market in the next eight years[2]. Purchase costs for these vehicles are also expected to decrease, which should bring their total lifetime costs closer to equivalent gasoline or diesel vehicles.
- Due to their higher costs, these medium-duty AEVs may require additional subsidies to ensure cost savings during replacement of existing gasoline or diesel medium duty pickup trucks with EV equivalents. Current estimates indicate that replacing CWD's 11 medium duty pickup trucks would cost an additional $62,455 due to higher MSRP AEV prices. This estimate may change as additional, lower cost EV models become available over the next several years with net saving likely to follow.[3]
- These purchases should be planned for 2026-2030 in response to the market dynamics noted above.
- Replacing all of CWD's medium duty pickup trucks during Phase Two will further reduce lifetime carbon emissions by 332 short tons.

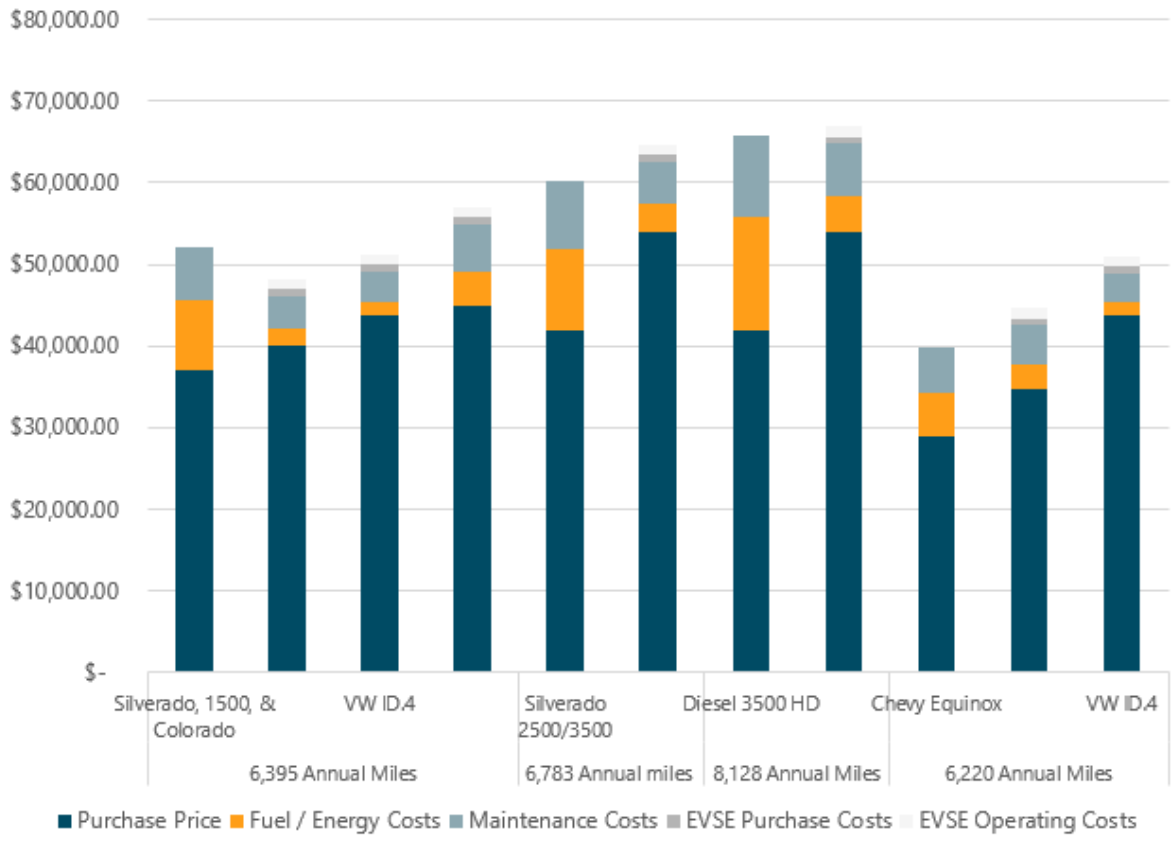
Charging Infrastructure (2022-2030)

[2] https://gmauthority.com/blog/2021/08/gm-has-plans-to-offer-a-new-all-electric-medium-duty-chevy-truck/
[3] DOE Projects Zero Emissions Medium- and Heavy-Duty Electric Trucks Will Be Cheaper than Diesel-Powered Trucks by 2035: https://www.energy.gov/articles/doe-projects-zero-emissions-medium-and-heavy-duty-electric-trucks-will-be-cheaper-diesel

- CWD should plan for installation of up to 19 additional electric vehicle supply equipment (EVSE) ports over the next 8 years
    - Each AEV pickup truck should have a dedicated Level 2 EVSE port to ensure they are fully-charged each morning and to minimize staff efforts to shuffle vehicles between any shared charging station ports
    - The PHEV compact SUV would benefit from having a dedicated EVSE port to ensure it is fully-charged each morning, but could share a port to decrease costs.
    - Selecting more basic, lower-cost EVSE options is recommended to reduce capital and operating costs to maximize lifetime TCO savings.

Over the course of both phases, CWD can expect to reduce lifetime carbon emissions by 458 short tons or 79% of their current emissions.

Figure ES-1. Lifetime total cost of ownership for Ford F-150 Lightning, Volkswagen ID.4 and Ford E-Transit (full-size cargo van) AEV compared to gasoline-powered options.



Funding Opportunities

CWD should pursue the following incentives to support EV and EVSE deployment and monitor for any additional opportunities that may become available:

- Green Mountain Power EV incentives – $1,500 per vehicle for AEVs and $1,000 per vehicle for PHEVs.[4]
- VT Department of Buildings and General Services – State Contract for EVSE: CWD could avoid engaging in a procurement process by participating in this program.[5] Future State procurements may also provide access to competitive vehicle pricing options.
- CWD's Energy Savings Account – CWD may be able to cover the purchase cost of EVSE with load management capabilities through their energy savings account.

[4] https://greenmountainpower.com/rebates-programs/business-innovation/electric-vehicles/

[5] https://bgs.vermont.gov/content/electric-vehicle-ev-charging-stations

Background

Champlain Water District (CWD) is a public drinking water utility headquartered in South Burlington, Vermont serving approximately 83,000 customers. CWD contacted VEIC to help them plan for a fully electrified vehicle fleet over the next eight years in order to reduce their carbon footprint and increase operational efficiency. This study identifies immediate candidates for vehicle electrification and lays the groundwork for more significant fleet transition in the future.

Recommendations

Vehicles

This study focused on evaluating potential AEV replacement for CWD's 19 light and medium-duty fleet vehicles.

Based on CWD's six-year typical vehicle lifetime, estimated annual mileage and operation needs of current vehicles, as well as projected market availability and purchase price by vehicle type, we recommend CWD deploy AEVs into their fleet in two distinct phases between now and 2030:

Recommended Phase One vehicles consist of light-duty pickup truck and compact SUV replacements which can occur within the next 4 years (2022-2025) due to availability of comparable EVs and projected lifetime cost savings.

Recommended Phase Two vehicles consist of medium-duty pickup truck replacements which should be planned for 2026-2030 when comparable EV medium-duty pickups should be available and more cost effective than current near-term projections.

The recommended vehicles present CWD's best opportunity for cost-effective electrification because their short, predictable daily range needs and moderate to high annual mileage can be easily met by existing AEVs and can charge overnight at their current parking locations. Based on known data, each of these vehicles are good operational candidates for replacement with AEVs and should achieve sufficient lifetime operating savings (nearly $9,000 per vehicle) to justify the higher initial capital investment into vehicle and charging station costs, after taking incentives into account.

Pickup Trucks

Phase One

We identified seven mid- and full-size pickup trucks in CWD's existing fleet that are strong candidates for replacement with all-electric full-size pickup trucks during Phase One. The current vehicles are four Chevy Silverado 1500 full-size pickups and three Chevy Colorado mid-size pickups, which are assigned to CWD's Water Quality, Engineering, Electrical, and General Manager departments. They travel an estimated average of approximately 6,500-miles per year with a maximum daily travel distance of roughly 100 to 200 miles for most (and one vehicle at 150 miles).

Of available AEV models, we recommend the all-electric Ford F-150 Lightning Pro as the most cost-effective AEV option for replacement of CWD's existing gasoline light-duty pickup trucks. Its 230-mile range will be more than sufficient to meet the 100 to 200 mile maximum daily mileage of most of CWD's pickups, including reductions in range due to cold-weather (which may reduce the range down to 138 miles).

We note that CWD does have one pickup identified with a maximum trip distance of 150 miles, which exceeds the Ford F-150 Lightning Pro's estimated minimum winter range. If this trip distance must be met during the coldest days of the year, Ford also offers an extended range option (300 miles) for an additional $10,000. Adding one or more longer-range pickups into CWD's light-duty fleet may also enable CWD to assess whether the additional battery capacity is worthwhile to have during extended emergency deployments. Alternatively, longer-range needs in winter could be met by one of CWD's existing gasoline or diesel light or medium-duty trucks in the near-term.

The Ford F-150 Lightning is the only fleet-focused mass-market all-electric pickup truck on the market currently. Additional options for CWD in the next three years will likely include the GM all-electric Silverado EV pickup, and possibly the Lordstown Endurance (base price $52,500, 250+ mi range) - however production and delivery details for these two models are not currently available. Luxury-oriented electric pickup trucks (like the Rivian R1T and GMC Hummer EV) have dramatically higher pricing (starting at $74,000) so are not projected to be cost-effective options.

Phase Two

We identified eleven medium duty sized pickup trucks in CWD's existing fleet that are strong candidates for replacement with plug-in hybrid or all-electric medium duty pickup trucks during Phase Two. The current vehicles are six Chevy Silverado 2500 HD pickups and five Chevy Silverado 3500 HD pickups, which are assigned to CWD's Electrical, Distribution, and Transmission departments. They travel an estimated average of approximately 6,800-miles per year with a maximum daily travel distance of roughly 100 to 200 miles.

There are currently no AEV medium-duty pickup trucks available on the market, and major truck manufacturers have not offered much information on pricing and delivery expectations. GM recently noted they plan to offer a medium duty pickup truck after 2025[6], but Ford has not committed to developing an equivalent electric medium-duty truck[7]. Third-party upfitters such as XL Fleet currently offer plug-in hybrid upfits of existing medium-duty pickup trucks[8], and will likely continue to do so until PHEV or all-electric options are offered by mainstream truck manufacturers. These PHEV upfits do improve fuel economy by up to 50%, but they do not currently offer travel in an electric-only mode. Additionally, upfit costs are high (roughly $25,000 per vehicle) so vehicles typically must be driven more than 20,000 miles per year to achieve lifetime cost savings.

