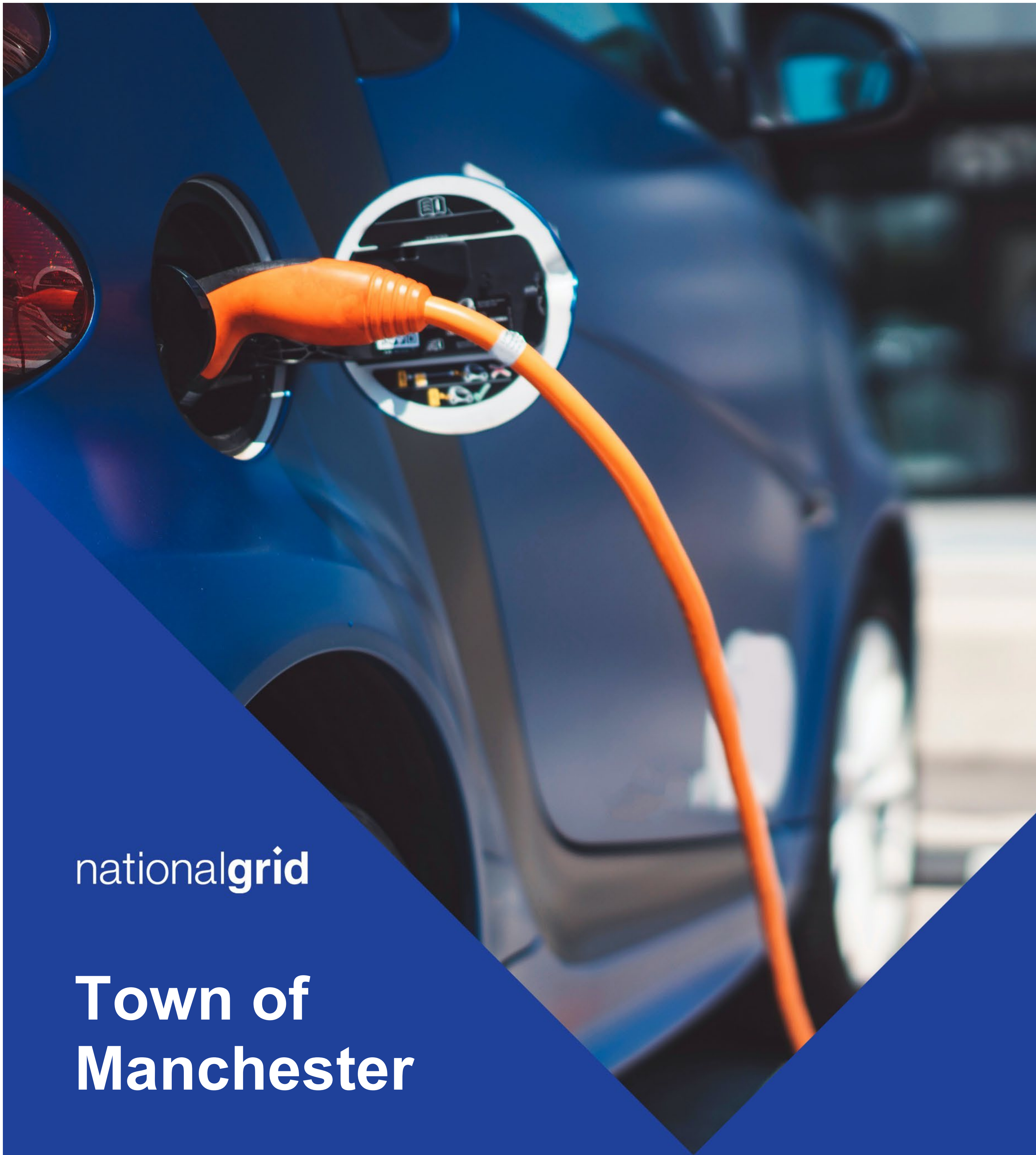

Town of Manchester

Fleet Electrification Assessment
November 21, 2022

Fleet advisory services provided by

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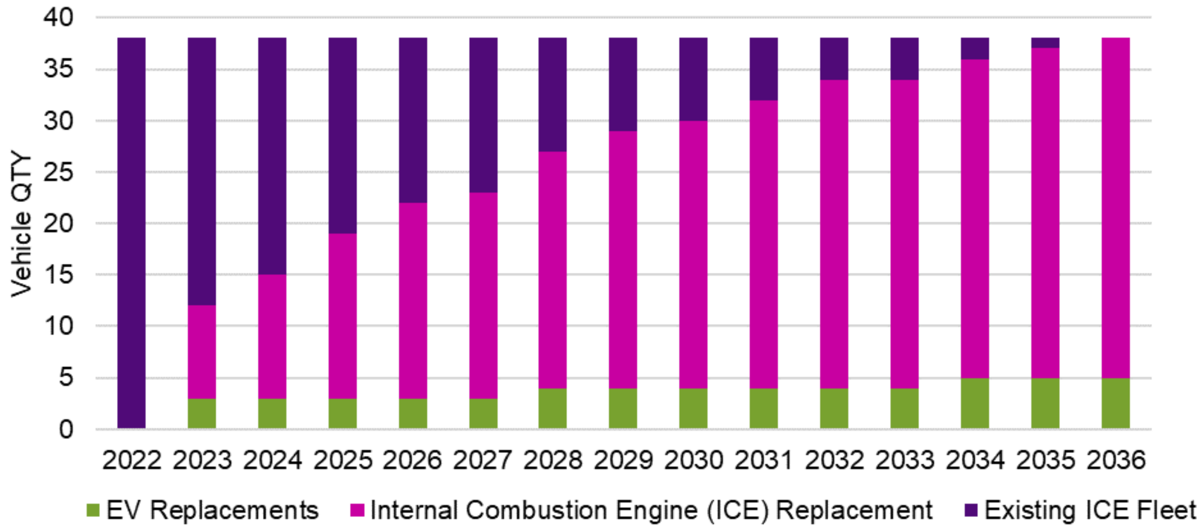
Executive Summary

National Grid's Massachusetts (MA) Fleet Advisory Services Program provides fleet electrification recommendations and objective guidance from our team of electric vehicle (EV) experts. We are here to help you, the Town of Manchester (Manchester), understand the impacts of shifting your fleet to EVs and support you every step of the way. This custom report identifies the vehicles that would be most cost-effective to convert to electric and summarizes the associated financial and environmental benefits.

The timeframe identified for the vehicle replacements is 2023 to 2036. The fleet total cost of ownership (TCO) analysis extends to 2048 to account for the ongoing fuel and maintenance costs from the vehicles acquired in 2036. We assessed the economic feasibility of 52 vehicles in Manchester's fleet, including 39 on-road vehicles and 13 non-road vehicles.[1] We identified 33 on-road vehicles that have EV options available and 5 of those that would be beneficial to convert over the next 14 years. Chart A illustrates the phasing in of these EVs as you replace your existing fleet vehicles. These 5 vehicles would result in a net present value (NPV) TCO savings of $42,000 over the next 26 years, which accounts for the savings across the vehicles' full lifespans.

Chart A. Recommended EV Replacement Timeline: Fuel Types



The report also details the analysis assumptions, specific vehicle recommendations, financial and environmental impacts, and next steps. Your MA Fleet Advisory Services Program Account Manager (Account Manager) will continue to check in with you and provide one-on-one support for the length of the program as you navigate fleet electrification. Please review this report and reach out to your Account Manager at FleetAdvisoryMA@icf.com or 617-218-2100 with any questions or to discuss next steps.

[1] There are 13 non-road vehicles included in the total vehicle counts that are excluded from the Electric Vehicle Acquisition Recommendations and Fleet Environmental Impact Analysis sections of this report. Non-road vehicles are discussed separately in the Non-Road Equipment Section.

Based on our analysis, converting 5 on-road vehicles to EVs is estimated to produce the following impacts:

$42,000
TCO savings over **26** years*

$15,687
fuel cost savings over **26** years*

$22,625
maintenance savings over **26** years*

184
metric tons (MT) of CO_2 eliminated over **26** years

*NPV assumes a 5% discount rate.

Over 26 years, those estimated CO_2 reductions equate to:

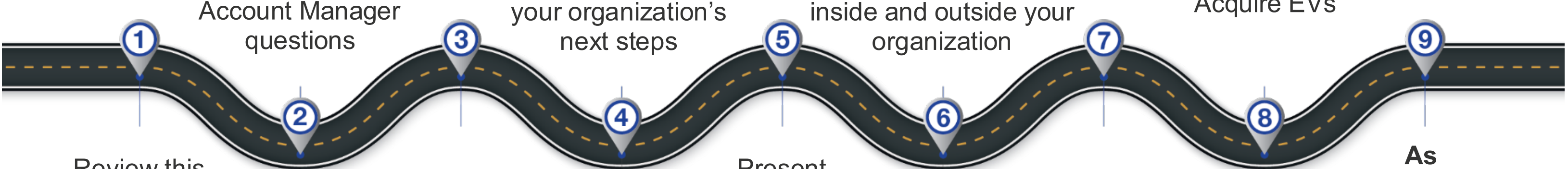
eliminating **21** homes' energy use for one year, or:

switching **6,991** incandescent lamps to LEDs, or:

recycling **63** tons of waste instead of landfilling it, or:

planting **3,036** trees.