Due to greater weight and power demands, medium-duty pickup trucks will require larger batteries than existing light-duty all-electric vehicles. As battery prices continue to decrease in the coming decade we expect capital costs for these and other medium and heavy duty vehicles will also decrease, bringing their total lifetime costs closer to equivalent gasoline or diesel vehicles.[9]

SUVs

Phase One

We identified one compact SUV in CWD's existing fleet as a strong candidate for replacement with either a plug-in hybrid or all-electric SUV during Phase One - the Chevy Equinox, which is assigned to CWD's Water Quality department. The Equinox travels an estimated average of approximately 6,200-miles per year with a maximum daily travel distance of roughly 50 to 100 miles.

If CWD chooses to procure a PHEV SUV replacement the plug-in hybrid electric Hyundai Tucson PHEV would make a suitable cost-effective option for replacement of CWD's existing compact gasoline SUV. Its 33-mile electric range (and 420-mile combined range) will be more than sufficient to meet the 50-mile maximum daily mileage of CWD's SUV and should enable the majority of trips to be completed solely on electric power. This is true even in winter months when CWD should expect to see up to a 40% reduction in battery range on the coldest days.[10]

[6] https://gmauthority.com/blog/2021/08/gm-has-plans-to-offer-a-new-all-electric-medium-duty-chevy-truck/
[7] https://insideevs.com/news/550764/ford-superduty-lightning-not-planned/
[8] https://xlfleet.com/vehicles/
[9] Decarbonizing Medium- & Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis (nrel.gov)
[10] Report: AAA Electric Vehicle Range Testing, February 2019 - *https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range/*

In contrast, if CWD chooses to procure an AEV SUV replacement the Volkswagen ID.4 AWD would be a suitable option to consider. Its 280-mile electric range would be more than sufficient to meet the 50-mile maximum daily mileage of CWD's SUV.

CWD may need to seek additional subsidies to achieve total cost of ownership savings to replace their compact SUV with an AEV equivalent. Current estimates indicate an AEV SUV replacement would cost an additional $11,228 in total cost of ownership - although this estimate is likely to decrease as additional lower-cost AEV models become available in the next few years. CWD would need to exceed 18,000 miles annually with an AEV SUV to ensure a break-even on total cost of ownership without external subsidies. Similarly, we estimate a PHEV option would need to exceed 15,500 miles per year to break-even.

Charging Stations

We recommend that CWD install up to 19 charging station ports to support the recommended AEVs.

Each AEV should have a dedicated Level 2 charging station port to ensure they are fully-charged each morning. If CWD chooses one or more PHEVs, each new PHEV would benefit from its own charging station port to ensure vehicles are fully charged when needed, and to avoid staff time and coordination spent managing vehicle charging when there are fewer chargers than vehicles. However, because of their smaller batteries and reduced charging time, PHEVs could share ports if desired.

Note that the number and timing of AEV deployment may be limited by how many Electric Vehicle Supply Equipment (EVSE, aka Charging Stations) units can be deployed at overnight parking locations, and how quickly.

Location Selection

CWD fleet vehicles are parked in two main parts of their facility – the Maintenance Garage and the Wastewater Treatment Plant. Most vehicles are parked overnight at these two locations (though two vehicles are typically taken home by employees).

Table 1. Number of recommend EVSE installations by location and phase

Parking Location	Phase One (2022-2025)	Phase Two (2026-2030)
Water Treatment Plant (WTP)	4	1
Maintenance Garage	2	10
Home	2	0
Total	**8**	**11**

The vehicles recommended for replacement during Phase One are parked in a variety of locations, with the greatest concentration at the wastewater treatment plant. In contrast, nearly all vehicles recommended for replacement during Phase Two are parked at the Maintenance Garage.

We recommend CWD continue to work with Green Mountain Power to assess existing electrical infrastructure and develop phased plans for any necessary infrastructure upgrades, as well as purchase and installation of charging stations, that align with the expected timing of vehicle replacements at these two main locations.

For example, CWD may wish to focus on planning for deployment of five (or more) charging station ports at their WTP parking area in the next 3-4 years to accommodate expected Phase One vehicle replacements, while postponing detailed planning and site work for the 10+ charging station ports expected to be needed at the maintenance garage until closer to Phase Two. However, CWD and GMP can assess and plan for overall fleet and facility-wide charging needs between these two parking areas based on full fleet electrification by 2030, and determine whether any infrastructure upgrades (such as transformers, switchgears, panels or conduit runs) will need to be made in order to enable deployment of up to 19 charging station ports by 2030, and how these upgrades should be staged.

Alternatively, if CWD is planning facility upgrades in the near term that could streamline EVSE installation, then vehicle parking locations may be adjusted to provide lower-cost access to AEV replacements recommended in the first phase of implementation.

Two light-duty pickup trucks that are currently taken home by management staff each night, are typically parked at the WTP during at least part of the workday and travel an average daily distance of 43 and 17 miles respectively. As a result, we expect that these two vehicles may be able to charge during the day at unoccupied chargers while other vehicles are in the field. If not, CWD may wish to add additional charging stations at the WTP to accommodate daytime charging for the vehicles.

Note that these recommendations do not include consideration of additional charging stations for employee workplace charging. CWD may wish to assess during their EVSE planning process

whether they would like to support employee personal EV adoption by providing workplace charging opportunities, and if so, whether this could be accomplished by making unoccupied fleet charging stations available to employee personal vehicles during the day, or whether additional designated employee or guest charging stations should be deployed concurrently with Phase One or Two fleet charging stations.

EVSE Equipment

Power: We recommend that CWD consider mid-power Level 2 charging stations for most of their parking locations. All Level 2 charging stations operate on 240V power, and mid-powered units require 50-60A circuits while providing roughly 9 – 12 kW of charging power. For a standard-range Ford F-150 Lightning, these charging stations would be able to deliver 15-20 miles of range per hour of charging.

CWD may also wish to consider dual-port Level 2 charging stations that can run off a single 80A circuit and either deliver a slightly faster charge when one vehicle is plugged in, or a slightly slower charge when two vehicles are plugged in.

As CWD's electric fleet expands, and medium-duty electric trucks with larger batteries begin to be added, CWD may also want to consider adding one or several higher-powered charging stations to enable faster charging of specific vehicles when needed. These options include:

- High-powered Level 2 charging stations - 240V alternating current (AC), requiring 100A circuits, while providing 19.2kW of charging power. Roughly 30 miles of range per hour of charging for standard range Ford F-150 Lightning.
- Medium-powered Level 3 Direct Current (DC) charging stations - typically either 240V (single phase) or 480V DC (three phase), 60A circuits, while providing up to 24kW of charging power. Roughly 40 miles of range per hour of charging for standard range Ford F-150 Lightning.
- High-powered Level 3 Direct Current (DC) charging stations - 480V DC, requiring three-phase power, while providing 50kW or more of charging power. Roughly 85 miles of range per hour of charging for standard range Ford F-150 Lightning at 50kW.

Features: To reduce annual operating costs and maximize lifetime AEV savings, we recommend that CWD select basic, lower-cost EVSE options with the following capabilities and design for their charging locations:

- Level 2 charging stations that are networked via WiFi. CWD would provide WiFi (if not already in place) rather than purchase cellular service that require additional service plans with monthly service charges.
- Level 2 charging stations that are networked and offer "managed charging" capability though a software management platform. This would enable CWD to reduce power demands (and electricity costs) when many vehicles are anticipated to be plugged in at the end of the day, while still ensuring all vehicles will be fully charged the following morning.
- Make any needed repairs on an as-needed basis, rather than paying higher upfront costs for extended warranties and maintenance plans. As-needed repairs are likely to be more cost-effective for chargers installed in non-public locations, which are less prone to damage from abuse.
- Wall-mounted charging stations with manual cable wraps will be more cost-effective than more expensive pedestal-mounted charging systems with integrated cord management.

If CWD's facilities are accessible only to staff and guests, their charging stations are less likely to encounter heavy use, misuse, or vandalism, making them ideal candidates for lower-cost, more basic EVSE. Charging infrastructure costs are detailed later in this report under Costs and Benefits of Electrification.

Electric Vehicle Incentives and Funding Programs:

There is significant policy activity at the state and federal level that could increase the availability of incentives or other funding for electric vehicles and charging equipment. It is recommended that CWD monitor legislation and take advantage of new programs as they become available. The following is information on existing programs.

1. Utility – Because CWD is a utility customer, they can access utility incentives. Green Mountain Power offers the following incentives: $1,500 for an all-electric vehicle and $1,000 for a plug-in hybrid electric vehicle https://greenmountainpower.com/rebates-programs/business-innovation/electric-vehicles/
2. CWD's Energy Savings Account – CWD may be able to cover the purchase cost of EVSE with load management capabilities through their energy savings account.
3. The State Department of Buildings and General Services has a State contract for AEV charging equipment that CWD can access. CWD could avoid engaging in a procurement process by participating in this program. https://bgs.vermont.gov/content/electric-vehicle-ev-charging-stations

4. Federal – the federal tax credits won't apply for a municipal fleet purchases but leasing options may incorporate the credits. The Climate Mayors EV Purchasing Collaborative has leasing programs that factor in the federal tax credit and provide other resources to municipalities (https://driveevfleets.org/). The now-stalled Build Back Better legislation would have allowed the federal AEV incentive to be claimed at the point of sale which could have made it more accessible for municipalities and non-profits. These provisions may return in a future bill with better prospects of passage.
5. State – the State of Vermont incentives are only currently available to individual purchasers. The Vermont Climate Action Plan finalized in late 2021 included a recommendation to extend EV incentives to public and private fleets, but it is not clear if/when the Vermont Legislature might enable this.

At this point, there are no state or federal incentives for medium or heavy-duty vehicles. However, the state's Volkswagen Settlement program can be used to replace medium and heavy-duty diesel-powered vehicles. This program is administered by the Agency of Natural Resources and CWD should watch for project solicitations. In addition, GMP could provide customized incentives through their Tier III program to support procurement of these vehicles and associated charging infrastructure:

https://greenmountainpower.com/rebates-programs/business-innovation/electric-vehicles/

GMP also has incentives for public and workplace charging, including a low interest financing option through the State Infrastructure Bank (VEDA) that may be of interest: https://greenmountainpower.com/rebates-programs/business-innovation/electric-vehicles/workplace-charging/

Costs and Benefits of Electrification

Replacing gasoline-powered fleet vehicles with AEVs will increase capital costs for vehicle purchases and charging station deployment but should result in lower annual operating costs and overall lifetime total cost of ownership along with significant emissions reductions.

Vehicle Costs

AEVs and PHEVs currently cost more than their fossil fuel counterparts, with a typical price premium of around $8,000-$10,000 for a AEV or PHEV SUV. However, AEVs achieve operational energy and maintenance savings relative to conventional gasoline vehicles over their lifetime. AEVs have fewer moving parts requiring less maintenance. Their electric motors and regenerative braking capability enable them to operate much more efficiently than gasoline-powered internal combustion engine vehicles. PHEVs generally achieve smaller fuel cost savings than AEVs (depending on how much of their travel is in electric-only mode) but achieve only

marginal maintenance savings, as they contain both electric and conventional powertrains which require regular maintenance.

In addition, CWD's cost of electricity is roughly equivalent to $0.93-$1.23 per gallon of gas on a kWh basis, compared with VT average pricing (March 2022) of approximately $3.67 per gasoline gallon and $4.17 per diesel gallon[11]. Table 2 presents the per-vehicle budgetary estimates for EV planning purposes. (Methodology and assumptions are documented in Appendix C – Methodology).

Table 2. Example per-vehicle EV capital and operating budgetary estimates

	AEV Light-Duty Pickup replacing Gasoline Pickup	PHEV SUV replacing Gasoline SUV	AEV Medium-Duty Pickup replacing Gasoline Pickup
One-time Upfront Capital Costs			
Purchase Premium	-$1,474	-$4,750	-$10,500
EVSE Capital Cost	-$1,500	-$1,500	-$1,500
Total Upfront Cost	-$2,974	-$6,250	-$12,000
Annual Operating Costs			
Electricity/Fuel Cost	-$355	-$484	-$559
Avoided Vehicle Maintenance	$394	$119	$516
Avoided Fuel Cost	$1,096	$394	$1,078
EVSE Operating & Maintenance Costs	-$215	-$215	-$215
Total Annual Operating Cost Savings	$1,275	$298	$1,380
Lifetime Savings			
Lifetime Operating Cost Savings	**$7,648**	**$1,788**	**$8,278**
Net Lifetime Savings	**$4,674**	**-$4,462**	**-$3,722**

When calculating total cost of ownership for AEVs, expected investments in the charging infrastructure needed for them to operate are factored in to provide a more complete picture of overall costs and savings.

[11] AAA Gas Prices

Energy Costs

Because electric vehicles are considerably more efficient than conventional vehicles, per-vehicle annual energy savings are predicted to range from $400 to over $1,000 based on per-kWh electricity rates.

However, EVs (and especially AEVs) can draw enough power while charging to increase monthly electricity demand charges for the facility where they are charged. This is most likely to occur at facilities that have steady electricity demand throughout the day and night, and where multiple EVs are charged at the same time. Demand charges could add approximately $640 in annual electricity costs per AEV pickup for off-peak charging and $2,225 per AEV pickup for on-peak charging if not properly managed. These demand charges were not included in the total cost of ownership estimates in this report.

For example, CWD's recommended fullsize pickup replacements are anticipated to consume roughly 3,750 kWh of electricity per vehicle per year, assuming they travel 6,500 miles/year. The recommended Ford F-150 Lightning Pro draws up to 11.3 kW of power when charging with its standard onboard charger.

CWD's electric rate class was assumed to be Rate 63 from Green Mountain Power (GMP)[12] for their various buildings and parking facilities. Rate 63 is a Time of Use (TOU) rate, with volumetric energy costs ($/kWh) and power demand costs ($/kW) differing between peak times (6am-11pm Monday-Friday) and off-peak times (all other hours). These rates are:

Peak kW: $16.401

Off-peak kW: $4.723

Peak kWh: $0.11573

Off-peak kWh: $0.08795

VEIC estimated that approximately 80% of CWD's EV charging will occur during off-peak hours between 11pm and 6am, with 20% occurring during the day on weekdays (to account for any midday charging opportunities that CWD may choose to utilize). As a result, VEIC developed a blended rate of $0.0935/kWh to reflect this anticipated charging approach, and used this rate for all TCO calculations.

The roughly 8,000 kWh of electricity consumption at a rate of $0.0935/kWh would cost roughly $350 per year (which is included in the TCO estimates in this report). If the AEV pickup was charged when the facility electricity demand was already at its highest point, the overall electricity demand of the facility would increase by up to 11.3 kW. If this occurred during off-peak hours, this would result in a demand charge increase of $53/month (or $640 annually). If

[12] Rate-63-65-Commercial-and-Industrial-10.1.21.pdf (greenmountainpower.com)

this occurred during on-peak hours, this would result in a demand charge increase of $185/month (or $2,225 annually).

Smaller AEVs and PHEVs commonly draw 6-7 kW while charging, and so have the potential to increase demand charges by $31/month (or $375 annually) off peak and by $108/month (or $1,300 annually) on-peak .

To minimize these potential costs:

- Work with Green Mountain Power and/or Efficiency Vermont to analyze rate structure, current electricity demand and costs and potential measures to reduce the impact of EV charging activity on facility demand peaks.
- Use networked EVSE with capability to modulate charging to reduce power demand while ensuring vehicles are fully charged when needed
- Schedule charging to occur when facility demand is lowest during both peak and off-peak hours.

Charging Infrastructure Costs

Charging infrastructure costs can vary considerably based on charging station power, features, and amenities. VEIC's analysis assumes low-end costs for EVSE. Note that expenses will increase with higher-end, fully featured options that include extended warranties, maintenance contracts, higher annual network fees and more consumer-oriented optional amenities (such as cable management, pedestal mounts and user payment interfaces). Table 3 lays out EVSE costs to CWD.

Table 3. Comparative Costs of Basic vs High-end Level 2 Networked Charging Stations (Per Port)[13]

Per Port	Basic EVSE	High-end EVSE
Purchase Cost	$1,300	$3,500
Installation Cost	$3,000	$3,000
Annual Maintenance	$95	$250
Annual Network Fees	$120	$220
Ten-Year Total Cost to CWD	**$6,450**	**$11,200**

[13] EVSE equipment and networking cost estimates came directly from EVSE manufacturers. Maintenance costs were estimated based on data provided by current fleet and commercial EVSE owners.

The difference of $4,750 in per-port EVSE lifetime operating costs at the bottom line of Table 3 is a key factor in EV cost-effectiveness. If CWD chooses to deploy a single higher-end charging station port per recommended EV, lifetime savings (which range up to $4,700 per vehicle for LD pickups) will likely *decrease* by up to $2,900 per vehicle.

Medium-powered DC fast chargers (25kW) are more expensive ($10,000-$15,000 for more basic equipment to more than $40,000 for larger, more powerful stations, and typically $50,000 or greater for high-powered DC fast charging stations (50kW or greater).

Installation costs are highly variable based on many site-specific considerations, such as whether existing electrical infrastructure needs to be upgrade and/or run to a new location, and whether trenching will be required. Table 3 provides a placeholder Level 2 charging station installation cost value of $3,000 per port for high-level planning purposes, but those costs at specific sites could vary between $1,000 to over $10,000 per port for installation (depending on the complexity/difficulty).

Medium and high-powered charging stations have considerably higher installation costs due to more robust electrical infrastructure requirements (such as 480V, three-phase power supply). These costs can range $4,000 to $15,000 per port on the lower end to over $50,000 for larger and more complex projects.

VEIC assumes an anticipated charging station unit lifespan of 10 years, and a lifespan of 25 years for the electrical infrastructure supporting the charging station (circuits, wires, conduit, panel, concrete pad, etc.). Because CWD replaces their vehicles roughly every 6 years, the costs highlighted in Table 3 have been amortized over the expected lifespan of the charging stations and infrastructure, and only the portion of these costs corresponding to expected vehicle lifespan are applied to the vehicle total cost of ownership analysis.

EVSE Equipment Costs

Level 2 charging stations can range in price from about $1,300 per port up to $3,000 per port. For charging at CWD's limited-access facilities, lower-cost, more basic EVSE should suffice. Instead of pedestal-mounted systems with integrated cord management, CWD should seek wall-mount units with manual cord wraps to maximize cost-savings.

Figure 1. L to R - Single wall-mounted EVSE (Juicebox, ChargePoint); Dual pedestal-mounted EVSE (ChargePoint)

EVSE Operating Cost

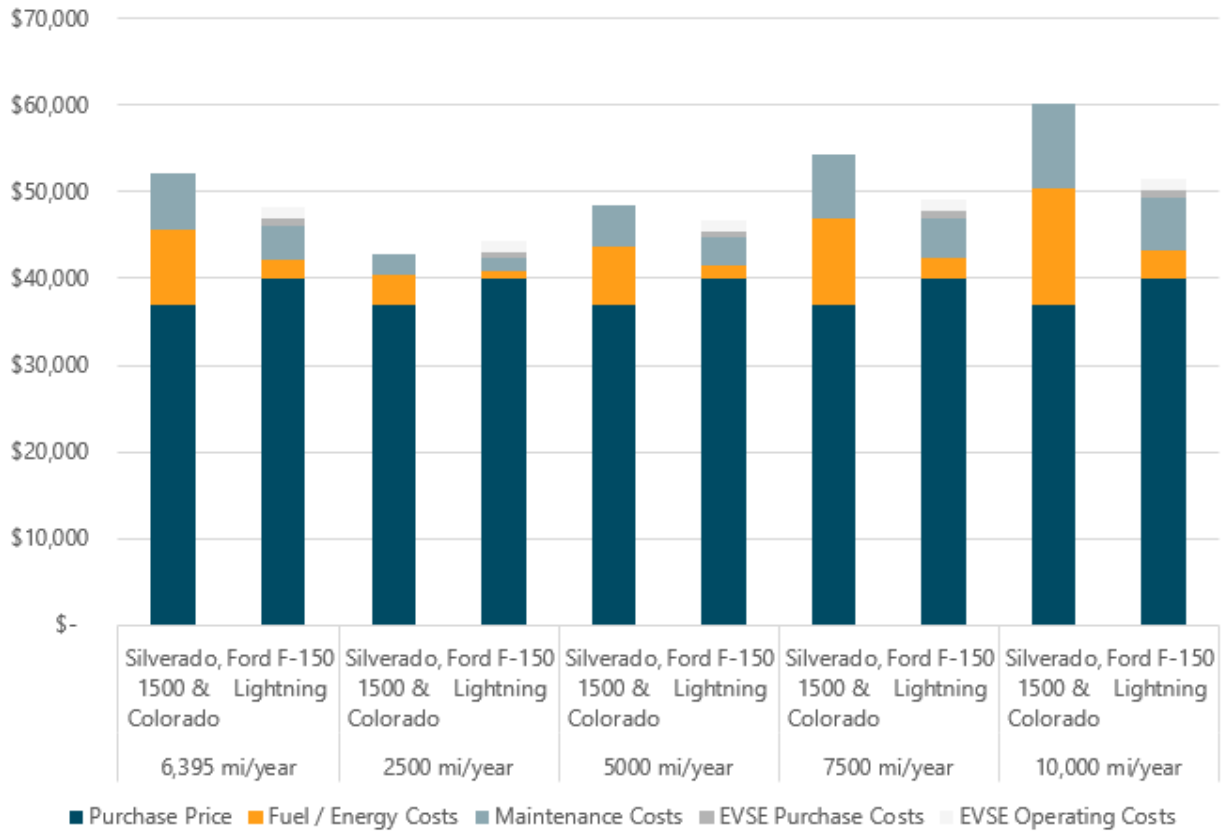
Networked charging can provide numerous benefits, such as the ability to manage charger access and user fees, station, and energy use analysis, as well as minimize electricity demand charges through automated "managed charging" protocols. Annual network fees can be substantial. Lower-cost options are available if CWD can provide site WiFi.