Your Roadmap to Fleet Electrification



1. Review this report
2. Ask your Account Manager questions
3. Review the MA Fleet Advisory Services Program portal at http://fleetadvisoryma.nationalgrid.com/ for resources on incentives, grants, training, news, updates, and more
4. Work with your Account Manager to plan your organization's next steps
5. Present information to stakeholders, including available incentives
6. Share electrification plans with stakeholders inside and outside your organization
7. Discuss charging infrastructure with National Grid
8. Acquire EVs
9. **As opportunities or challenges arise, talk to your Account Manager**

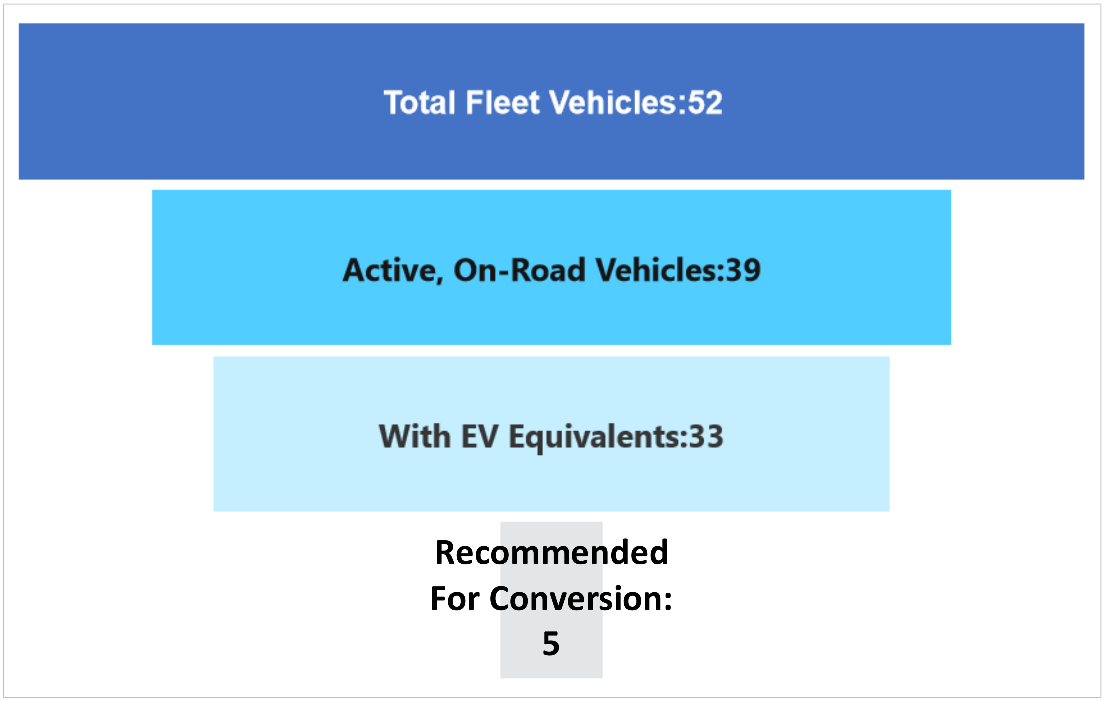
Project Information

On August 3, 2022, representatives from the town of Manchester, met with the Account Manager, Justin Eichenberger, and other program staff for an initial intake call. The discussion covered topics including an overview of the MA Fleet Advisory Services Program, fleet data availability, fleet usage characteristics, and the fleet's motivation for exploring EV options. A key takeaway of the intake call was the need for all vehicles to be all wheel drive capable. We've accounted for this by restricting our EV recommendations to just vehicles that meet this requirement.

Manchester provided an initial fleet dataset on June 23, 2022, and a secondary dataset on August 9, 2022. Manchester's fleet dataset was used to establish a fleet baseline in the model.

There are 52 vehicles in Manchester's current fleet, 39 on-road vehicles and 13 pieces of non-road equipment. Of the 39 on-road vehicles, 33 have EV equivalents commercially available and 5 would be cost beneficial to convert to EVs at this time. This breakdown is illustrated in Chart B. Note that non-road vehicles are included in the total vehicle counts but are excluded from the Electric Vehicle Acquisition Recommendations and Fleet Environmental Impact Analysis sections of this report. Non-road vehicles are discussed separately in the Non-Road Equipment section.

Chart B. Fleet Assessment Vehicle Breakdown



Existing On-Road Fleet Makeup

There are 39 on-road vehicles in Manchester's current fleet, all of which are gasoline- and diesel-powered as shown in Table A. The fleet is made up of light- and heavy-duty vehicles as illustrated in Chart C below. Police patrol vehicles are assessed separately due to their significantly different duty cycles and applications. The estimated retirement schedule for the existing fleet is represented in Chart D. This schedule informs the recommended EV replacement schedule, which is shown later in Chart G.

TABLE A. Existing Fleet Fuel Type Distribution

Vehicle Type	Gasoline	Diesel
Sport Utility Vehicle (SUV)	9	-
Minivan	1	-
Light-Duty Pickup	3	
Medium-Duty Pickup	5	4
Van	3	-
Heavy Truck	-	7
Motorcycle	1	-
Other	-	6
TOTAL	**22**	**17**

Chart C. Existing Fleet - Vehicle Types

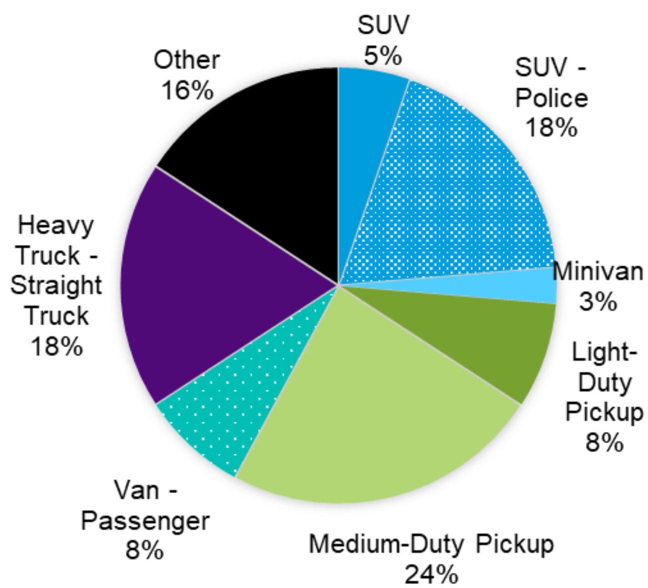
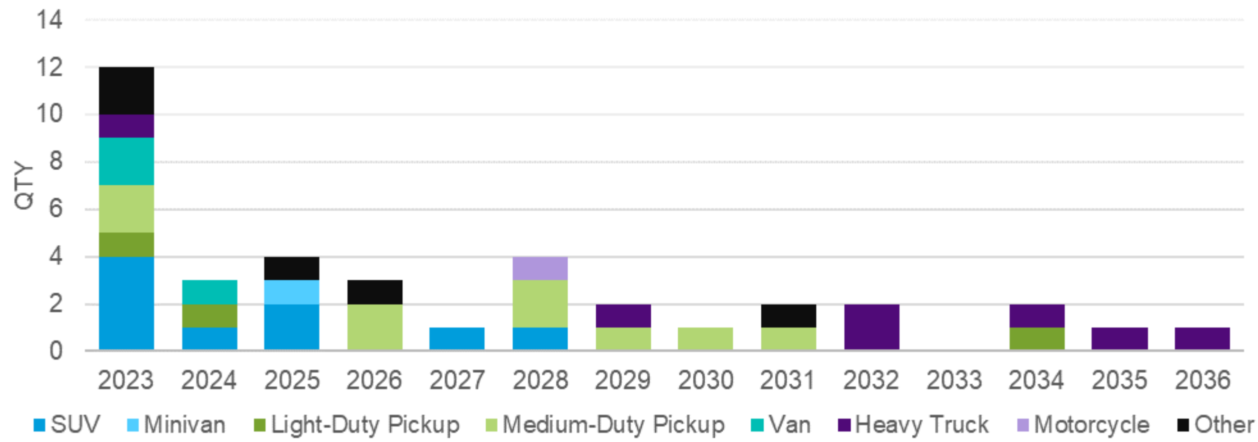


Chart D. Existing Fleet – Retirement Schedule



The 6 vehicles identified as "Other" and 13 pieces of non-road equipment are summarized in Table B below and were excluded from this analysis, and the Electric Vehicle Acquisition Recommendations section of this report, for one of 2 reasons:

- 13 are non-road equipment (see the Non-Road Equipment Section for more information).
- 6 are fire trucks, ambulances, or other emergency response vehicles that do not have commercially available EV models. Electric fire trucks and ambulances are currently in the development and testing phases. Pierce Manufacturing delivered its first plug-in hybrid electric fire truck to the Madison Fire Department in Madison, WI, for testing in June 2021, and Rosenbauer is developing an extended range plug-in hybrid electric fire truck, which the Los Angeles Fire Department (LAFD) received in May 2022. Lightning eMotors and REV Group Inc. expect to deliver their first electric ambulance by the end of this year. These models will be included in future analyses if deemed suitable for Manchester's fleet.

Follow-up report refreshes will be available as additional EV models become available.

TABLE B. Vehicle Types Excluded from Analysis

Vehicle Type	Quantity	Reason for Exclusion
Ambulances	2	No EV models commercially available
Fire Trucks	4	
Non-Road Equipment	13	Non-road equipment (See Non-Road Equipment section)
TOTAL	19	

Key Assumptions

Key assumptions and data sources that were used in this analysis include the following. The Electric Vehicle Acquisition Recommendations section below provides additional detail on the financial assumptions in the model.

- **Recommendation Threshold:** EVs are recommended only when the EV TCO is less than the TCO of the comparable internal combustion engine (ICE) vehicle.

- **Vehicle Pricing:** The model uses manufacturer suggested retail prices (MSRPs) for EVs where available. When MSRP pricing is unavailable, the model uses average pricing based on vehicle and fuel type based on Argonne National Laboratory's Alternative Fuel Life Cycle Environmental and Economic Transportation (AFLEET) Tool and ICF's *Comparison of Medium- and Heavy-Duty Technologies in California* report for the California Electric Transportation Coalition.