Maintenance contracts pushed by vendors can be expensive and are generally not cost-effective for protected, private EVSE. CWD should either negotiate for a very low-cost maintenance contract for their new stations or plan to assign CWD staff to check EVSEs for damage quarterly. If any locations are accessible to the public and subject to vandalism, they may warrant consideration of service contracts.

Lifetime Cost-Savings

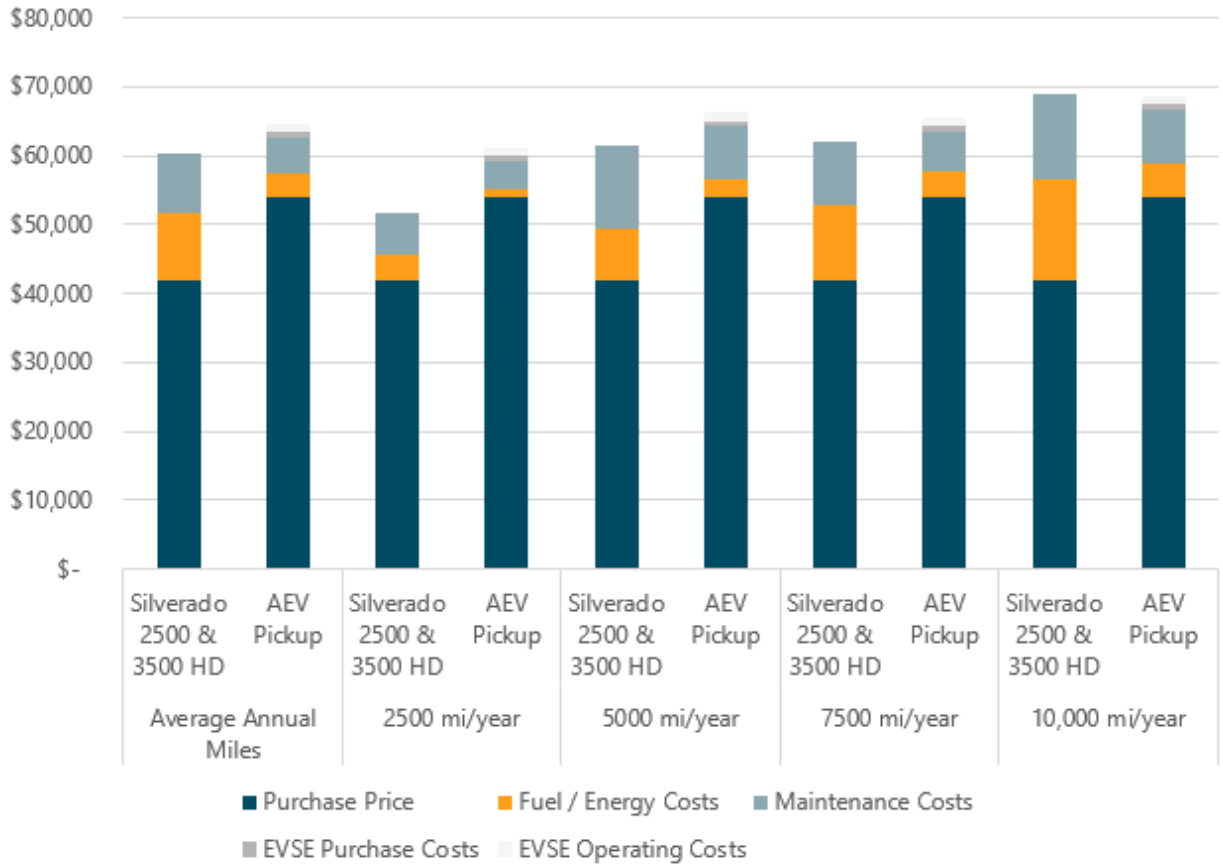
Based on known data, each of the following figures demonstrate CWD's fleet total cost of ownership (TCO) for replacement with EVs and highlight potential **lifetime operating savings for their light-duty pickup trucks of $4,674 per vehicle** to justify the higher initial capital investment into vehicle and charging station costs, after taking incentives into account. Figure 2 presents a visualization of simple total cost of ownership, assuming low-end EVSE costs and average annual mileage by vehicle type.

Figure 2. Lifetime total cost of ownership for Ford F-150 Lightning compared to a Chevy gasoline-powered full-size pickup truck.



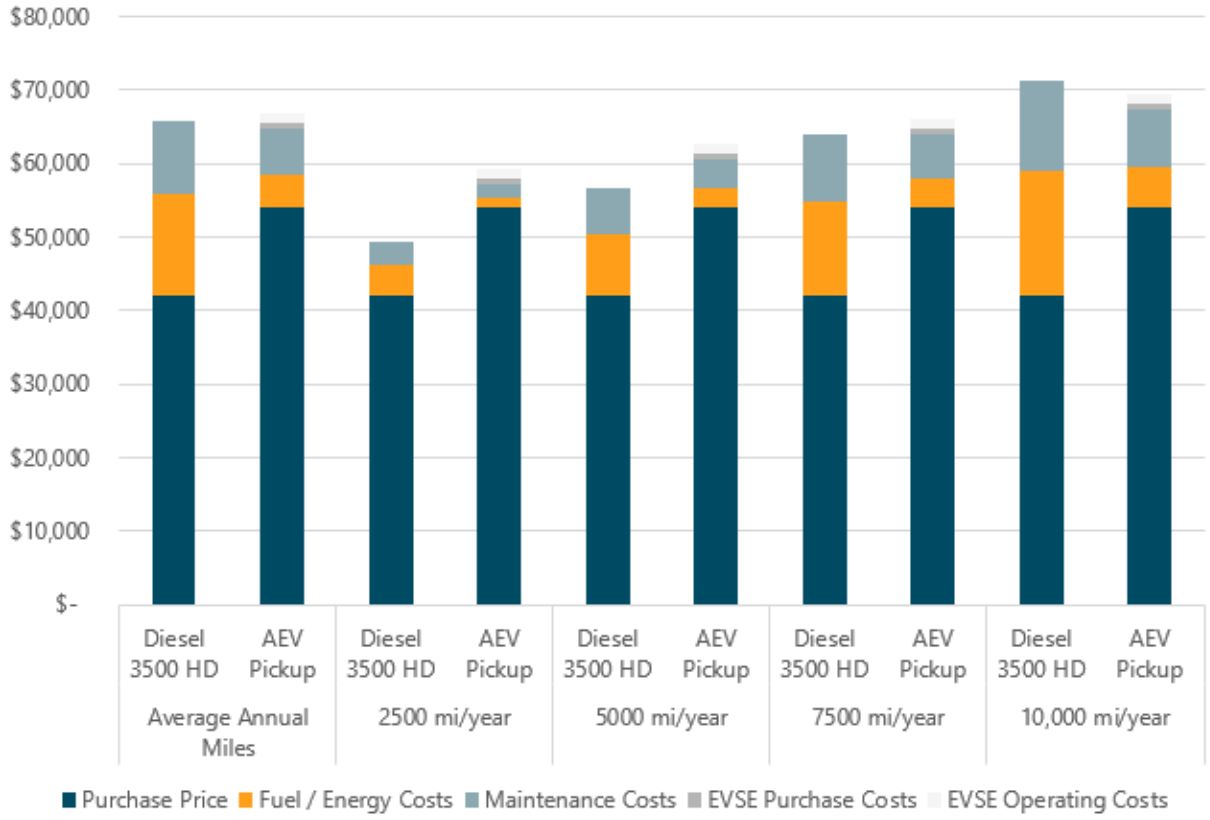
Based on the average annual miles traveled (6,395 mi), the Ford F-150 Lightning is most cost effective for CWD's light-duty pickup trucks with a net savings of $4,674 over the lifetime of each vehicle due to lower fuel/energy costs and maintenance costs. Figure 2 shows how lifetime savings for the F-150 Lightning increase as annual mileage increases up to 10,000 miles.

Figure 3. Lifetime total cost of ownership for medium-duty AEV pickup compared to gasoline-powered Chevy 2500 and 3500 HD pickup.



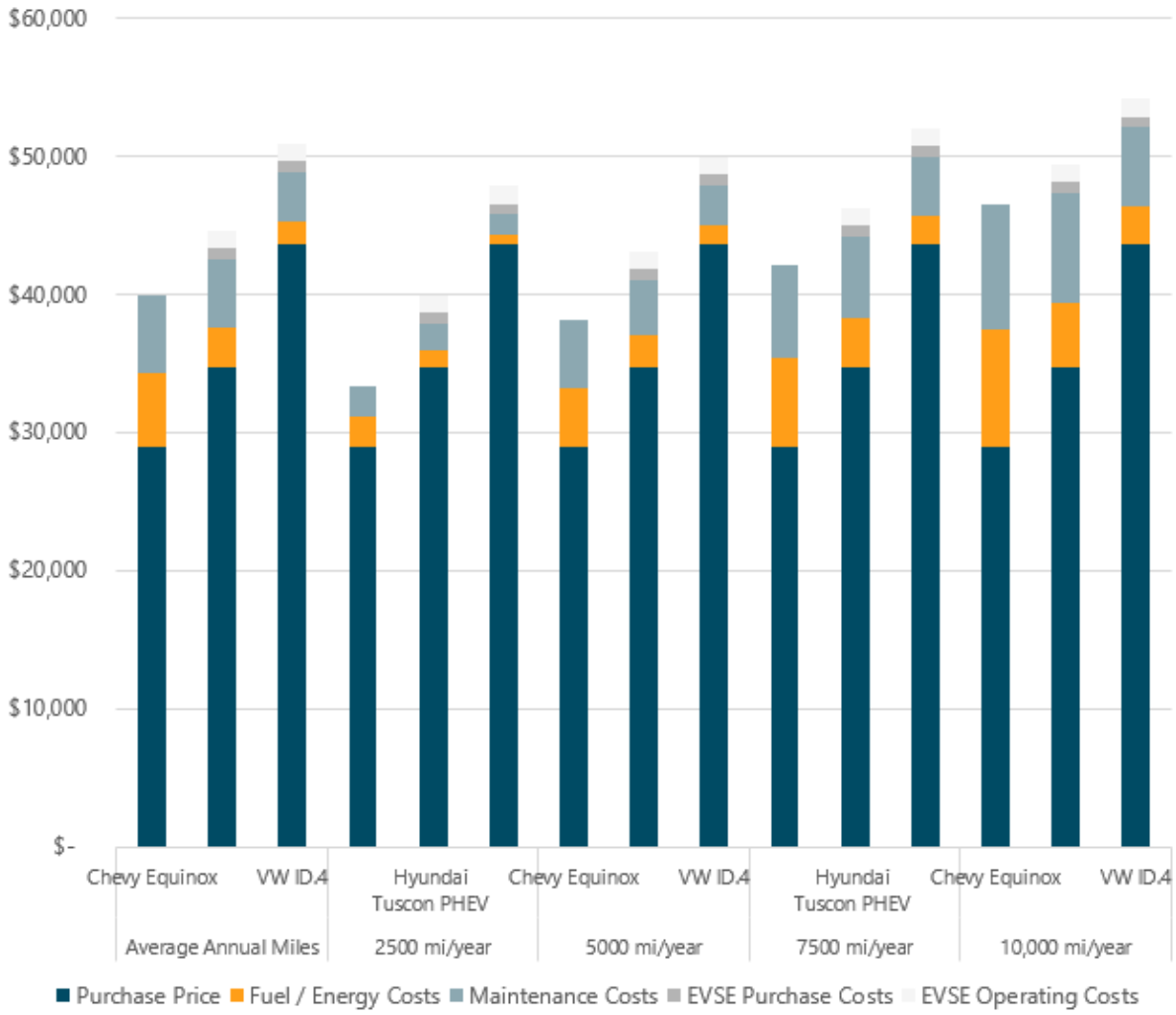
Based on the average annual miles traveled (6,783 mi), a (currently theoretical) AEV medium-duty pickup truck has a higher lifetime TCO compared to a gasoline-powered equivalent – requiring an additional subsidy of $3,722 over the lifetime of each vehicle due primarily to a significantly higher predicted AEV MD pickup truck purchase price in 2026-2030. Figure 3 show increasing operating cost savings for the AEV MD pickup truck as annual mileage increases generating positive savings starting when mileage threshold reaches at least 10,000 miles.

Figure 4. Lifetime total cost of ownership for medium-duty AEV pickup compared to diesel-powered Chevy 3500 HD pickup.



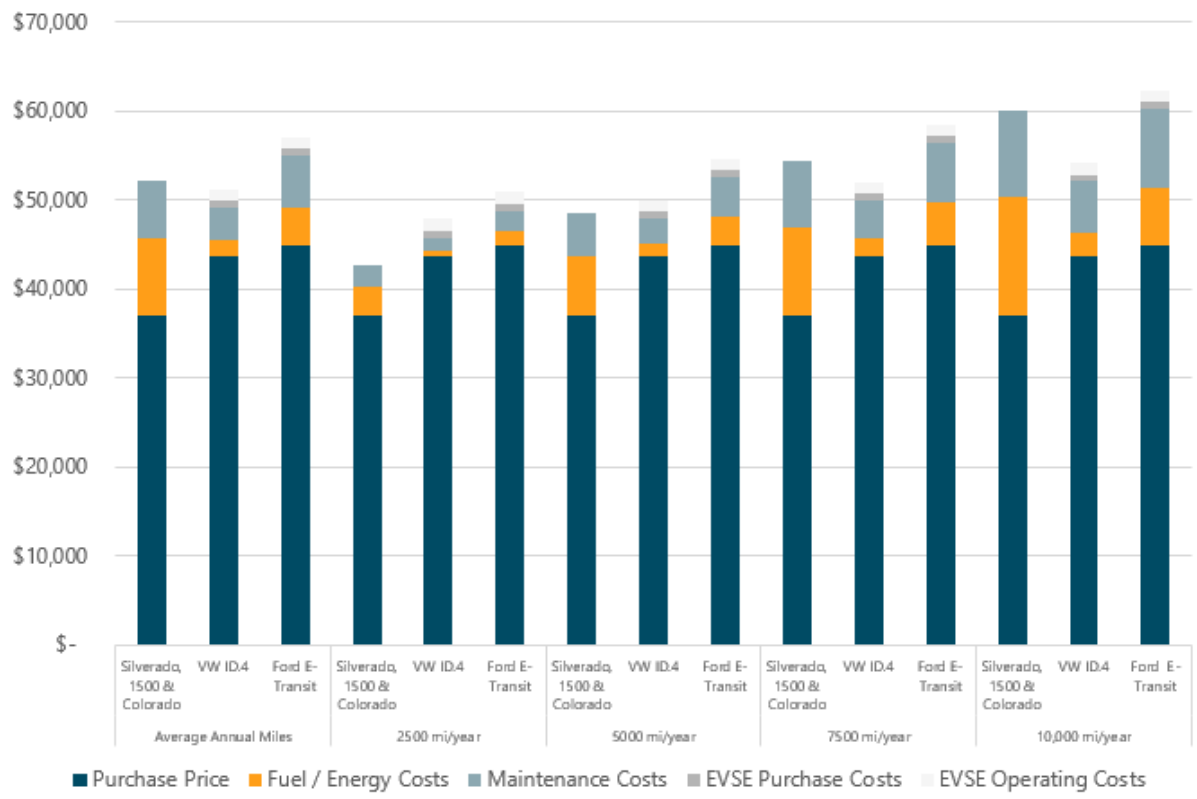
Based on the average annual miles traveled (8,128 mi), a (currently theoretical) AEV medium-duty pickup truck has a higher lifetime TCO compared to a diesel-powered equivalent – requiring an additional subsidy of $213 over the lifetime of each vehicle due primarily to a significantly higher predicted AEV MD pickup truck purchase price in 2026-2030. Figure 4 show increasing operating cost savings for the AEV MD pickup truck as annual mileage increases generating positive savings starting when mileage threshold reaches at least 10,000 miles.

Figure 5. Lifetime total cost of ownership for PHEV and AEV SUV compared to gasoline-powered Chevy Equinox.



Based on the average annual miles traveled (6,220 mi), a PHEV and AEV SUV are not cost effective compared to CWD's Chevy Equinox SUV over the vehicle lifetime - requiring an additional subsidy of $4,462 for a PHEV replacement and $10,288 for AEV replacement due to higher predicted vehicle purchase prices. Figure 5 show cost savings increasing as annual mileage increases for a PHEV and AEV replacement. However, savings are not sufficient to generate a positive return on investment under 10,000 miles.

Figure 6. Lifetime total cost of ownership for AEV SUV and AEV van compared to gasoline-powered Chevy full-size pickup truck.



Based on the average annual miles traveled (6,533 mi), a AEV SUV is most cost effective compared to CWD's light-duty pickup trucks with a net savings of $1,643 over the lifetime of each vehicle due to lower fuel/energy costs and maintenance costs. Figure 6 shows how lifetime savings for the VW ID.4 increase as annual mileage increase up to 10,000 miles.

In this same comparison, an AEV van is not cost effective compared to CWD's light duty pickup trucks with a net loss in savings of -$4,129 for an AEV van due to significantly higher vehicle purchase price. Figure 6 show cost savings increasing as annual mileage increases for an Ford E-Transit AEV replacement. However, savings are not significant to generate a positive return on investment under 10,000 miles.

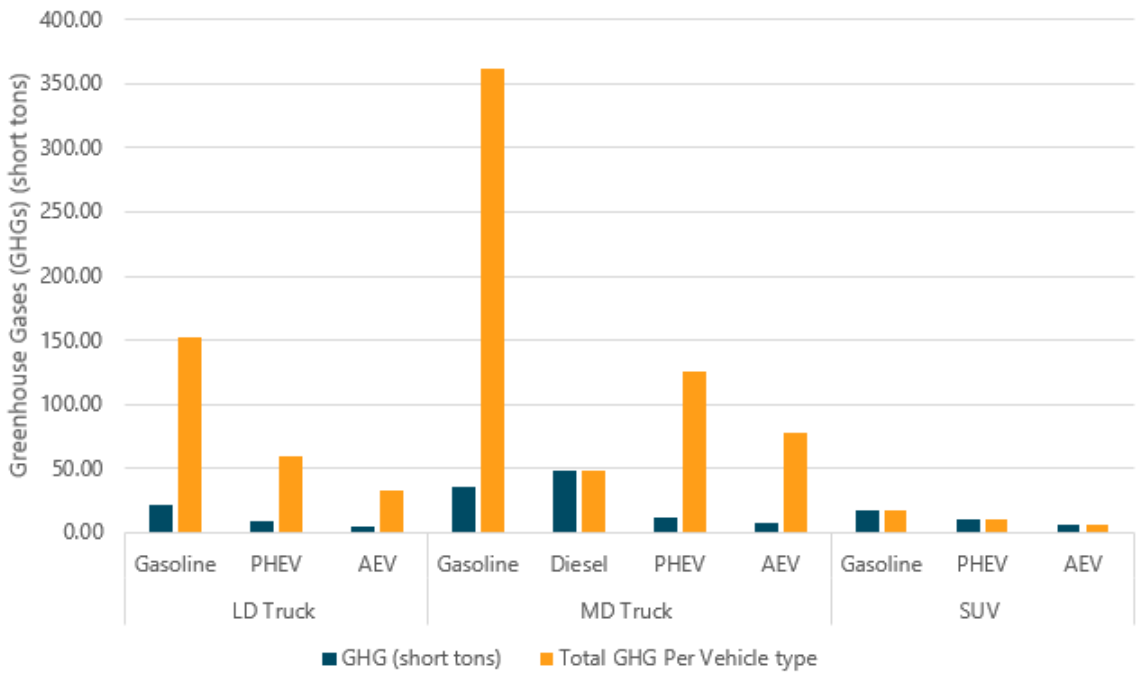
Note that in both of these comparisons, MSRP pricing for AEV Compact SUVs and Cargo Vans are higher than the base Ford F-150 Lightning pickup truck without offering dramatic additional operating cost savings. Consequently, AEV SUVs or Cargo vans are not recommended as a cost-effective alternative to an AEV light-duty pickup truck.

Emission Reductions

An important goal for CWD is to reduce greenhouse gas emissions associated with their fleet. If all nineteen vehicles are replaced with recommended PHEVs and AEVs during Phase One and Two, there is the potential to reduce GHG emissions by 458 short tons (or 1,009 barrels of oil) over the lifetime of the vehicles, a reduction of 79%.