- **Fuel:** The existing fleet fuel costs were estimated using the vehicles' annual mileage, AFLEET fuel economy assumptions by vehicle and fuel type, and base fuel prices per gallon. The model uses $3.00 per gallon of diesel and $2.65 per gallon of gasoline, based on the U.S. EIA's New England average pricing for the past 5 years. The model escalates gasoline and diesel prices annually using projections from the U.S. EIA's 2022 AEO Reference Case for Transportation.

- **Maintenance:** Existing fleet maintenance costs were estimated using AFLEET dollar per mile assumptions by vehicle type and by fuel type. Maintenance costs were escalated 2.2% annually.

- **Electricity Pricing:** The model uses $0.17/kWh base rate, escalated annually using projections from the U.S. EIA's 2022 AEO Reference Case for Transportation: Electricity.

- **Vehicle Replacements:** Manchester provided estimated retirement years for most existing vehicles. Where not provided, the estimated retirement year is calculated as vehicle model year plus the assumed vehicle lifespan, with the minimum being 2023.

- **Timeframe:** This analysis focuses on vehicle replacements for 2023 through 2036, with TCO calculations extending out across the vehicle lifespans to 2048.

- **Discount Rate:** 5% was used for NPV calculations.

- **Vehicle Ranges:** The EV mileage ranges per charge were accounted for when recommending vehicle replacements. The analysis used an average temperature range of 22 to 88°F to assess the potential impact temperatures can have on EV ranges; this reduced EV model ranges to 80% of their maximum mileage range.

- **Electric Vehicle Supply Equipment (EVSE) Pricing and Incentives:** The EVSE pricing assumptions and incentive program amounts applied in the analysis are detailed further in the Incentives and Funding Source Assumptions Applied section below.

- **Vehicle Required Capabilities:** Assumes that all fleet vehicles need to be AWD capable, and all DPW trucks need to be plow capable.

Electric Vehicle Acquisition Recommendations

There are 52 Manchester vehicles scheduled for retirement between 2023 and 2036, and 5 of them will be cost effective to convert to battery electric vehicles (BEVs) or plug-in hybrid electric vehicles (PHEVs). Chart E below shows the TCO for the 5 recommended vehicles each year if they were replaced with conventional, ICE vehicles versus with the recommended EVs. This timeline is based on the existing fleet retirement schedule outlined in Chart D above. Based on these estimates, you may see an immediate financial payback in 2023. The recommended EVs are estimated to return total cost of ownership savings over the internal combustion alternatives in each year of the TCO timeframe as shown in Chart E. The overall total cost of ownership is lower as shown by the cumulative TCO comparison in Chart F.

Chart E. TCO Fleet Comparison - Annual

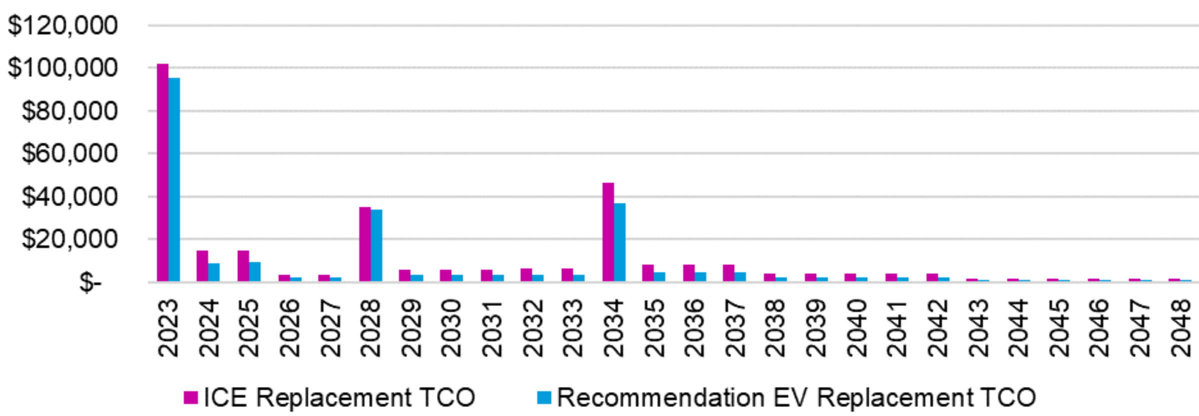


Chart F. TCO Fleet Comparison - Cumulative

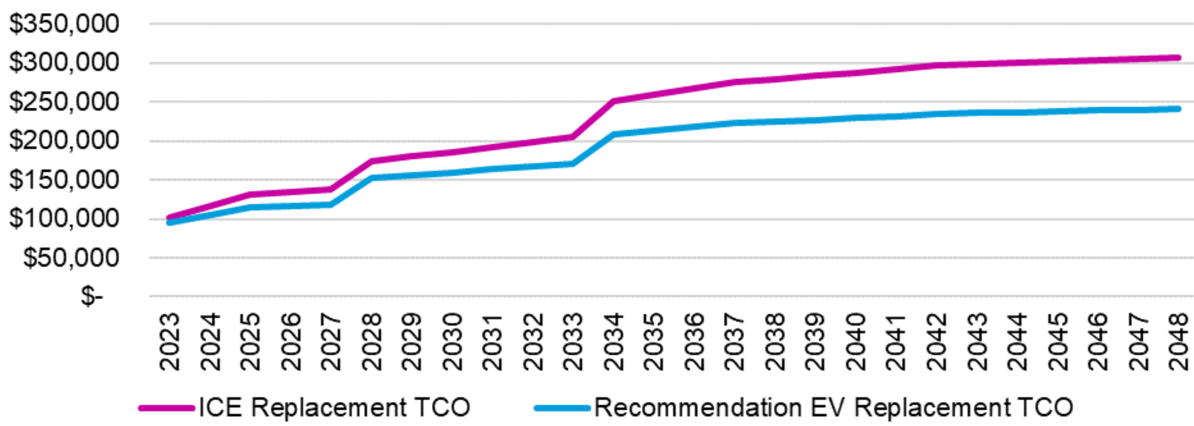


Table C identifies the vehicles that will be cost effective to convert to electric within the next 14 years. Chart G illustrates the recommended replacement timeline for these vehicles. Each vehicle within your fleet has been assessed to identify the lowest cost option, while also accounting for potential mileage and charging time restrictions.

The financial savings and greenhouse gas (GHG) emission reductions represent the difference between replacing the recommended vehicles with EVs compared to replacing them with ICE vehicles. The TCO used in the financial savings accounts for the following, as applicable:

- Capital costs
- Charging infrastructure hardware costs
- Charging infrastructure installation costs
- Annual fuel costs
- Annual maintenance costs
- Potential EV or EVSE incentives or grants

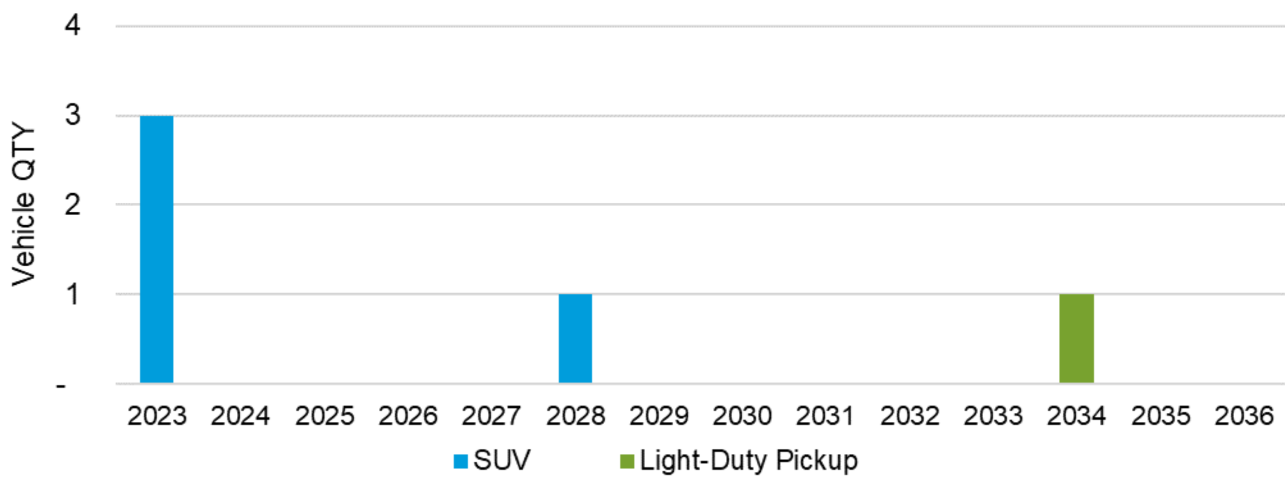
There are 28 vehicles with EV equivalents that are not recommended for conversion, due to the TCO for the ICE vehicle being lower than that of any EVs that met the AWD and plow-capability requirements. Future EV model options or incentive program availability may open opportunities for these to be converted; this will also be considered in future report updates.