The magnitude of greenhouse gas emissions reductions is most dramatic with the AEV medium-duty pickup deployments, accounting for three-quarters of CWD's projected emissions savings due to the number of pickups recommended for replacement and their relatively high existing fuel consumption.

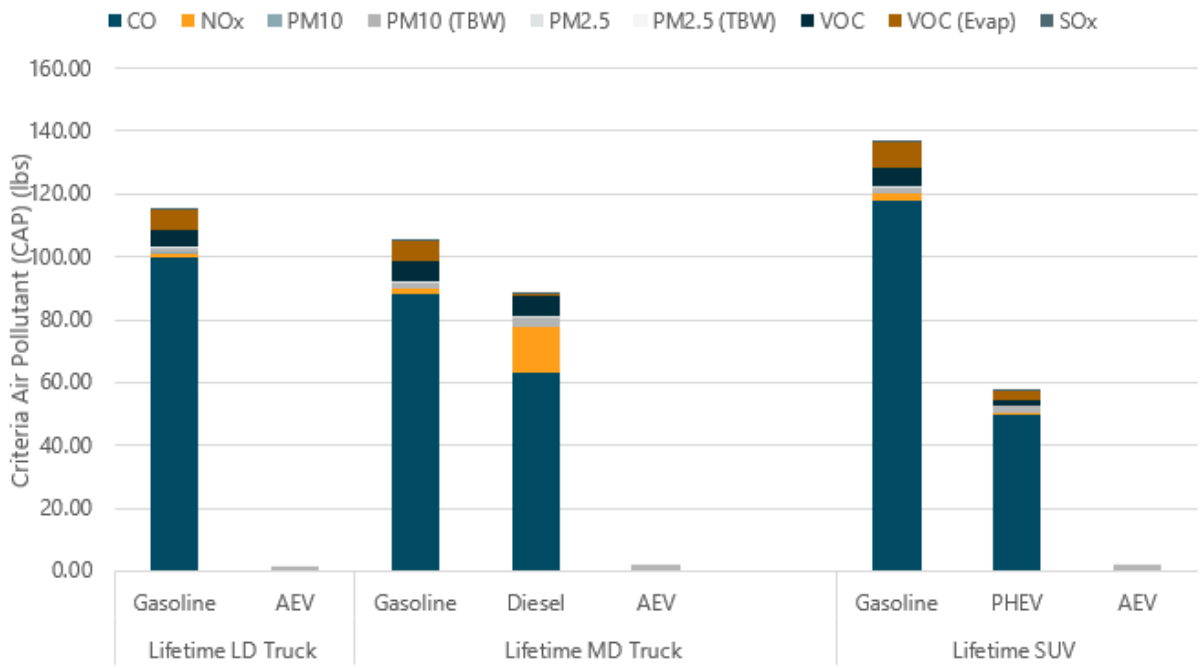
Figure 7. Lifetime greenhouse gas emissions for EV SUVs and pickup trucks compared to gasoline and diesel-powered equivalents (on a per vehicle basis (blue) and total by vehicle type (orange).[14]



[14] Diesel contains the highest GHG potential based on per vehicle basis. However, there is only one diesel vehicle making it appear less pollutant in comparison to all other vehicles in the fleet.

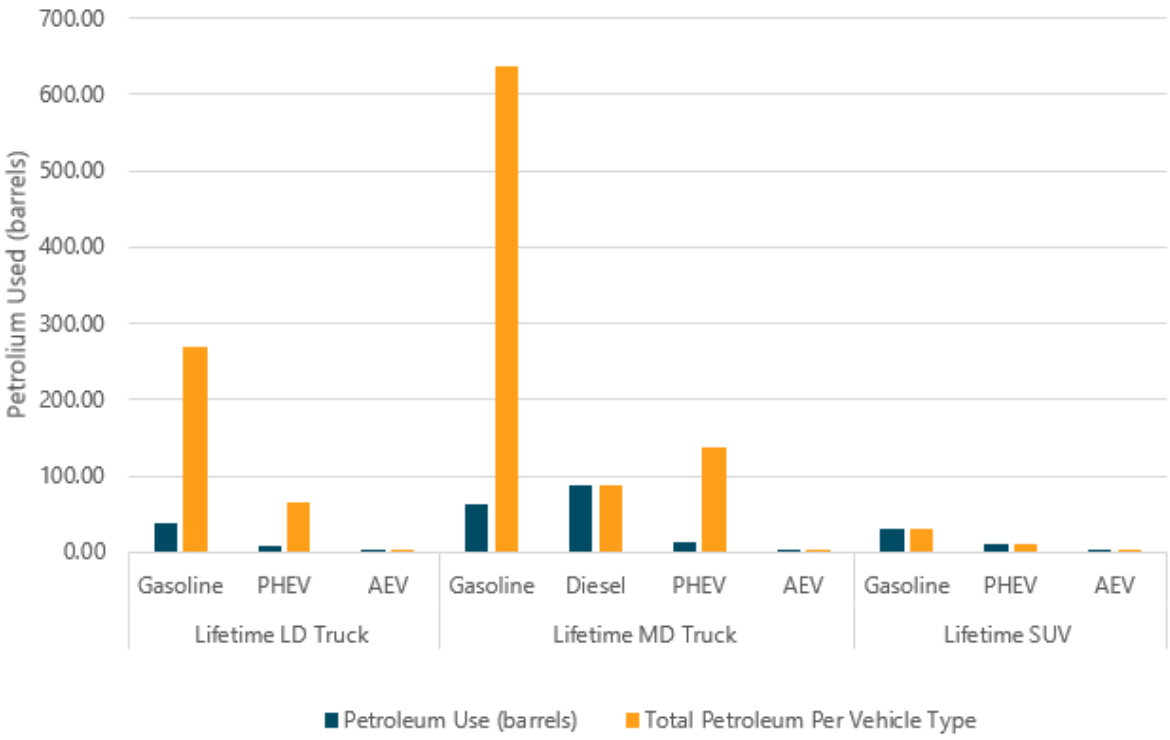
EVs will also considerably decrease criteria air pollutants (CAPs) such as nitrogen oxides (NO_x), particulate matter (PM_{10} and $PM_{2.5}$) and volatile organic compounds (VOC) compared to gasoline-powered vehicles (Figure 8). AEV pickups and SUVs should reduce CAPs by approximately 95% compared to gasoline. Note that tire and brake wear (TBW) produces PM emissions for all vehicles.

Figure 8. Lifetime criteria air pollutant emissions for EV SUVs and pickup trucks compared to gasoline-powered equivalents (per vehicle).



Note that the estimated PHEV GHG and CAP emissions savings included in this report are conservative, and that actual PHEV emissions may be further reduced if PHEVs are charged daily and operated exclusively on electricity the majority of the time.

Figure 9. Lifetime petroleum use for EV SUVs and pickup trucks compared to gasoline and diesel-powered equivalents (total by vehicle type).[15]



AEVs will also considerably decrease total petroleum use over the lifetime of each vehicle. (Figure 5). By replacing all nineteen vehicles CWD can expect to save 1,009 barrels of oil, a 98% reduction.

Appendices

Appendix A – EV Candidates

[15] Diesel consumes the highest amount of fuel per vehicle. However, note there is only one diesel vehicle making it appear less energy intensive in comparison to all other vehicles in the fleet.

Recommended EV Candidates: Vehicles to be replaced by 2026

Table A-1. AEV Phase One vehicle candidates

Overnight Parking Location	Department	Vehicle Type	Vehicle ID	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime AEV Savings
Home	Distribution	LD Pickup	1GCGTBEN8L1228252	Chevrolet	Colorado	2020	1	2,812	105	$4,674
Home	General Manager	LD Pickup	1GCUYAEF9LZ124698	Chevrolet	Silverado 1500	2020	1	3,464	150	$4,674
Maint. Garage	Distribution	LD Pickup	3GCUKNEC7JG422873	Chevrolet	Silverado	2018	1	1,596	140	$4,674
Maint. Garage	Engineering	LD Pickup	1GCNKPEA7BZ137400	Chevrolet	Silverado 1500	2011	1	2,208	40	$4,674
WTP	Water Quality	LD Pickup	1GCGTBE30G1110636	Chevrolet	Colorado	2016	1	7,320	95	$4,674
WTP	Water Quality	LD Pickup	1GCGTBEN4K1135226	Chevrolet	Colorado	2019	1	2,020	95	$4,674
WTP	Water Quality	Compact SUV	3GNAXREV6JS620734	Chevrolet	Equinox	2018	1	6,196	95	$4,674
WTP	Electrical	LD Pickup	1GCNKPEC9FZ310809	Chevrolet	Silverado 1500	2015	1	6,220	105	-$4,462
Total							8	3,980	103.125	$19,408

Table A-2: AEV Phase Two vehicle candidates

Overnight Parking Location	Department	Vehicle Type	Vehicle ID	Make	Model	Model Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime AEV Savings
Maint. Garage	Distribution	MD Pickup	1GB1KUEGXHF161450	-$3,722	Silverado 2500	2017	1	4,132	140	-$3,722
Maint. Garage	Distribution	MD Pickup	1GB5KYCG6FZ533471	-$3,722	Silverado 2500	2015	1	5,136	140	-$3,722
Maint. Garage	Distribution	MD Pickup	1GB5KYCG9FZ136594	-$3,722	Silverado 2500	2015	1	6,860	140	-$3,722
Maint. Garage	Distribution	MD Pickup	1GC0KUEG4GZ256672	-$3,722	Silverado 2500	2016	1	7,360	140	-$3,722
Maint. Garage	Distribution	MD Pickup	1GC5YSE78LF189319	-$3,722	Silverado 2500	2020	1	10,204	140	-$3,722
Maint. Garage	Transmission	MD Pickup	1GB3KYC80GF240197	-$213	Silverado 3500 HD	2016	1	804	100	-$213
Maint. Garage	Transmission	MD Pickup	1GC3KYCG1JZ254909	-$3,722	Silverado 3500 HD	2018	1	7,716	100	-$3,722
Maint. Garage	Transmission	MD Pickup	1GC3YSE72MF128959	-$3,722	Silverado 3500 HD	2021	1	10,016	100	-$3,722
Maint. Garage	Transmission	MD Pickup	1GC3YSE79LF177736	-$3,722	Silverado 3500 HD	2020	1	10,604	100	-$3,722
Maint. Garage	Transmission	MD Pickup	1GC4KVCG7KF221824	-$3,722	Silverado 3500 HD	2019	1	8,128	100	-$3,722
WTP	Electrical	MD Pickup	1GC5YLE78LF188905	-$3,722	Silverado 2500	2020	1	1,132	105	-$3,722
Total							11	6,554	119	-$37,436

Appendix B – Vehicle Lifetime Total Cost of Ownership and Emissions

Table B-1. Trucks: Lifetime (6,533 mi) total cost of ownership for AEV trucks compared equivalent light-duty gasoline pickup truck

	Silverado, 1500, & Colorado	Ford F150 Lightning AEV
Purchase Price	$37,000	$39,974
Fuel / Energy Costs	$8,708	$2,132
Maintenance Costs	$6,389	$4,028
EVSE Purchase Costs	$0	$780
EVSE Installation Costs	$0	$720
EVSE Operating Costs	$0	$1,290
Incentives	$0	$(1,500)
Total	**$ 52,098**	**$47,424**

Figure B-1. Trucks: Lifetime (6,533 mi) total cost of ownership for AEV trucks compared equivalent light-duty gasoline pickup truck.

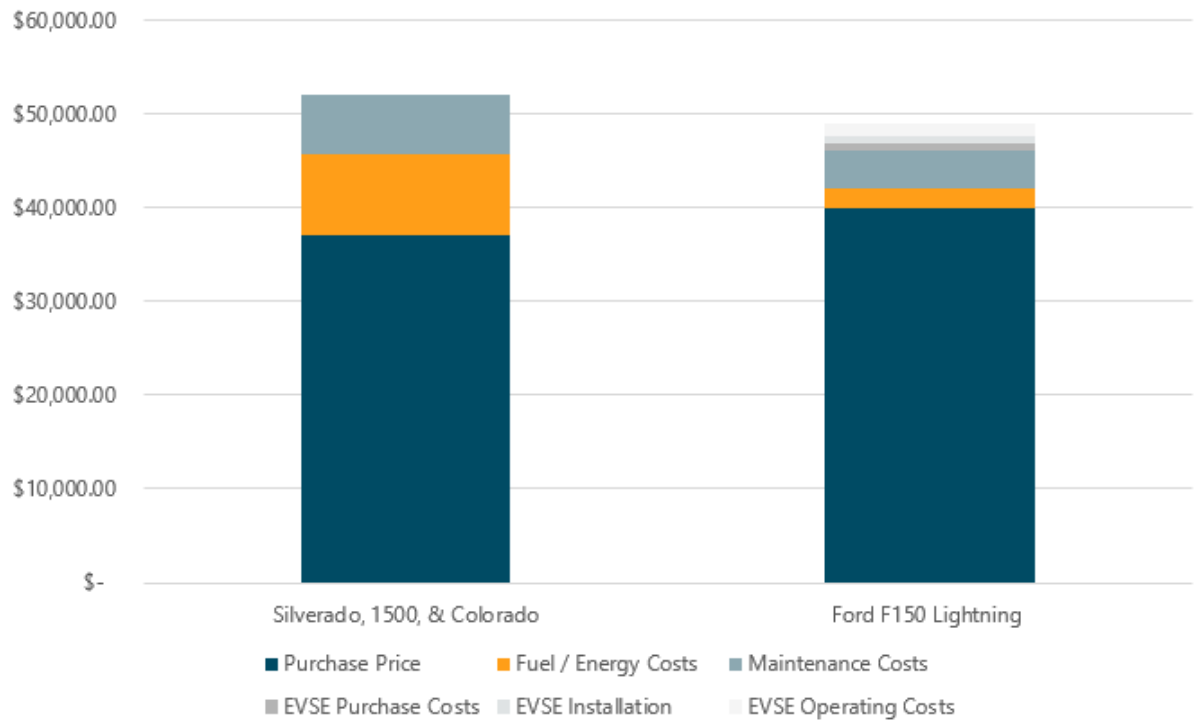


Table B-2. Trucks: Lifetime (6,783 mi) total cost of ownership for AEV trucks compared equivalent medium-duty gasoline pickup truck

	Silverado 2500 &3500 HD	AEV Pickup
Purchase Price	$42,000	$54,000
Fuel / Energy Costs	$9,826	$3,357
Maintenance Costs	$8,384	$5,286
EVSE Purchase Costs	$0	$780
EVSE Installation Costs	$0	$720
EVSE Operating Costs	$0	$1,290
Incentives	$0	$(1,500)
Total	**$60,210**	**$63,932**

Figure B-2. Trucks: Lifetime (6,783 mi) total cost of ownership for AEV trucks compared equivalent medium-duty gasoline pickup truck.

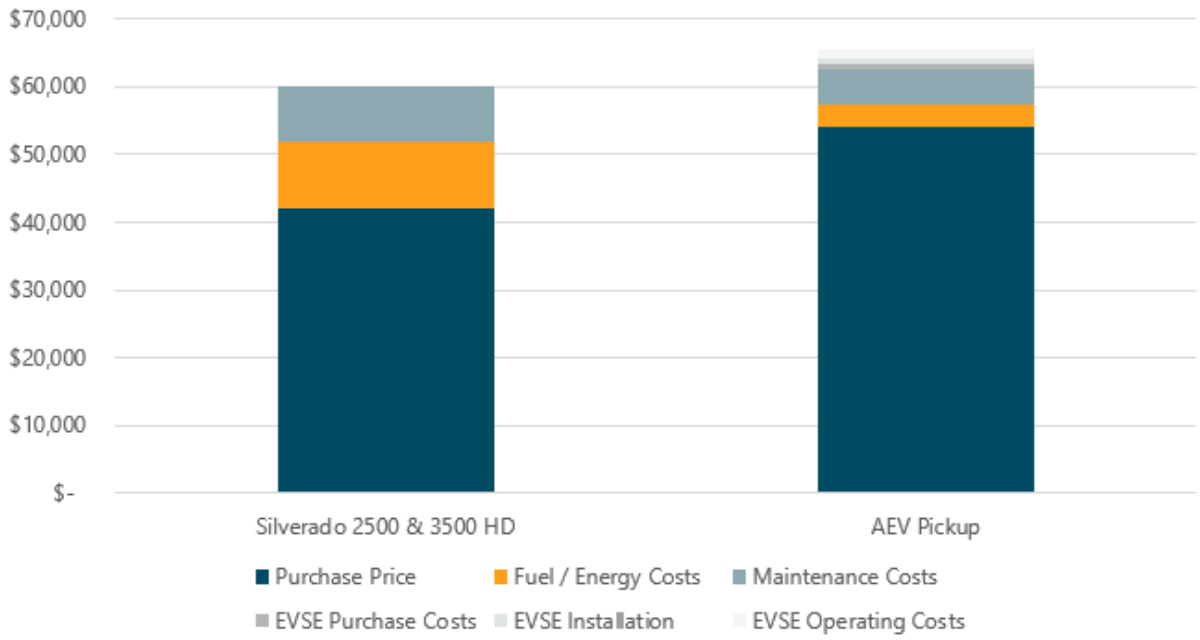


Table B-3. Trucks: Lifetime (8,128 mi) threshold for AEV trucks compared equivalent to medium-duty diesel pickup truck

	Diesel 3500 HD	AEV Pickup
Purchase Price	$42,000	$54,000
Fuel / Energy Costs	$13,834	$4,469
Maintenance Costs	$10,046	$6,334
EVSE Purchase Costs	$0	$780
EVSE Installation Costs	$0	$720
EVSE Operating Costs	$0	$1,290
Incentives	$0	$(1,500)
Total	**$65,880**	**$66,093**

Figure B-3. Trucks: Lifetime (8,128 mi) threshold for AEV trucks compared equivalent to medium-duty diesel pickup truck.

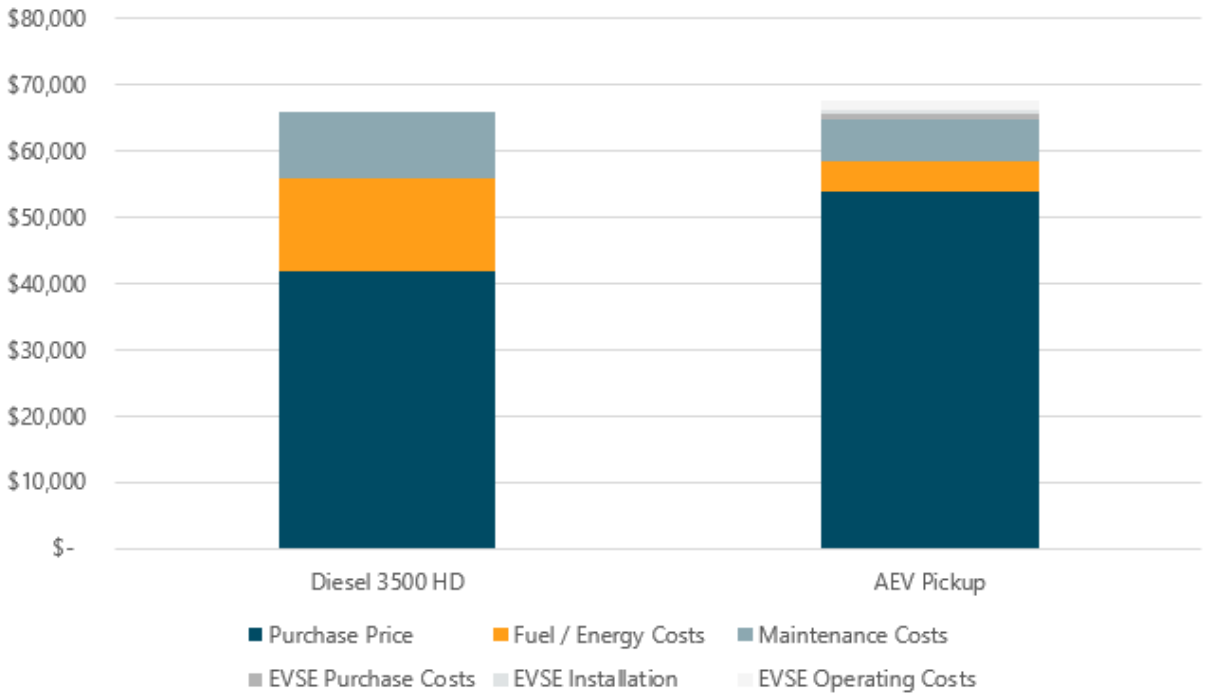


Table B-4. SUV: Lifetime (6,220 mi) threshold for PHEV SUV and AEV SUV compared equivalent to light-duty gasoline SUV

	Chevy Equinox	Hyundai Tuscan PHEV	VW ID.4
Purchase Price	$29,000	$34,750	$43,675
Fuel / Energy Costs	$5,268	$2,906	$1,674
Maintenance Costs	$5,635	$4,919	$3,553
EVSE Purchase Costs	$0	$780	$780
EVSE Installation Costs	$0	$720	$720
EVSE Operating Costs	$0	$1,290	$1,290
Incentives	$0	$(1,000)	$(1,500)
Total	**$39,903**	**$44,365**	**$50,192**

Figure B-4. SUV: Lifetime (6,220 mi) threshold for PHEV SUV and AEV SUV compared equivalent to light-duty gasoline SUV.