TABLE C. 14-Year Electrification Recommendations

Vehicle Type	Quantity Up for Retirement (in 14 Years)	Quantity Recommended to Convert to Electric	Recommended Make/ Model/ EV Type	Financial Savings (across 26 years)	GHG Emission Reductions (across 26 years, MT)	Recommended EVSE L2	Recommended EVSE DCFC
SUVs – Police	7	2	Ford/Mustang/Mach-E/Select/AWD/Standard Range (Police)	$6,560	44	2	-

Vehicle Type	Quantity Up for Retirement (in 14 Years)	Quantity Recommended to Convert to Electric	Recommended Make/ Model/ EV Type	Financial Savings (across 26 years)	GHG Emission Reductions (across 26 years, MT)	Recommended EVSE L2	Recommended EVSE DCFC
SUVs	2	2	Fisker/Ocean/BEV	$28,201	114	2	-
Minivan	1	0	N/A	-	-	-	-
Light-Duty Pickups	3	1	Ford/F-150/Lightning Pro/Crew Cab/BEV	$7,238	26	1	-
Medium-Duty Pickups	9	0	N/A	-	-	-	-
Vans	3	0	N/A	-	-	-	-
Heavy Truck - Straight	7	0	N/A	-	-	-	-
Motorcycle	1	0	N/A	-	-	-	-
TOTAL	**33**	**5**		**$42,000**	**184**	**5**	**0**

Chart G. Recommended EV Replacement Timeline: Vehicle Types



EV Charging Infrastructure Assumptions Applied

About EV Charging Infrastructure

EVs require access to chargers, also known as EVSE. In a fleet application, most of the charging is typically done at the fleet facility – overnight or between shifts. Facility-based charging can be supplemented with periodic charging at workplaces, idle locations, and public destinations as needed.

There are three types of EV chargers: Level 1, Level 2, and Direct Current (DC) Fast.

Level 1 chargers provide charging through a 120-volt (V) AC plug. A Level 1 charger plugs directly into a household outlet on one end, and into the vehicle's SAE J1772 charge port on the other end. Level 1 chargers are the slowest category of EVSE and provide 2 to 5 miles of range per hour of charging.

Level 2 chargers provide charging through 240 V or 208 V electrical service. Level 2 charging equipment is common for home, public, and workplace charging. Most public chargers in the United States are Level 2. Level 2 chargers can operate at up to 80 Amperes (Amps) and 19.2 kilowatts (kW) and provide faster charging than Level 1 EVSE. Typically, a Level 2 charger provides 10 to 20 miles of range per hour of charging.

DC Fast chargers enable rapid charging through 208/480 V three-phase input. Installing DC Fast chargers may require infrastructure upgrades and these high-powered chargers cost significantly more than a Level 2 charger. DC Fast chargers will typically add 75-150 miles of range for every 30 minutes spent charging. The range of miles added depends on various factors, such the vehicle type and the DC Fast charger capacity. For example, the Ford Mustang Mach-E RWD Extended Range can go from 10% to 80% battery charge in about 45 minutes and the Ioniq 5 RWD Long Range can go from 10% to 80% battery charge in about 18 minutes.

Vehicle-to-Grid (V2G) Charging

Vehicle-to-grid (V2G) charging is the bi-directional flow of energy and data between an EV and the grid. V2G strengthens resilience by enabling EVs to be used as flexible energy storage assets that provide on-demand back-up power to a building or to the grid. V2G can also help users optimize energy consumption by charging only when energy rates are low and exporting stored power back to the grid only when energy rates are high. A bidirectional charger is required for V2G capability. It relies on the presence of an AC current in the vehicle's battery to reverse the direction of charge. Only CHAdeMO charger adapters currently support bi-directional charging, but V2G-capable Combined Charging System (CCS, also known as SAE J1772 combo) charger adapters are in development now and expected to be available to consumers by 2025.

Most V2G projects are still in pilot stages, such as the school bus pilot in Beverly, MA. School buses are particularly well-suited for V2G because they have large batteries and remain parked for many hours at a time. Available battery electric vehicles that are capable of V2G charging include:

- Blue Bird Vision Electric Type C School Bus

- Micro Bird G5 Electric Type A School Bus
- Ford F-150 Lightning Light-Duty Pickup
- Nissan Leaf S/SL/SV
- Phoenix Zeus Medium-Duty Shuttle/School Bus
- Thomas Built Buses Saf-T Liner C2 Jouley Type C School Bus

Vehicle-to-everything (V2X) refers to the applications that EVs batteries can support for purposes other than powering the car. It is a collective term for referring to capabilities such as V2G, vehicle-to-home, and vehicle-to-vehicle. As an example of vehicle-to-vehicle capabilities, the Hyundai Ioniq 5 EV can charge other EVs using its battery. Other EV manufacturers producing V2X-capable light-duty vehicles include Ford, Mitsubishi, Nissan, and Toyota. If you are interested in learning more about V2G and V2X, refer to a recent report from the U.S. Department of Transportation Federal Highway Administration and reach out to National Grid to discuss opportunities for your fleet.

EV Charging Infrastructure Assumptions in Your Analysis

Manchester will need a maximum of 5 Level 2 chargers and zero DC Fast Chargers to support the recommended 5 EVs. See Table D for more specifics on the chargers recommended for each vehicle type. This conservatively assumes a one-to-one vehicle-to-charger ratio and does not account for any existing chargers at Manchester's fleet facilities. Depending on the scheduled duty cycles of the vehicles, it may be possible to reduce the number of chargers. The determination of charger type (Level 2 versus DC Fast) is made based on battery size, range, mileage, number of shifts per day, and time charge between shifts and at night.

It may be possible to reduce the number of chargers, including the number of DC Fast chargers, by:

- Manipulating the duty cycles of the vehicles to allow for successive (non-overlapping) charging schedules;
- Identifying managed charging solutions to optimize charger use; and
- Garaging EVs together to allow for shared chargers.
- Leveraging publicly available EVSE, where appropriate
- Make use of opportunity charging when vehicles are stationary, but still in-use.

The charger equipment and installation cost assumptions used for your analysis are summarized in Table D below.

Table D. EVSE Equipment and Installation Cost Assumptions

Vehicle Type	L2 Charger		DC Fast Charger	
	Equipment Cost	Installation Cost	Equipment Cost	Installation Cost
Minivan	Not Recommended	Not Recommended	Not Recommended	Not Recommended
SUV	$3,450	$6,650	Not Recommended	Not Recommended
SUV - Police	$3,450	$6,650	Not Recommended	Not Recommended
Light-Duty Pickup	$3,450	$6,650	Not Recommended	Not Recommended
Medium-Duty Pickup	Not Recommended	Not Recommended	Not Recommended	Not Recommended
Van	Not Recommended	Not Recommended	Not Recommended	Not Recommended
Heavy Truck	Not Recommended	Not Recommended	Not Recommended	Not Recommended
Motorcycle	Not Recommended	Not Recommended	Not Recommended	Not Recommended

Note that these are estimates and do not consider any incentives (see below for more information). For more detail on estimated hardware, permitting, and installation costs by charger type, see the Resources page of the MA Fleet Advisory Services Program portal (*FleetAdvisoryMA.NationalGrid.com/Resources*). The Resources page of the portal also provides information on:

- Operational (including maintenance and warranty) costs;
- Code requirements, including federal, state, and municipal codes and standards;
- Siting considerations, including mounting, location, Americans with Disabilities Act requirements, signage, and pavement markings;
- Opportunities for maximizing your charging station investment (e.g., accessibility for public and workplace charging when not in use by the fleet);
- Networked stations, managed charging, and vehicle-to-grid opportunities;
- Other considerations (e.g., screen protection, collision protection, cord length, cord management);
- A checklist for charger installation; and

- Chargers available to fuel vehicles off-site or when traveling long distances.

Charging Options for Take Home Vehicles

There are 4 vehicles in Manchester's fleet that have been identified as take-home vehicles. Enabling take-home EVs to charge at home reduces the need for additional trips, decreases reliance on public chargers, improves uptime, and lessens the need for infrastructure investment at fleet facilities. The easiest way to charge an EV at a residence is by plugging the vehicle into a 120V wall outlet using the Level 1 charger that was purchased with the vehicle. Level 2 chargers are also popular for home charging but rely on a 240V outlet and require the purchase and installation of Level 2 charging hardware.

If Manchester plans to reimburse employees for home charging, the cost of electricity used to charge the vehicle is easy to calculate. Vehicle telematic data that quantifies total energy usage is available through the vehicle manufacturer's smartphone application or the vehicle's dashboard. To calculate the cost of home charging, multiply the amount of energy used to charge the EV by the price of electricity.

We strongly encourage Manchester to reach out to National Grid before installing any new charging infrastructure. Your Account Manager can also answer questions on charging best practices.

Incentives and Funding Source Assumptions Applied

Incentives are available for the purchase of EVs and EVSE. Table E summarizes the incentives included in your fleet analysis, as well as additional information about how to capitalize on these incentives. Incentives in the analysis are capped at 100% of the vehicle capital and EVSE costs, so the table identifies how the incentives were prioritized and specifically applied through the TCO analysis.

Manchester may also want to reach out to the local planning agency to discuss Congestion Mitigation and Air Quality Improvement (CMAQ) and other funding opportunities. The local transportation planning agencies may be able to assist cities and transit agencies with grants that reduce emissions

TABLE E. Incentive and Funding Sources

Program	Light Duty EVs	Medium Duty EVs	Heavy Duty EVs	Administrator	Vehicle Costs	EVSE Installation	EVSE Hardware	Program Offerings	Upcoming Deadlines	TCO Funding Assumptions
EV Charging Station Program	✓	✓	✓	National Grid		✓	✓	Up to 50% of EVSE hardware and 100% of installation costs for BEV fleets[2]	TBD[3]	50% of EVSE hardware and 100% of installation costs for BEV vehicles EVSE installed before 2024
MassEVIP Fleet Incentives	✓			Massachusetts Department of Environmental Protection (MassDEP)	✓			Light-duty vehicles only. BEVs: $7500/purchase; PHEVs: $5000/purchase[4]	First-come, first-serve	BEVs: $7500/purchase; PHEVs: $5000/purchase
MassEVIP EVSE	✓	✓	✓	MassDEP		✓	✓	Up to 60% of EVSE hardware and installation costs	First-come, first-serve	60% of EVSE hardware & installation costs for BEV EVSE
Diesel Emission Reduction Act (National)		✓	✓	EPA	✓	✓	✓	Up to 45% of EV and EVSE costs, must replace a diesel vehicle with 7,000+ annual miles	TBD[5]	45% of Heavy Truck EV capital costs for vehicles over 7,000+ annual miles

[2] Up to 75% of hardware costs covered for publicly accessible ports and 100% for environmental justice (EJ) community sites. Prescriptive incentives are available for less than five charging stations. Equipment must be installed by 12/21/2023.
[3] While the EV Charging Station Program deadline has passed, National Grid has proposed a much larger program to the Department of Public Utilities. The MA Fleet Advisory Services Program will provide an update if this extension is granted.
[4] MassEVIP application caps were considered in this analysis. MassEVIP Fleet incentives for vehicles have a limit of 25 vehicles per applicant, so incentives were only applied to the first 25 vehicles to retire.
[5] Current program is open until 3/16/2021, but the Consolidated Appropriations Act passed on 12/22/2020 included reauthorization of the DERA Program through 2024.

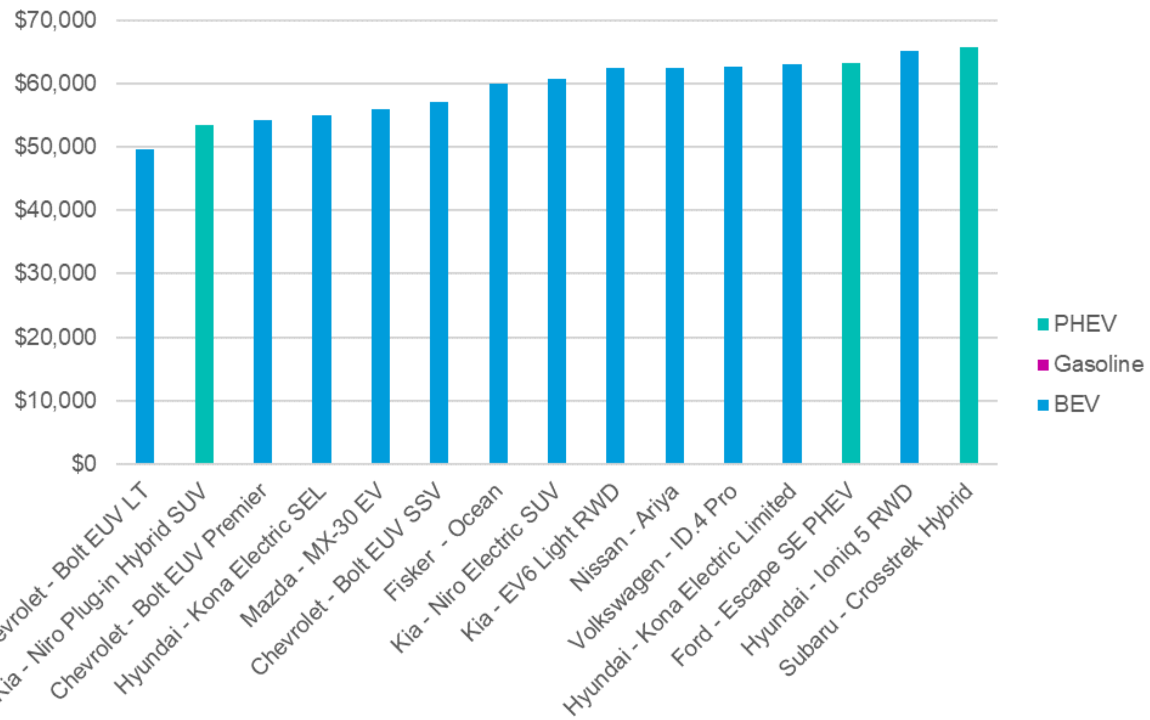
Program	Light Duty EVs	Medium Duty EVs	Heavy Duty EVs	Administrator	Vehicle Costs	EVSE Installation	EVSE Hardware	Program Offerings	Upcoming Deadlines	TCO Funding Assumptions
MOR-EV Trucks		✓	✓	MA DOER	✓			$7,500 - $90,000 per vehicle over 8,501 GVWR (lbs.)[6]	First-come, first-serve	$7,500 for Vans, $15,000 for medium duty pickups, $90,000 for heavy trucks
Green Communities Grant Program	✓	✓	✓	MA DOER	✓			BEVs: $7500/purchase or $5000/lease; PHEVs: $5000/purchase or $3000/lease[7]	9/30/2022 (Program offered annually)	$7,500 for BEVs and $5,000 for PHEVs purchased

EV Model Comparison

There are over 500 EV models in our EV library that were assessed across your fleet's vehicle types and range requirements to compare TCOs and recommend replacement models. While our EV acquisition recommendations are based on the model with the lowest TCO available that fits your fleet's needs, there may be additional EV models within the same price range. Chart H through Chart J highlight the lowest TCOs for each vehicle type within your fleet. This analysis is for 1 vehicle for each vehicle type, uses Manchester's average annual mileage and miles driven per day by vehicle type, and assumes a 15-year vehicle life. This simple comparison across EV model types does not include any charging infrastructure costs or apply any potential grants or incentives for EVs, however that level of detail is included in the sample financial analysis on the following pages.

[6] Purchases of BEVs with a sales price of more than $50,000 and having a gross vehicle weight rating (GVWR) of more than 8,500 pounds made on or after February 16, 2021, are eligible for a rebate in the MOR-EV Trucks Program. Rebates vary depending on vehicle GVWR and block schedule.
[7] Additional funds available for charging stations (up to $7,500) but they must be publicly accessible and were excluded from this analysis. Green Communities Grant Program funding may be available in future years but amounts by year vary.

Chart H. SUV EV Model TCO Comparison



[8]

[8] Comparable Gasoline SUV has a TCO of $68,919.

Chart I. SUV (Police) EV Model TCO Comparison

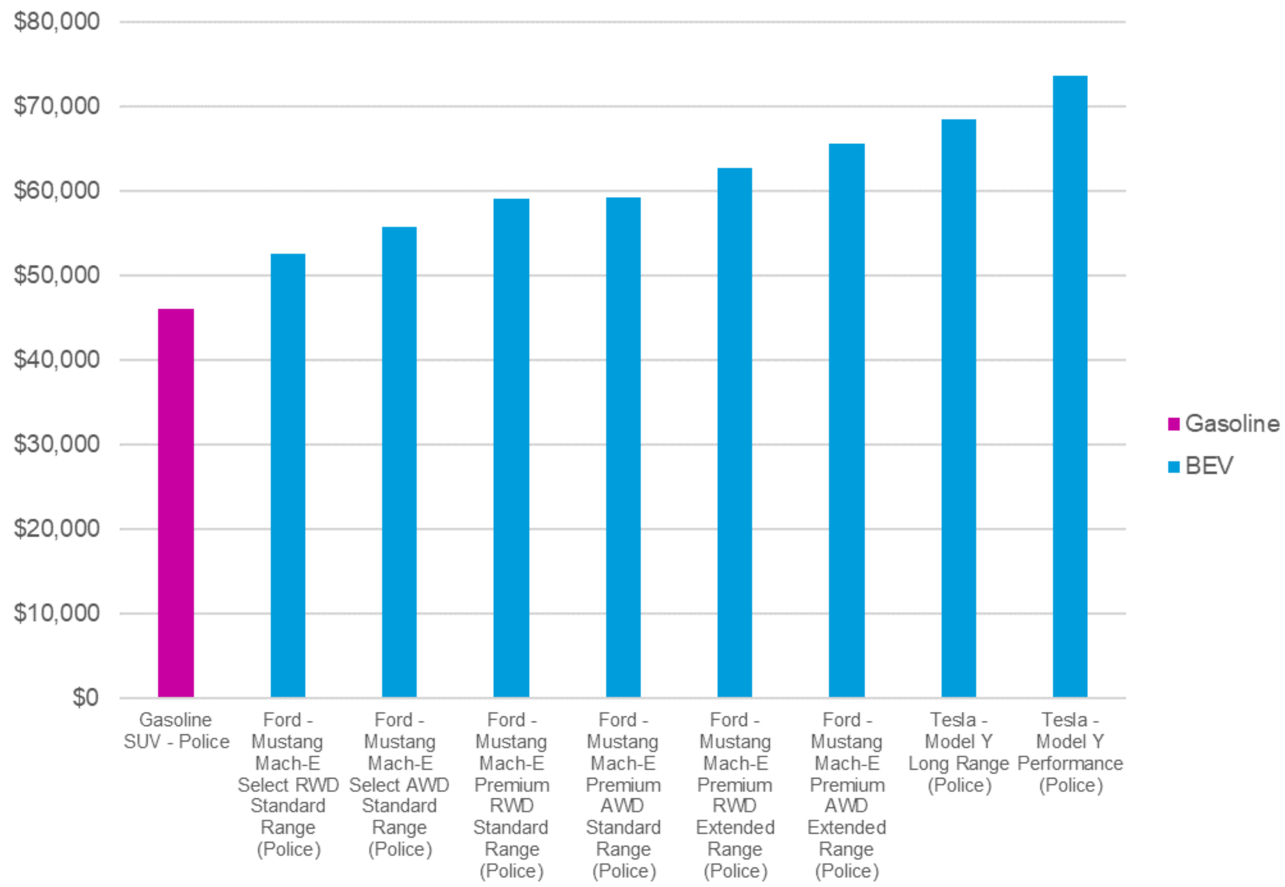
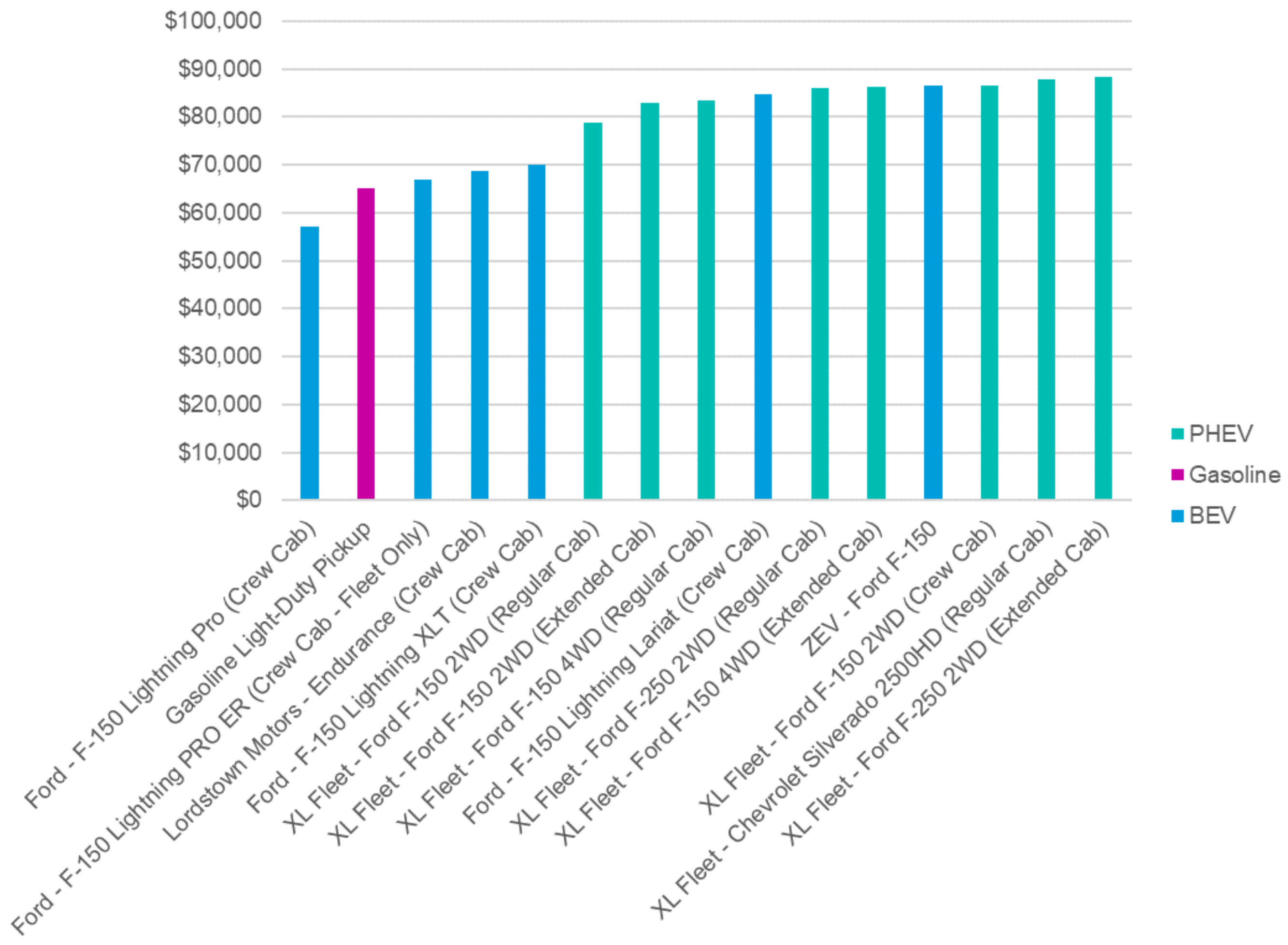


Chart J. Light-Duty Pickup EV Model TCO Comparison



Electric Vans
Currently available from most Ford dealerships, the new Ford E-Transit cargo van is an electrified version of the Ford Transit, America's best-selling van. National Grid is partnering with Ford to pilot a pre-production E-Transit model. Ford will use feedback and data from the pilot program to validate real-world vehicle performance and further refine their product for commercial release.

Electric Police Patrol Vehicles
Currently, only five EV models, including three sedans and two SUVs, are being used as police patrol vehicles in a handful of police fleets in the United States. These models have been considered in Manchester's fleet analysis, and additional models will be added as more EVs are piloted for police use. Additionally, the Hyundai Kona Electric SUV is being piloted by some police fleets in Europe and will be included in future analyses if deemed suitable for Manchester's police fleet.

- Chevrolet Bolt (sedan)
- Tesla Model 3 (sedan)
- Tesla Model S (sedan)
- Ford Mustang Mach-E (SUV)
- Tesla Model Y (SUV)

Electric Snowplows
There are no commercially available electric vehicles that are compatible with snowplows.[9] However, several PHEV aftermarket conversions are capable of plowing. These PHEVs are equipped with more torque and longer range than their ICE counterparts, making them especially capable of pushing heavy loads for many hours at a time. Available PHEVs that are compatible with snowplows are:

- XL Fleet Ford F-Series
- XL Fleet GM 2500/3500 HD
- XL Fleet GMC 3500/4500 Cutaway

Used Vehicles
Sales of EVs increased rapidly toward the end of the last decade, and as such, used EVs are becoming available for fleet purchase. Used vehicles have not been included in this analysis but may be a cost-effective option for purchase. Considerations of battery life and quality, range, and maintenance that accompanied the first generation of new EVs are pertinent. However, due to regenerative braking, EVs typically have less wear and tear on the drivetrain and therefore are a good fit to extend the vehicle lifespan. Batteries are generally expected to last upwards of 10 years, with newer models capable of longer lifetimes. On average, EV battery degradation is about 2% per year.

According to the World Resources Institute, 80% of all new EVs that are leased enter the used vehicle market just a few years later at a much lower price, under 40,000 miles, and only halfway through their warranties (EV manufacturers' warranties typically cover 8 years, or 100,000 miles). Additionally, with fewer moving parts, EVs require little maintenance in comparison to ICE vehicles, further factoring into a positive investment. For further information on used EV availability and pricing, see the Recurrent Used Electric Car Prices & Market Report.

[9] According to ATLIS Motor Vehicles, the ATLIS XT electric medium-duty pickup is compatible with snowplows and will be commercially available in 2023.

Sample Light-Duty Pickup Financial Analysis

Table F provides a sample TCO comparison for a single, purchased light-duty pickup. This analysis uses a 15-year vehicle life and a 6,156 annual mileage assumption, based on the average annual mileage for light-duty pickups within your fleet.

TABLE F. Light-Duty Pickup TCO Comparison

	Gasoline	PHEV (XL Fleet – Ford F-150 2WD (Regular Cab)	BEV (Ford F-150 Lightning Pro Crew Cab BEV)
Capital Cost	$37,000	$55,850	$39,974
Charging Infrastructure Hardware (L2)	N/A	$3450	$3450
Charging Infrastructure Installation	N/A	$6650	$6650
Incentives[10]	N/A	($12,070)	($25,445)
Annual Fuel/Energy Costs	$874	$609	$513
Annual Maintenance Costs	$1,003	$917	$633
15-Year Total Costs[11]	$54,728	$67,159	$35,346

Charts K and L provide a visual representation of the annual and cumulative cost comparisons across a gasoline, PHEV, and BEV light-duty pickup. The BEV has the lowest 15-year total cost due to annual fuel and maintenance savings as well as the incentives that reduce the upfront cost to less than that of the gasoline vehicle.

[10] Assumes MassEVIP Vehicle funding ($7,500 per BEV), Green Communities ($7,500 per BEV), National Grid Electric Vehicle Charging Station Program (100% of BEV EVSE installation costs), and MassEVIP (60% of BEV EVSE installation costs) incentives. EV capital and infrastructure costs shown in table does not have incentives applied.

[11] NPV assumes a 5% discount rate.

Chart K. Light-Duty Pickup 15 Year Annual Cost Comparison

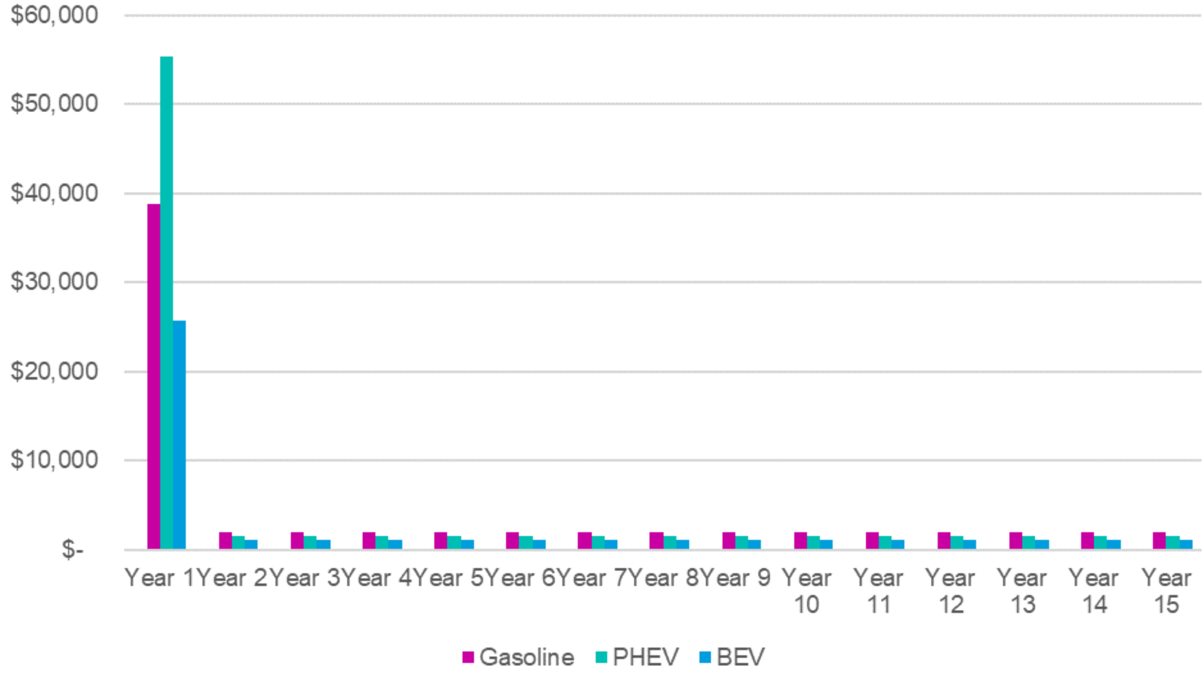
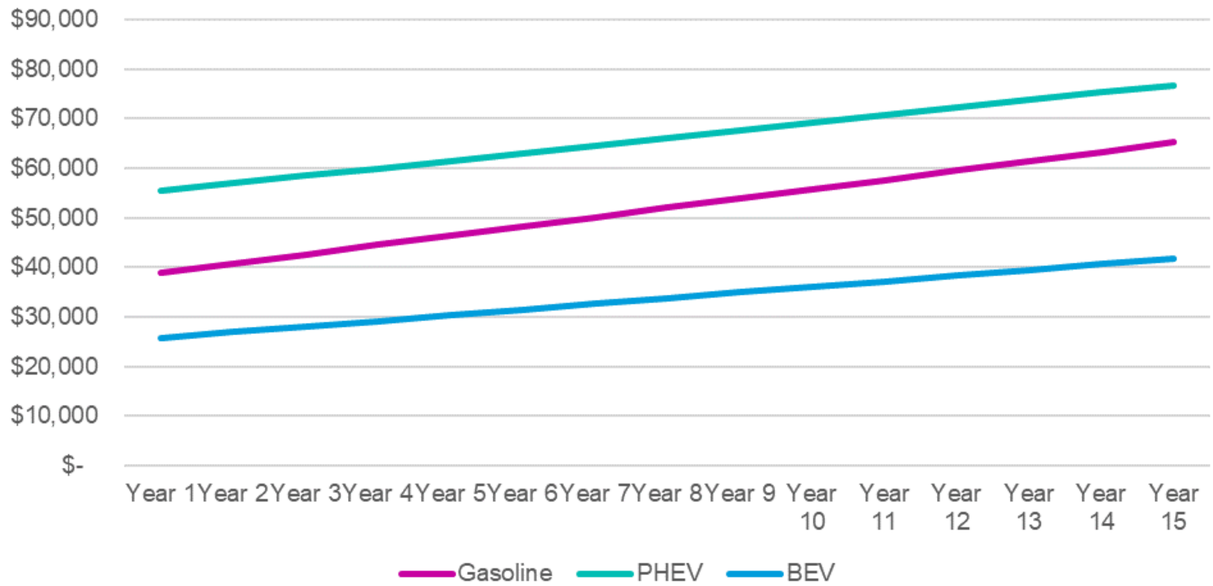


Chart L. Light-Duty Pickup 15 Year Cumulative Cost Comparison



Sample SUV Financial Analysis

Table G provides a sample TCO comparison for a single, purchased SUV. This analysis uses a 15-year vehicle life and a 6,156 annual mileage assumption, based on the average annual mileage for SUVs within your fleet.

TABLE G. SUV TCO Comparison

	Gasoline	PHEV (Kia – Niro Plug-in Hybrid SUV)	BEV (Chevrolet – Bolt EUV LT SUV)
Capital Cost	$29,000	$24,590	$28,195
Charging Infrastructure Hardware (L2)	N/A	$3450	$3450
Charging Infrastructure Installation	N/A	$6650	$6650
Incentives[12]	N/A	($12,070)	($25,445)
Annual Fuel/Energy Costs	$1,162	$553	$489
Annual Maintenance Costs	$1,499	$1,370	$945
15-Year Total Costs[13]	$55,243	$41,510	$27,126

Charts M and N provide a visual representation of the annual and cumulative cost comparisons across a gasoline, PHEV, and BEV SUVs. The BEV has the lowest 15-year total cost due to annual fuel and maintenance savings as well as the incentives that reduce the upfront cost to less than that of the gasoline vehicle.

[12] Assumes MassEVIP Vehicle funding ($7,500 per BEV), Green Communities ($7,500 per BEV), National Grid Electric Vehicle Charging Station Program (100% of BEV EVSE installation costs), and MassEVIP (60% of BEV EVSE installation costs) incentives. EV capital and infrastructure costs shown in table does not have incentives applied.
[13] NPV assumes a 5% discount rate.

Chart M. SUV 15 Year Annual Cost Comparison

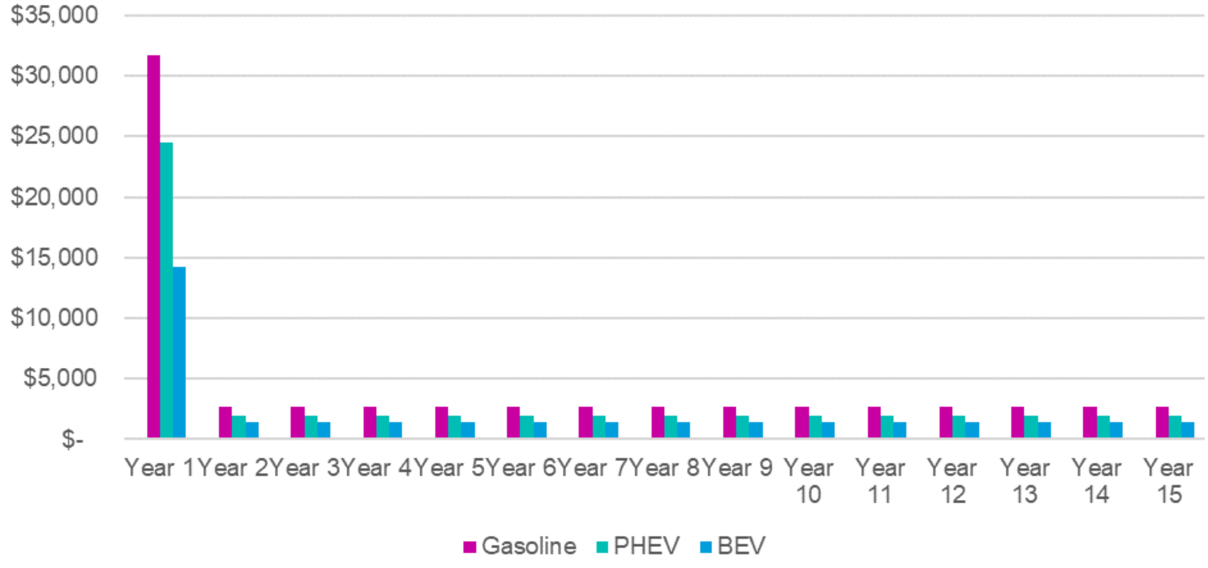
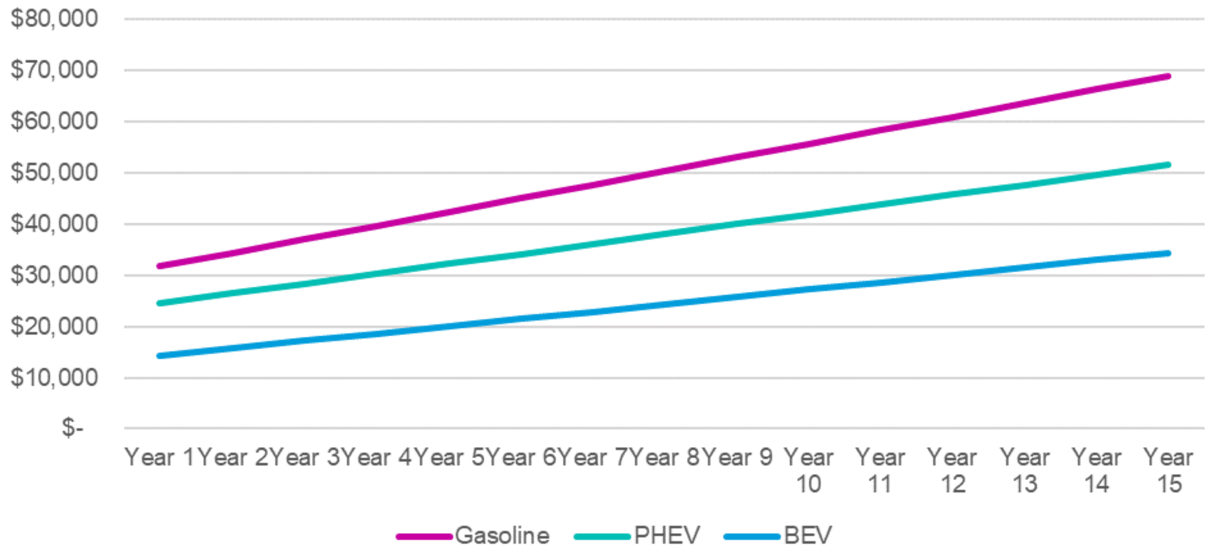


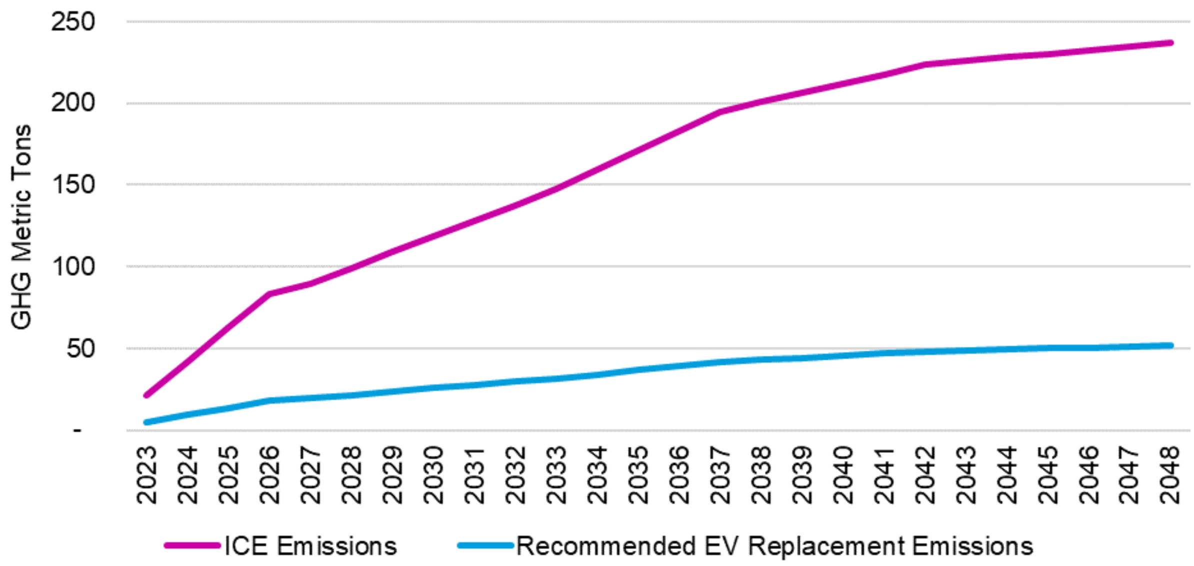
Chart N. SUV 15 Year Cumulative Cost Comparison



Fleet Environmental Impact Analysis

By converting the 5 recommended on-road vehicles to EVs, you could reduce GHG emissions by 184 MT and NOx emissions by 73 pounds (lbs) over 26 years. Chart O below illustrates the cumulative GHG emissions for ICE replacements compared to EV replacements. The GHG emissions included in this analysis account for both tailpipe and source (fuel production) emissions, while the NOx emissions account for only tailpipe emission reductions.

Chart O. Cumulative Greenhouse Gas Emissions



184 GHG Emission Reductions (MT over 26 years)

40 Equivalent to removing passenger vehicles from the road for one year

73 NOx Emission Reductions (Lbs. over 26 years)

3,036 Equivalent to tree seedlings grown for 10 years

Non-Road Equipment

There are 13 vehicles in Manchester's fleet identified as non-road equipment, summarized in Table H below. Of these vehicles, 3 were identified as cost beneficial opportunities to convert to electric: 1 All-Terrain Vehicle / Utility Terrain Vehicle (ATV/UTV), and 2 commercial lawn mowers. Electric non-road equipment is quiet, requires little maintenance, and produces no site emissions. Electric non-road equipment could help Manchester further reduce fuel costs, maintenance costs, and site emissions.

TABLE H. Non-Road Equipment

Equipment Type	Quantity	Quantity Recommended to Convert to Electric	Financial Savings (across vehicle lifespan)	GHG Emission Reductions (across vehicle lifespan)
ATV/UTV	1	1	$6,432	7
Mower	2	2	$6,526	74
Backhoe	1	0	-	-
Other[14]	9	N/A	N/A	N/A
Total	**13**	**3**	**$12,958**	**81**

ATV/UTVs

Manchester's current ATV/UTV is a 2016 gasoline-powered Honda Rancher. We recommend Manchester explore electric ATV/UTV options when looking to replace this ATV/UTV. Electric ATV/UTVs are cost competitive with diesel models, as seen in Chart O, and can help reduce fuel and maintenance costs by up to 60%. In the sample ATV/UTV TCO Comparison shown in Table I, the electric ATV/UTV results in an overall $9,822 TCO savings.

[14] Non-Road equipment classified as other and excluded from the analysis include boat motors, pump systems, and sidewalk snowplows.

Chart O. Comparable UTV Capital Costs

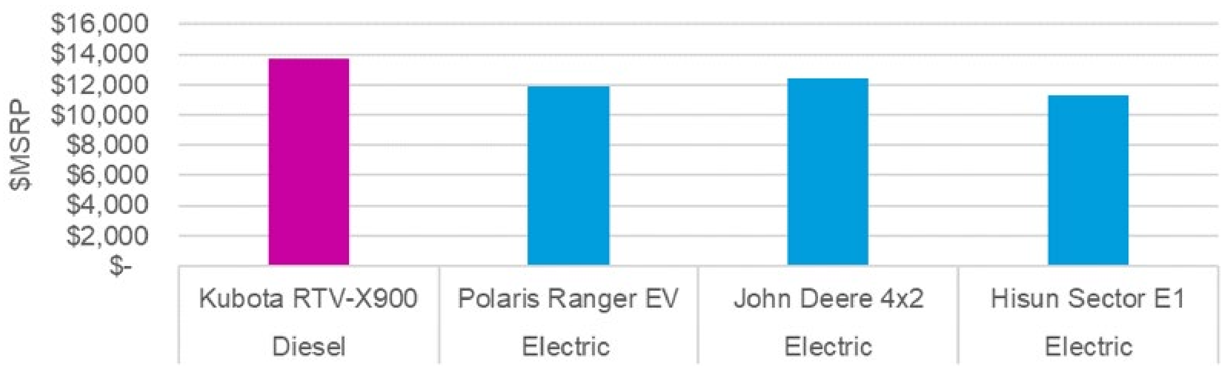


TABLE I. UTV TCO Comparison

	Diesel	Electric
Capital Cost	$13,700	$11,900
Annual Fuel/Energy Costs	$1,700	$850
Annual Maintenance Costs	$500	$300
10-Year Total Costs[15]	$30,035	$20,213

Backhoes

Manchester currently owns 1 diesel backhoe. While a relatively new technology, there are a few electric backhoe models available through CASE, Volvo, John Deere, JCB, and MultiOne. While capital costs are much higher than diesel backhoes (2-3 times the cost) electric backhoes can help reduce operational costs, noise, and emissions. National Grid is partnering with CASE and John Deere to test fully electric backhoe options.

Mowers

Manchester operates 2 diesel commercial lawn mowers, a 2018 Walker and a 2010 Scag. A high-use commercial lawn mower can consume more fuel than a typical car.[16] Some electric mower examples include Weibang's E-Rider (MRSP $3,250), Ryobi's Zero-Turn Rider (MSRP $4,399) and Cub Cadet's Ultima (MSRP $4,999). These manufacturers, in addition to Turf One and Ariens, produce a range of electric battery models including rear engine riders and zero turn mowers.

[15] NPV assumes a 5% discount rate.
[16] Clean Cities Guide to Alternative Fuel Commercial Lawn Equipment

Next Steps

☐ **Get Support.**
Have questions about this report? Contact your Account Manager to discuss challenges and answer questions.

☐ **Explore Resources for Electrifying.**
Log onto the MA Fleet Advisory Services Program's online portal to find resources about available incentives, charger and vehicle trainings, checklists, news and updates, and more.

☐ **Move Forward with Electrifying Your Fleet.**
Circulate the findings of this report with key stakeholders in your organization. Contact your Account Manager for additional support in preparing to present these findings.

☐ **Connect with National Grid for EV infrastructure needs.**

Your Fleet Advisory Portal has the tools you need to succeed.

Log in at
http://fleetadvisoryma.nationalgrid.com/
and you can:

- See your MA Fleet Advisory Services reports
- Explore funding opportunities
- Find RFP language to help your fleet acquire EVs
- Find partners that can support your transition to EVs
- Find information about EV and EVSE operation and maintenance
- Identify trainings
- Stay up to date on the latest industry news

We're here to help.

Contact us for help with your report, support navigating next steps, or just to speak with an expert.

Web: http://fleetadvisoryma.nationalgrid.com/

Email: FleetAdvisoryMA@icf.com

Phone: 617-218-2100

Appendix: Frequently Asked Questions

Will additional training be needed for our drivers or maintenance staff?
Driving an EV is very similar to an ICE, but there are a few differences that your team may need help with, such as charging the vehicle and how to shift it into "drive." The level of training needed may vary depending on the vehicle type. The MA Fleet Advisory Services Program portal (*FleetAdvisoryMA.NationalGrid.com)* provides training materials to help address your needs.

What is the impact of cold weather on electric vehicle (EV) operation?
This assessment accounts for potential regional temperature impacts on range prior to identifying recommended vehicle replacements. Extreme outside temperatures do reduce range, because more energy must be used to heat or cool the cabin. In New England, this can equate to small range reductions in the fall and spring, and up to 30-50% in the winter. For estimates of range reductions on various light-duty EVs, see findings from Recurrent.

How long do EVs last?
A manufacturer's warranty of a light-duty EV typically covers 8 years or 100,000 miles, and the expected battery lifetime is 10 to 12 years. Batteries in newer EV models should be capable of longer miles and lifetimes. On average, EV battery degradation is about 2% per year. An EV reaches the end of its useful life when the battery has less than 80% of its initial capacity remaining.

What electrical infrastructure upgrades will be needed to install chargers for my fleet? What are the associated costs?
While the specifics around electrical upgrades are not the focus of this analysis, your Account Manager can connect you with vetted charging station installers, as well as the National Grid EV Implementation Team, to better understand the costs of upgrades. We will also estimate the cost of charging infrastructure in the TCO calculation in this report.

Which Massachusetts fleets have gone electric and what funding did they receive?
The MA Fleet Advisory Services Program portal (*FleetAdvisoryMA.NationalGrid.com)* provides links to case studies of EV fleet deployment in Massachusetts. If you would like additional or more specific examples, please contact your Account Manager.

If my fleet doesn't have the budget to purchase EVs right now, how should we proceed?
This report provides 14-year recommendations for EV purchases. It also identifies applicable incentives and funding that may help cover some of the costs. You and your Account Manager will develop a schedule for report refreshes over the next few years, as more funding and vehicle models become available.

Who do I contact with additional questions?
Your Account Manager at FleetAdvisoryMA@icf.com or 617-218-2100.