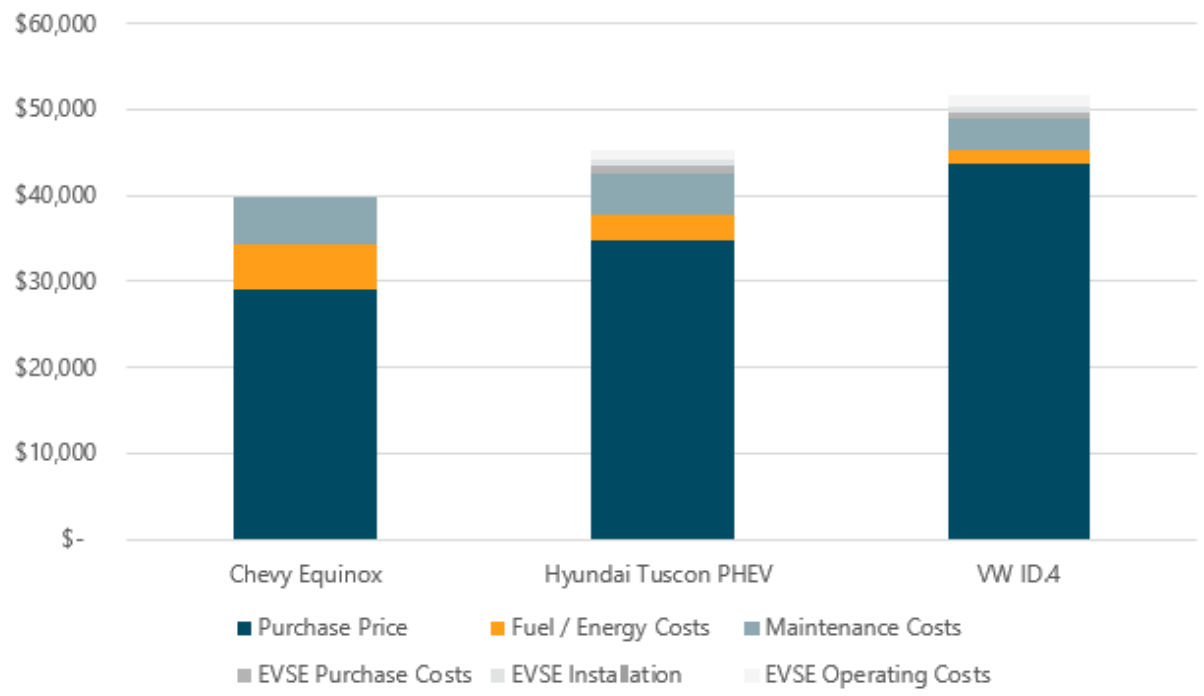
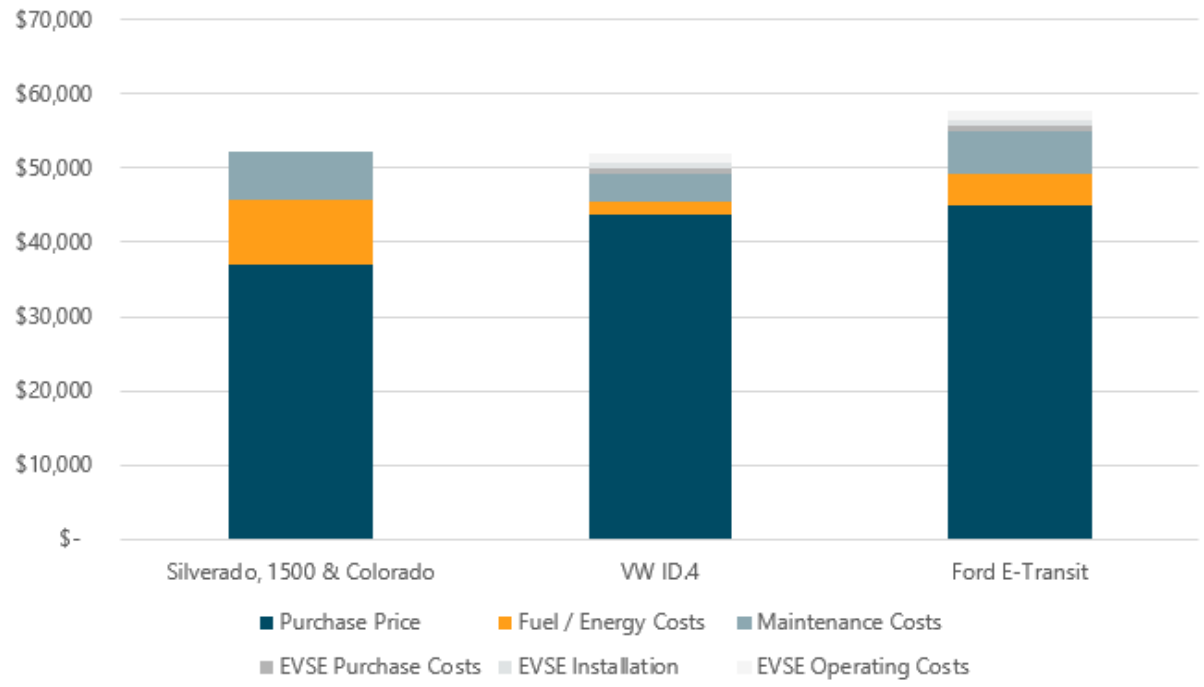


Table B-5. Truck: Lifetime (6,533 mi) threshold for PHEV SUV and AEV SUV compared equivalent to light-duty gasoline truck

	Silverado, 1500 & Colorado	VW ID.4	Ford E-Transit AEV
Purchase Price	$37,000	$43,675	$45,000
Fuel / Energy Costs	$8,708	$1,758	$4,203
Maintenance Costs	$6,389	$3,732	$5,734
EVSE Purchase Costs	$0	$780	$780
EVSE Installation Costs	$0	$720	$720
EVSE Operating Costs	$0	$1,290	$1,290
Incentives	$0	$ (1,500)	$(1,500)
Total	**$52,098**	**$50,455**	**$56,226**

Figure B-5. Truck: Lifetime (6,533 mi) threshold for PHEV SUV and AEV SUV compared equivalent to light-duty gasoline truck.



Emissions: Total lifetime greenhouse gas and criteria air pollutant emissions for AEV, PHEV and gasoline SUV, full-size gasoline pickup truck, and medium duty gas and diesel pickup truck equivalents. Note that tire and brake wear (TBW) produce PM emissions for all vehicles.

Table B-6. Lifetime emissions per vehicle

	Lifetime LD Truck (6,533)			Lifetime MD Truck (6,783)					Lifetime SUV (6,220)		
	Units	Gasoline	PHEV	AEV	Gasoline	Diesel	PHEV	AEV	Gasoline	PHEV	AEV
Greenhouse Gases (GHG)	Short Tons	21.78	8.48	4.77	36.10	48.92	11.38	7.06	16.88	10.37	5.66
CO	lbs	99.63	38.80	0.00	88.28	63.02	35.58	0.00	118.13	49.80	0.00
NOx	lbs	1.58	0.52	0.00	1.73	14.80	0.58	0.00	1.87	0.66	0.00
PM10	lbs	0.12	0.05	0.00	0.11	0.09	0.05	0.00	0.14	0.06	0.00
PM10 (TBW)	lbs	1.67	1.67	1.67	1.76	2.90	1.76	1.76	1.97	1.97	1.97
PM2.5	lbs	0.14	0.05	0.00	0.11	0.18	0.05	0.00	0.16	0.07	0.00
PM2.5 (TBW)	lbs	0.21	0.21	0.21	0.20	0.36	0.20	0.20	0.25	0.25	0.25
VOC	lbs	5.01	1.05	0.00	6.19	6.01	1.35	0.00	5.94	1.35	0.00
VOC (Evap)	lbs	6.56	2.55	0.00	6.72	0.64	2.71	0.00	7.78	3.28	0.00
SOx	lbs	0.21	0.05	0.00	0.35	0.55	0.07	0.00	0.16	0.06	0.00

Appendix C – Methodology

Fuel Costs

Fuel cost is CWD's estimated fuel cost based on VT average fuel pricing (March 2022) of approximately $3.67 per gasoline gallon and $4.17 per diesel gallon[16].

Electricity Costs

CWD's electric rate class was assumed to be Rate 63 from Green Mountain Power (GMP)[17] for their various buildings and parking facilities. Rate 63 is a Time of Use (TOU) rate, with volumetric energy costs ($/kWh) and power demand costs ($/kW) differing between peak times (6am-11pm Monday-Friday) and off-peak times (all other hours). These rates are:

Peak kW: $16.401

Off-peak kW: $4.723

Peak kWh: $0.11573

Off-peak kWh: $0.08795

VEIC estimated that approximately 80% of CWD's EV charging will occur during off-peak hours between 11pm and 6am, with 20% occurring during the day on weekdays (to account for any midday charging opportunities that CWD may choose to utilize). As a result, VEIC developed a blended rate of $0.0935/kWh to reflect this anticipated charging approach, and used this rate for all TCO calculations.

Demand charges associated with EV charging were not estimated or incorporated into TCO analyses or results.

Avoided Maintenance Costs Through Electrification

EV's offer fleets operational savings achieved through reduced fueling and maintenance costs. Based on our analysis, we estimate maintenance savings of 37% for AEVs and 13% for PHEVs relative to gasoline vehicles, and savings of 59% for AEVs and 43% for PHEVs relative to diesel vehicles. Vehicles are assumed to be replaced at vehicle type-specific lifetime mileage thresholds based on CWD's current fleet operating practices. Current vehicle fuel and maintenance costs were estimated based on defaults utilized from Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool[18], which also provided additional defaults for replacement vehicles.

[16] AAA Gas Prices
[17] Rate-63-65-Commercial-and-Industrial-10.1.21.pdf (greenmountainpower.com)
[18] https://greet.es.anl.gov/afleet_tool

Emissions

Gasoline pollutant emissions are from Argonne National Laboratory's GREET model.[19] Electricity greenhouse gas data is from the EPA's Emission Factors for Greenhouse Gas Inventories[20]

[19](24 lbs CO_{2eq} /gallon gasoline) https://greet.es.anl.gov/

[20] (981 lbs CO_{2eq} / MWh electricity for the New England Region) https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid