Town of Barrington

EV Fleet Study Final Report

August 2022

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List of Acronyms

AFLEET - Alternative Fuel Lifecycle Environmental and Economic Transportation Tool

AWD – All Wheel Drive

BEV - Battery Electric Vehicle

EV – Electric Vehicle

EVSE – Electric Vehicle Supply Equipment

MSRP – Manufacturer's Suggested Retail Price

PHEV - Plug-In Hybrid Electric Vehicle

SUV – Sport Utility Vehicle

TCO – Total Cost of Ownership

This study was funded through Rhode Island Energy's Electric Vehicle Charging Station Program – Fleet Advisory Services.[1]

[1] https://www.rienergy.com/RI-Business/Energy-Saving-Programs/Electric-Vehicle-Charging-Station-Program

Executive Summary

To achieve sustainability goals and reduce long-term costs, the Town of Barrington (Barrington) should plan to replace 14 current sedans, SUVs, fullsize cargo vans and pickup trucks with equivalent Battery Electric Vehicles (BEV[2]) and Plug-in Hybrid Electric Vehicles (PHEVs) in the next five years. By procuring these vehicles, Barrington could save up to $142,795 in net lifetime costs relative to conventional gasoline-powered vehicles and reduce lifetime carbon emissions by 975 short tons. We recommend the following:

Vehicles – Replace 14 current fleet pickup trucks, SUVs, and compact cargo vans with EVs over the next 5 years

- These vehicles present Barrington's best opportunity for cost-effective electrification because their short, predictable daily range needs and low to high annual mileage can be easily met by existing PHEVs and BEVs
- Based on known data, each of these vehicles are good operational candidates for replacement with EVs and most should achieve sufficient lifetime operating savings (from $6,700 to $45,000 per vehicle) to justify the higher initial capital investment into vehicle and charging station costs, after taking incentives into account (Figure ES-1, below).

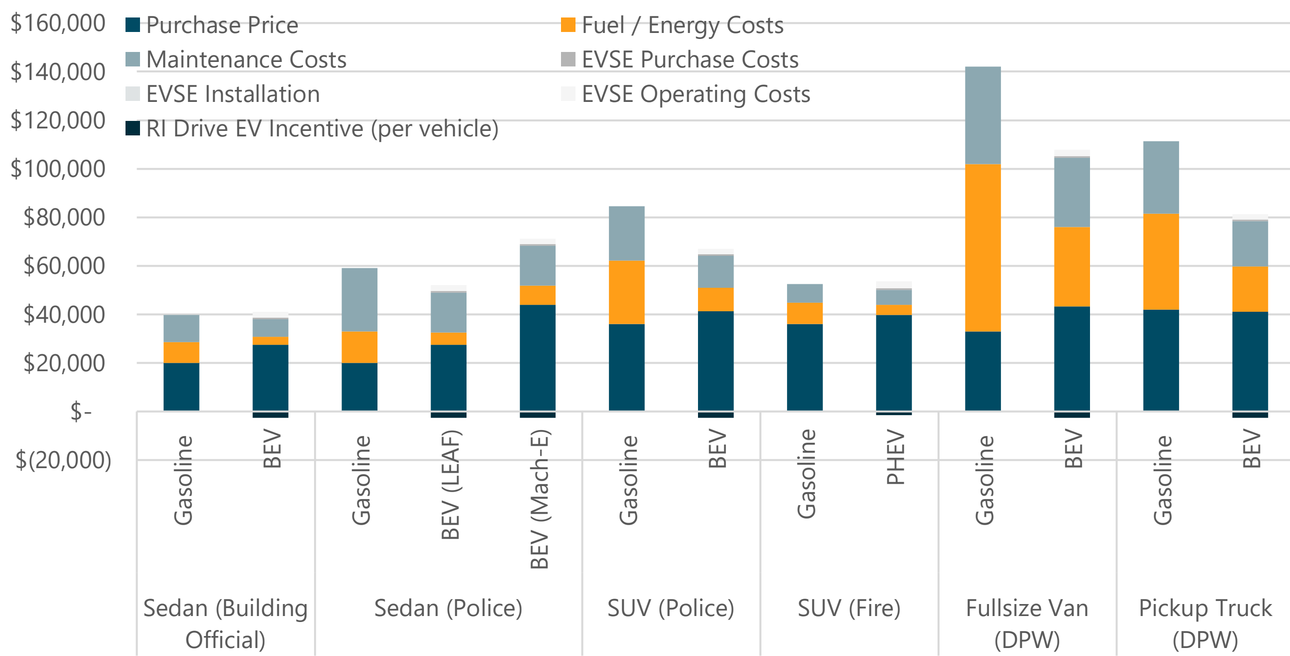

Figure ES-1. Lifetime total cost of ownership for Nissan LEAF, Ford Mustang Mach-E, Volkswagon ID.4, Ford E-Transit, and Ford F-150 Lightning compared to gasoline-powered sedan, SUV, fullsize van, and pickup truck equivalents.

[2] Battery Electric Vehicles (BEVs) 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 BEVs and PHEVs. See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for details.

- Note that while the recommended EV police sedan replacements have a higher projected lifetime cost than current gasoline powered sedans, these additional costs can be offset by anticipated savings from the other recommended vehicle replacents over their lifetimes - resulting in an overall net savings of $142,795.
- Of available EV models, we recommend:
  - BEV Sedans: The standard-range Nissan LEAF (149 mi range) is the most cost-effective option for replacement for basic sedans (ex. Building Official sedan), and the Mustang Mach-E with all-wheel drive (224-303 mi range) for sedans with higher-performance requirements (ex. Police sedans).
  - BEV SUV: the all-electric Volkswagen ID.4 BEV (245 mi range) with option AWD is the best value EV option for replacement of Barrington's existing Police Department medium-sized gasoline AWD SUVs.
  - PHEV SUV: the plug-in hybrid electric Toyota RAV4 PHEV (42-mile electric range and 600-mile combined range) is the best value EV option for replacement of Barrington's existing Fire Department medium-sized gasoline AWD SUV.
  - BEV Ford E-Transit Van: The all-electric Ford E-Transit (126 mi range) is the best EV option for replacement of Barrington's existing fullsize cargo vans.
  - BEV Pickup: the all-electric 4WD Ford F-150 Lightning (230-300 mi range) is the most cost-effective option for replacement of Barrington's existing fullsize pickup trucks.
- These recommended models will all easily meet the roughly 20-50 mile maximum daily miles traveled of the 14 vehicles identified for replacement in Barrington's fleet
- If all 14 vehicles are replaced, there is the potential to reduce GHG emissions by 975 short tons (or 2,270 barrels of oil) over the lifetime of the vehicles, a reduction of 75% compared to equivalent new gasoline-powered vehicles.

Charging Stations - Install up to 14 additional charging station ports over the next 5 years.

- Each BEV should have a dedicated Level 2 charging station port to ensure they are fully-charged each morning and to minimize staff efforts to shuffle vehicles between any shared charging station ports
- Each PHEV would benefit from having its own charging station port to ensure vehicles are fully-charged each morning, but could share ports if desired.
- Charging Equipment: Select the more basic, lower-cost Electric Vehicle Supply Equipment (EVSE, aka charging station) options when possible to reduce annual operating costs and maximize lifetime TCO savings.

Funding Opportunities

Barrington should pursue the following incentives to support EV and EVSE deployment:

- Rhode Island Energy's Electric Vehicle Charging Station Program for Government Light Duty Fleet[3], which covers 100% of EVSE installation and 50% of EVSE hardware costs.
- RI Master Purchase Agreements for Vehicles (MPA 563) and EVSE (MPA 509), which offers discounts of roughly 5-10% off the MSRP purchase costs of covered vehicles and 20-30% off the MSRP purchase costs of covered charging stations (though not network fees).[4]
- Climate Mayors Electric Vehicle Purchasing Collaborative[5], which offers competitive pricing on electric light, medium and heavy duty vehicles and associated charging stations for public entities, and is managed by Sourcewell.[6]
- Rhode Island D**RI**VE EV Rebate Program – starting in summer 2022, the RI Office of Energy Resources plans to open this rebate program, which is expected to offer purchase incentives of $2,500 for BEVs and $1,500 for PHEVs. Vehicles must have an MSRP below $50,000 and fleets are limited to a total of 5 vehicle rebates per fleet.[7]

Background

In Rhode Island, the transportation sector accounts for 40% of the state's greenhouse gas (GHG) emissions, more than any other sector, and double the emissions of the state's electricity consumption.[8] In 2018 National Grid (now Rhode Island Energy) received approval from the Rhode Island Public Utilities Commission (PUC) to conduct a series of customer fleet electrification studies. Fleet electrification can dramatically reduce fleet energy usage and GHG emissions, as well as reduce vehicle fueling and maintenance costs. Fleets are excellent candidates for EV adoption for the following reasons: predictable routes and/or duty cycles and optimized fleet management that can maximize battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) fuel savings.

The Town of Barrington has a Resilience and Energy Committee dedicated to promoting "energy efficiency, creating savings and reducing the environmental impact of the town energy usage through conservation and use of sustainable resources."[9] As a result, Barrington has developed a Strategic Energy Plan to "reduce overall municipal and school building and fleet energy usage by at least 10% by 2015."[10] It's unclear if this goal was achieved since the last strategic plan was published in 2011 and there is no status or evaluation report. Barrington recently demonstrated its commitment to reducing carbon emissions by announcing that the Town's Police Department

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[3] https://www.rienergy.com/RI-Business/Energy-Saving-Programs/Electric-Vehicle-Charging-Station-Program
[4] MPA 563 – Passenger Vehicles & MPA 509 - Electric Vehicle Charging Stations and Related Services - https://www.ridop.ri.gov/contract-board/
[5] Offerings | Drive EV Fleets
[6] Fleet | Sourcewell (sourcewell-mn.gov)
[7] http://www.drive.ri.gov/
[8] Rhode Island Executive Climate Change Coordinating Council, Greenhouse Gas Emissions Reduction Plan, 2016: http://climatechange.ri.gov/documents/ec4-ghg-emissions-reduction-plan-final-draft-2016-12-29-clean.pdf
[9] https://www.barrington.ri.gov/resilience-energy
[10] https://www.barrington.ri.gov/_files/ugd/9ae2cd_c23476f8049044beb1bd1dead530343b.pdf

is deploying its first EV (a Ford Mustang Mach-E) and is the first police department in Rhode Island to do so.[11]

Recommendations

Vehicles

This study focused on evaluating potential EV replacement for a 37 vehicle subset of Barrington's light, medium, and heavy-duty fleet vehicles and heavy equipment. This report focuses on fleet vehicles that have potential plug-in replacement options, including SUVs, mini- and full-sized vans, pickup trucks, and medium-duty utility trucks.

A full assessment of Barrington's light-duty fleet is provided in Appendix E – Barrington Electric Vehicle Fleet Study - Existing Conditions.

Based on Barrington's vehicle-specific replacement plans and estimated annual mileage of current vehicles, **we have identified 14 vehicles that are good operational and cost-effective candidates for EV replacement in the next five years** (see Appendix A for the complete list).

These vehicles present Barrington'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 PHEVs and BEVs and can charge overnight at their current parking locations. Based on known data, each of these vehicles are good operational candidates for replacement with EVs and most should achieve sufficient lifetime operating savings (ranging from $6,700 to $45,000 per vehicle) to justify the higher initial capital investment into vehicle and charging station costs, after taking incentives into account.

Sedans

Building Official Sedan

Barrington's building official also drives a Ford Fusion less than 50 miles a day and averages 6,000 miles per year. Because estimated maximum daily miles traveled for the Building Official sedan is relatively low, and AWD or other higher-performance features are not needed, Barrington has the opportunity to choose a more-economical, low- to mid-range BEV replacement to reduce initial capital costs and maximize lifetime savings.

[11] https://www.barrington.ri.gov/_files/ugd/0606cc_77ff99cb59ee48a8bdda91bbb4071fe0.pdf

Of available BEV models, we recommend the standard range Nissan LEAF as the most cost-effective option for replacement of the Building Official sedan. Its 149-mile range will be more than sufficient to meet the 50-mile maximum daily mileage of the current sedan, including decreases in range in cold-weather. Table 1 shows the standard-range Nissan LEAF compared to other BEV options.[12]

Table 1: Recommended BEV replacement options for identified Barrington Sedans[13]

Make / Model	EV Type	Class	Standard Electric Range (mi)	Cold-Weather Electric Range (mi)	Cargo (ft3)	Base Model MSRP
Nissan LEAF	BEV	Midsize Sedan	149	89.4	23.6	$27,400
Chevrolet Bolt	BEV	Hatchback Sedan	259	155.4	16.6	$31,500
Ford Mustang Mach-E	BEV	Crossover SUV	224-303	134-181	29.7	$43,895
Tesla Model 3	BEV	Hatchback Sedan	267-334	160-200	14.0	$46,990

Police Sedans

Barrington's police department currently includes five Dodge Chargers and Ford Interceptors that travel less than 50 miles a day and average 10,600 miles per year. These vehicles are each used for one shift per day, and either assigned to individival detectives or supervisors for daily use, or used as needed for detail assignments (where they are understood to mostly be parked, providing traffic or crowd control, security or other related services). Two of the five current sedans have AWD. Most are parked at the police station each night, whereas one (assigned to the Patrol Lieutenant) is taken home at night.

Of available BEV models, we recommend the Ford Mustang Mach-E as the most versatile option for replacement these police sedans. While this vehicle is not pursuit-rated and Ford does not

[12] Note that recommendations in this report are made based on net purchase and operating costs, among other considerations, and that neither VEIC nor Rhode Island Energy endorse any specific vehicle or charging station model or brand

[13] See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for details.

currently have a Mustang Mach-E police package, it is the first electric vehicle to be tested at the annual Michigan State Police Vehicle Evaluations, and its performance was well-received.[14] It offers AWD as an option, and provides acceleration and braking performance that is superior to Ford's existing pursuit-rated SUVs. The City of New York Police Department (NYPD) is deploying 184 of these vehicles and putting them into service as patrol vehicles[15], and as noted earlier, the Barrington Police Department has already ordered a Mustang Mach-E for their department.

Many early EV-adopting police departments have deployed Teslas as pursuit vehicles with significant customization required. While high-performing and long-range, space-limitations from Tesla Model 3s and Ys have been cited by some departments as a challenge to broader deployment.[16]

While we recommend the Mustang Mach-E, unfortunately its versatility and performance come at a notable price premium compared to a conventional gasoline-powered police sedan (costing an additional $9,655 per vehicle over their anticipated lifetime after incentives).

However, because Barrington is strongly motivated to become the first police fleet in Rhode Island to deploy BEVs, we **recommend Barrington utilize a portion of the projected savings from the recommended EV SUV, cargo van and pickup truck replacements to offset the additional $48,000 in lifetime costs for the recommended 5 sedans** – while resulting in an **overall net-project savings of $142,795**.

To maximize cost savings, Barrington may also consider a standard-range Nissan LEAF for any current or future non-emergency response police vehicles (such as parking enforcement, detectives, or administrative functions), including those that don't require all-wheel drive. **Selecting a Nissan LEAF over a Mustang Mach-E so could potentially save over $19,000 per vehicle in capital and energy costs (or $9,581 in net lifetime savings compared to a gasoline sedan).**

SUVs (Police)

We identified two medium-sized SUVs in Barrington's existing fleet that are strong candidates for replacement with all-electric compact AWD SUVs. The current vehicles are Ford Explorers and are assigned to Barrington's Police department. They travel an estimated average of approximately 12,000 miles per year with a maximum daily travel distance of roughly 50 miles.

Of available AWD BEVs and PHEVs, we recommend the Volkswagen ID.4 BEV as the most cost-effective EV replacement option. This all-electric compact SUV is available with optional AWD, and its 245-mile base-model electric range will be more than sufficient to meet the 50-mile

[14] Is Ford's Electric Mustang SUV a Game-Changing Patrol Vehicle Option? - Vehicle Ops - POLICE Magazine
[15] Get a First Look at NYPD's New Ford Mustang Mach-E - Green Fleet - Government Fleet (government-fleet.com)
[16] https://www.police1.com/patrol-cars/articles/too-small-for-police-work-thumbs-down-review-for-tesla-pilot-hv6rmvP6gzmvnLEI/

maximum daily mileage of Barrington's Police SUVs. This is true even in winter months when Barrington should expect to see up to a 40% reduction in battery range on the coldest days.[17]

Other options include the Toyota RAV4 Prime PHEV, which has an all-electric range of 42 miles (and a 600 mile combined range). It also provides AWD standard as well as significant power and acceleration performance which may be particularly desired for any emergency use.

Both the VW ID.4 and RAV4 Prime are smaller than Barrington's current midsized Ford Explorer SUVs. If current vehicle size and cargo capacity is required for any replacements, Barrington may wish to consider the Jeep Grand Cherokee 4xe PHEV, though its significantly higher purchase price makes it unlikely to achieve lifetime cost savings.

Table 2 shows the various cargo sizing, ranges, and prices for AWD SUV options.[18]

Table 2. Recommended AWD EV replacement options for identified Barrington's Police SUVs[19]

Make / Model	EV Type	Class	Standard Electric Range (mi)	Cold-Weather Electric Range (mi)	Total Gas & Electric Range (mi)	Cargo (ft3)	Base Model MSRP
Jeep Grand Cherokee 4xe	PHEV	Mid-Size SUV	26	15.6	470	37.7	$58,095
Hyundai Santa Fe PHEV	PHEV	Mid-Size Crossover SUV	30	18	440	36.4	$39,500
Toyota RAV4 Prime	PHEV	Compact Crossover SUV	42	25.2	600	33.5	$39,800
Volkswagen ID.4	BEV	Compact Crossover SUV	245-280	147-168	NA	30.3	$41,230*
Ford Mustang Mach-E	BEV	Compact Crossover SUV	224-303	135-180	NA	29.7	$43,895

**VW ID.4 base price including optional AWD is $44,910*

[17] Report: *AAA Electric Vehicle Range Testing, February 2019 - https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range/*

[18] Note that recommendations in this report are made based on net purchase and operating costs, among other considerations, and that neither VEIC nor Rhode Island Energy endorse any specific vehicle or charging station model or brand

[19] See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for details.

SUV (Fire)

We identified one medium-sized SUV in Barrington's Fire department fleet that is a strong candidates for replacement with all-electric compact AWD SUV. The current vehicle is a Ford Explorer, and travels an estimated 3,600 miles per year with a maximum daily travel distance of roughly 50 miles.

Of available AWD BEVs and PHEVs, we recommend the Toyota RAV4 Prime as the most versatile and best value EV replacement option for this midsized Fire Department SUV. Its 42-mile electric range (and 600-mile combined range) will be more than sufficient to meet the 50-mile maximum daily mileage the current SUV, and should enable the majority of trips to be completed solely on electric power. This is true even in winter months when Barrington should expect to see up to a 40% reduction in battery range on the coldest days.[20] It also provides AWD standard as well as significant power and acceleration performance which may be particularly desired for any emergency use.

Due to the relatively low annual miles traveled by the current SUV, it is unlikely to achieve lifetime cost savings with an all-electric (and higher priced) compact SUV such as the VW ID.4, which is why the RAV4 PHEV is recommended.

Pickup Trucks

We identified three fullsize pickup trucks in Barrington's existing fleet that are strong candidates for replacement with all-electric fullsize pickup trucks in the short term. The current vehicles are mid-sized Chevy Colorados and are assigned to Barrington's Department of Public Works (DPW). They travel an estimated average of approximately 15,000 miles per year with a maximum daily travel distance of less than 50 miles.

Of available BEV models, we recommend the all-electric Ford F-150 Lightning as the most cost-effective BEV option for replacement of Barrington's existing gasoline pickup trucks. Its 230-mile range will be more than sufficient to meet the roughly 50-mile maximum daily mileage of most of Barrington's pickups, including reductions in range due to cold-weather (which may reduce the range down to 138 miles). Note that Ford also offers the F-150 Lightning Pro which includes an extended range option (300 miles) for an additional $10,000 per vehicle for fleet customers.

DPW staff have noted that these pickup trucks (and cargo vans in the following section) are typically used just one shift daily under typical conditions, but under extreme weather conditions (ex. blizzards and hurricanes) these vehicles are viewed as essential and may need to used continuously. As a result, Barrington may wish to deploy one (or more) BEV pickups as pilot vehicles initially and assess how they are used and perform during extreme weather events (and

[20] Report: *AAA Electric Vehicle Range Testing, February 2019 - https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range/*

utilizing other gasoline-powered pickups in Barrington's existing fleet as backups as needed) before committing to additional BEV pickups. This testing could also help inform whether Ford's extended range F-150 Lightning would be worth deploying to help extend its usability during these events.

The Ford F-150 Lightning is the only fleet-focused mass-market all-electric pickup truck on the market currently. Additional options for Barrington in the next five years will likely include the Chevrolet Silverado (base price $40,000, 400 mi range), 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) and so are not projected to be cost-effective options.

Table 3. Recommended EV replacement options for identified Barrington's Pickup Trucks[21]

Make / Model	EV Type	Class	Standard Electric Range (mi)	Cold-Weather Electric Range (mi)	Base Model MSRP
Ford F150 Electric	BEV	Pickup Truck	230	138	$41,000
Ford F150 Electric (extended range)	BEV	Pickup Truck	300	180	$51,000
Chevrolet Silverado	BEV	Pickup Truck	400	240	$40,000
Lordstown Endurance	BEV	Pickup Truck	250	150	$52,000

Fullsize Vans

We identified two fullsize vans in Barrington's existing DPW fleet that are strong candidates for replacement with all-electric vans in the short term. The current vehicles are a Ford Transit and a GMC Savana Cargo Van. They travel an estimated average of approximately 15,000 miles per year with a maximum daily travel distance of less than 20 miles.

Of available BEV models, we recommend the all-electric Ford E-Transit as the most cost-effective BEV option for replacement of Barrington's existing fullsize cargo vans. Its 126-mile range will be more than sufficient to meet the maximum daily mileage throughout the year. It also offers

[21] See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for details.

great cargo capacity (315.2 ft^3) and there are currently no other all-electric or PHEV vehicles in this size and configuration known to be coming to market in the near term.

As noted in the prior section, due to expectations that these DPW cargo vans may be needed for continuous operations during extreme weather events, Barrington may wish to deploy one or both BEV vas as pilot vehicles initially and assess how they are used and perform during extreme weather events (and utilizing any other gasoline-powered vans in Barrington's existing fleet as backups as needed) before committing to additional BEV vans.

Table 4. Recommended EV replacement options for identified Barrington's Fullsize Vans[22]

Make / Model	EV Type	Class	Standard Electric Range (mi)	Cold-Weather Electric Range (mi)	Cargo (ft3)	Base Model MSRP
Ford E-Transit Van	BEV	Cargo Van	126	75.6	315.2	$43,295

Charging Stations

We recommend that Barrington install up to 14 charging station ports to support the recommended EVs.

Each BEV should have a dedicated Level 2 charging station port to ensure they are fully-charged each morning. 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 EV deployment may be limited by how many Electric Vehicle Supply Equipment (EVSE, aka Charging Stations) can be deployed at overnight parking locations, and how quickly.

[22] See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for details.

Location Selection

Seven of Barrington's recommended vehicles for EV replacement are parked overnight at the Public Safety building (which houses the Police and Fire Departments), five are parked at DPW, one is parked at the Town Hall, and one police vehicle is taken home. We recommend considering these three locations for charging station deployment and working with Rhode Island Energy to assess existing electrical infrastructure and develop plans for purchase and installation.

The single Police Department sedan that is currently taken home each night travels a maximum of 50 miles daily over the course of a single shift (and potentially less on a typical day). Because the recommended replacement EV has a range of 224 or 303 miles, it is unlikely to require daily charging. Charging options could include one or a combination of the following:

- Short, 1-2 hour Level 2 "opportunity" charging sessions mid-shift while the officer is at the Public Safety building (daily or every other day), either at unoccupied charging stations while other vehicles are in the field, or at an additional charging station dedicated for this vehicle.
- Once a week overnight charging at the Public Safety building while the officer brings home another fully charged EV sedan or gasoline-powered sedan
- Occasional short (30-60 minute) DC Fast Charging at nearby public DC fast charging stations

Note it may be more cost-effective to install dual-port units if Barrington anticipates adding additional EVs to department fleets parking at these locations over the next 3-10 years (or wish to have an extra port available for guest or employee use). Dual-port units can be less expensive to purchase than single port units on a per-port basis, though pricing varies considerably among vendors.

EVSE Equipment

To reduce annual operating costs and maximize lifetime BEV savings, we recommend that Barrington 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. Barrington would provide WiFi (if not already in place) rather than purchase cellular service that require additional service plans with monthly service charges.
- 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.[23]

These recommended configurations are eligible under Rhode Island Energy's Electric Charging Station Program. *See Charging Infrastructure Costs and Appendix D – Funding Opportunities for details*.

If Barrington'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.

Barrington may wish to explore charging station options and pricing with the vendor of their current charging stations, which may simplify their planning and procurement process and enable future charging stations to be added to and managed by Barrington's existing network service agreement (if applicable).

Funding Opportunities

We recommend that Barrington utilize the following incentives to support EVSE deployment:

- Rhode Island Energy's Electric Vehicle Charging Station Program for Government Light Duty Fleet[24], which covers 100% of EVSE installation and 50% of EVSE hardware costs.
- RI Master Purchase Agreements for Vehicles (MPA 563) and EVSE (MPA 509), which offers discounts of roughly 5-10% off the MSRP purchase costs of covered vehicles and 20-30% off the MSRP purchase costs of covered charging stations (though not network fees). Barrington is eligible to purchase from these agreements, which are in effect through 1/31/24 and 7/31/2022 respectively.[25]
- Climate Mayors Electric Vehicle Purchasing Collaborative[26], which offers competitive pricing on electric light, medium and heavy duty vehicles and associated charging stations for public entities, and is managed by Sourcewell.[27]
- Rhode Island D**RI**VE EV Rebate Program – starting in summer 2022, the RI Office of Energy Resources plans to open this rebate program, which is expected to offer purchase incentives of $2,500 for BEVs and $1,500 for PHEVs. Vehicles must have an MSRP below $50,000 and fleets are limited to a total of 5 vehicle rebates per fleet.[28]

[23] As noted, EVSE must be included on Rhode Island Energy's qualified equipment list (https://www.rienergy.com/media/ri-energy/pdfs/energy-efficiency/rie7387-mass-ri-evse-list.pdf) in order to participate in the Rhode Island Energy EV Charging Station program.
[24] https://www.rienergy.com/RI-Business/Energy-Saving-Programs/Electric-Vehicle-Charging-Station-Program
[25] MPA 563 – Passenger Vehicles & MPA 509 - Electric Vehicle Charging Stations and Related Services - https://www.ridop.ri.gov/contract-board/
[26] Offerings | Drive EV Fleets
[27] Fleet | Sourcewell (sourcewell-mn.gov)
[28] http://www.drive.ri.gov/

Implementation Plan

Barrington should act quickly in 2022 to take advantage of Rhode Island Energy's EVSE incentives. Table 5 lays out a possible project timeline.

Table 5. Proposed project implementation timeline for Barrington's EV and EVSE deployment

Establish goals around EV replacement rates – Barrington should determine how many of the recommended vehicles they intend to replace with EVs. This will provide staff with the support needed to develop budgets and schedule EV and EVSE deployment over the next five years.	**Q2 to Q3 2022**
Engage with Rhode Island Energy on EVSE incentives, installations, and eligibility – Rhode Island Energy staff will be able to advise on incentives eligibility and timing, specific site considerations (including electric rate structure and demand), qualified vendors, and eligible EVSE.	
Work with Rhode Island Energy, proceed with EVSE purchase and installation to support planned specific BEVs.	**Q3 to Q4 2022**
Schedule specific EV acquisitions to coincide with or shortly follow planned EVSE availability – BEVs require (and PHEVs benefit from) operational charging stations, and procurement/delivery should be coordinated with EVSE deployment.	
Procure EVs – Review and confirm any available vehicle purchase incentives, and investigate procurement options, especially if seeking to procure multiple identical EVs at a discount.	
Deploy EVs (ongoing)	**Q1 to Q2 2023**
Evaluate performance and purchase additional EVs as appropriate (ongoing) – following initial EV and EVSE deployments, staff can evaluate the performance of the various EVs to ensure they are meeting operational needs and achieving predicted cost savings, which will lay the groundwork for wider EV deployment in future years.	**Q3 2023+**

Costs and Benefits of Electrification

Replacing gasoline-powered fleet vehicles with EVs will require increased upfront capital costs for charging station deployment but will result in lower annual operating costs and overall lifetime cost and significant emissions savings.

Vehicle Costs

BEVs and PHEVs currently cost more than their fossil fuel counterparts, with a typical price premium of around $8,000-$10,000 for a BEV or PHEV SUV. However, BEVs achieve operational energy and maintenance savings relative to conventional gasoline vehicles over their lifetime. BEVs have fewer moving parts so require less maintenance, and 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 BEVs (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, as of March 2022 the cost of electricity in Rhode Island was equivalent to $1.55 per gallon of gas. Rhode Island's average prices for fuel include: $3.55 per diesel gallon, and $3.53 per gasoline gallon.[29] Tables 6 and 7 presents the per-vehicle budgetary estimates for EV planning purposes. (Methodology and assumptions are documented in Appendix C – Methodology).

When calculating total cost of ownership for EVs, 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. Note that the values in Table 6 and 7 include applicable Rhode Island Energy EVSE purchase and installation incentives and assume a vehicle lifetime in line with Barrington's current vehicle-specific replacement thresholds and estimated annual mileage of current vehicles.

Table 6 shows the net lifetime savings of each recommended vehicle replacement category with and without the RI Drive EV incentive. This incentive will begin in the summer of 2022 and will provide a $2500 incentive for BEVs and a $1500 for PHEVs. **Note that fleets are limited to five vehicle incentives per fleet.**

The sedans and the SUVs within the Police department and the vans and pickup trucks within the DPW department drive more annual miles making them more cost effective to transition to an EV. In contrast, vehicles in the Building Official and Fire department do not have positive net lifetime savings without the RI DRIVE incentive. These vehicles have lower annual mileage making them less cost effective to transition to an EV.

[29] https://gasprices.aaa.com/?state=RI

Table 6. Example per-vehicle EV capital and operating budgetary estimates

Department	Building Official	Police			Fire	DPW	
	Nissan LEAF replacing Gas Sedan	Nissan Leaf replacing Gas Sedan	Ford Mustang Mach E replacing Gas Sedan	Volkswagen ID.4 replacing Gas SUV	Toyota RAV4 PHEV replacing Gas SUV	Ford E Transit replacing Gas Fullsize Van	Ford 150 Lightning replacing Gas Pickup Truck
One-time Upfront Capital Costs							
Purchase Premium	-$4,900	-$4,900	-$21,395	-$2,730	-$2,300	-$7,795	$3,500
EVSE Capital Cost	-$650	-$650	-$650	-$650	-$650	-$650	-$650
Total Upfront Cost	-$5,550	-$5,550	-$22,045	-$3,380	-$2,950	-$8,445	$2,850
Annual Operating Costs							
Electricity/Fuel Cost	-$286	-$490	-$748	-$879	-$320	-$2,511	-$1,932
Avoided Vehicle Maintenance	$346	$912	$912	$851	$113	$896	$1,142
Avoided Fuel Cost	$427	$730	$472	$1,495	$362	$2,787	$2,144
EVSE Operating & Maintenance Costs	-$215	-$215	-$215	-$215	-$215	-$215	-$215
Total Annual Operating Cost Savings	$559	$1,427	$1,169	$2,131	$260	$3,468	$3,071
Lifetime Savings							
Lifetime Operating Cost Savings	$6,705	$15,131	$12,390	$23,439	$3,378	$45,081	$29,682
Net Lifetime Savings	$1,155	$9,581	-$9,655	$20,059	$428	$36,636	$32,532
Net Lifetime Savings without RI DRIVE EV Incentive	-$1,345	$7,081	-$12,155	$17,559	-$1,072	$34,136	$30,032

Table 7 shows the lifetime operating savings ($298,120) and net lifetime savings ($142,795). The net lifetime savings is the total of the 14 vehicles we recommend as candidates for EV replacement within the next 5 years. This includes the Building Official Sedan and the Fire SUV that are not net positive without the RI DRIVE Incentive. We included these because Barrington can take advantage of **5 BEV incentives (a total $12,500)** which will offet these costs.

Table 7. Total lifetime operating and net savings with and without RI DRIVE incentives

	Total Barrington Savings ($)
Lifetime Operating Savings	$298,120
Net Lifetime Savings	$130,295
RI DRIVE EV Incentives	$12,500
Net Lifetime Savings w/ incentive	$142,795

Energy Costs

Because electric vehicles are considerably more efficient than conventional vehicles, per-vehicle annual energy savings are predicted to range from $360 to over $2,700 based on per-kWh electricity rates.

However, EVs (and especially BEVs) 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 $1,000-$1,600 in annual electricity costs per BEV and $500 per PHEV if not properly managed. These demand charges were not included in the total cost of ownership estimates in this report.

For example, Barrington's recommended fullsize pickup replacements are anticipated to consume roughly 8,000 kWh of electricity per vehicle per year, assuming they travel 15,000 miles/year. The recommended Ford F-150 Lightning Pro draws up to 11.3 kW of power when charging with its standard onboard charger.

Rhode Island Energy's G-02 electric rate class (which Barrington is assumed to use for the majority of its facilities) has an effective electric rate of $0.146 per kWh, and a demand charge of $12.09 per kW/month. The roughly 8,000 kWh of electricity consumption at a rate of $0.146 per kWh would cost roughly $1,170 per year (which is included in the TCO estimates in this report). If the BEV 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, which would result in a demand charge increase of $137/month (or $1,640 annually).

Smaller BEVs commonly draw 6-7 kW while charging, and so have the potential to increase demand charges by $80/month (or $960 annually). PHEVs commonly draw about 3.3 kW while charging, and so have the potential to increase demand charges by $40/month (or $480 annually).

To minimize these potential costs:

- Work with Rhode Island Energy to analyze rate structure, current electricity demand and costs at individual facilities where BEV and PHEVs are being considered.
- Consider prioritizing EV deployment at facilities that already have high daytime electricity demand and/or off-peak overnight hours (which are available through Rhode Island Energy's G-32 Large Demand commercial rate), and charge the vehicles overnight.
- Use networked chargers modulate charging so that power demand is kept at a steady rate and vehicles are fully charged when needed
- Schedule charging to occur when demand is lowest (typically overnight).

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 4 lays out EVSE costs to Barrington when participating in the Rhode Island Energy EVSE incentive program.

Table 11. Comparative Costs of Basic vs High-end Charging Stations (Per Port)[30]

Per Port	Basic EVSE	High-end EVSE
Purchase Cost	$1,300	$3,500
Barrington's share of purchase price	$650	$1,750
Annual Maintenance	$95	$250
Annual Network Fees	$120	$220
Ten-Year Total Cost to Barrington	**$2,800**	**$6,450**

The difference of over $3,500 in per-port EVSE lifetime operating costs at the bottom line of Table 4 is a key factor in EV cost-effectiveness. If Barrington chooses to deploy a single higher-end charging station port per recommended EV, lifetime EV savings (which range from $400 to over $36,000 per vehicle) will likely *decrease* by up to $3,500 per vehicle.

[30] 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.

EVSE Installation Cost

Because Rhode Island Energy's Electric Charging Station Program currently covers 100% of installation costs for approved projects, Barrington's installation costs for this initial project are assumed to be $0.

EVSE Equipment Costs

Level 2 charging stations supported by the Rhode Island Energy program can range in price from about $1,300 per port up to $4,000 per port. For charging at Barrington's limited-access facilities, lower-cost, more basic EVSE should suffice. Instead of pedestal-mounted systems with integrated cord management, Barrington 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

EVSE supported by the Rhode Island Energy program are encouraged to have network connectivity to aid fleets with required charging data reporting, though networking is not required if a fleet can provide another means of data collection. 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 Barrington can provide site WiFi.

Maintenance contracts pushed by vendors can be expensive and are generally not cost-effective for protected, private EVSE. Barrington should either negotiate for a very low-cost maintenance contract for their new stations or encourage Barrington staff utilizing the EVSE regularly to report any issues or damange immediately. If any locations are accessible to the public and subject to vandalism, they may warrant consideration of service contracts.

See *Appendix F – Technical Memo –State of Technology: Light and Medium Duty Electric Vehicles and Charging Equipment* for additional information on EVSE considerations, including networked and managed charging.

Lifetime Cost-Savings

Based on known data, each of the vehicles identified are good operational candidates for replacement with EVs and most should achieve sufficient **lifetime operating savings (ranging from $6,700 to $45,000 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.

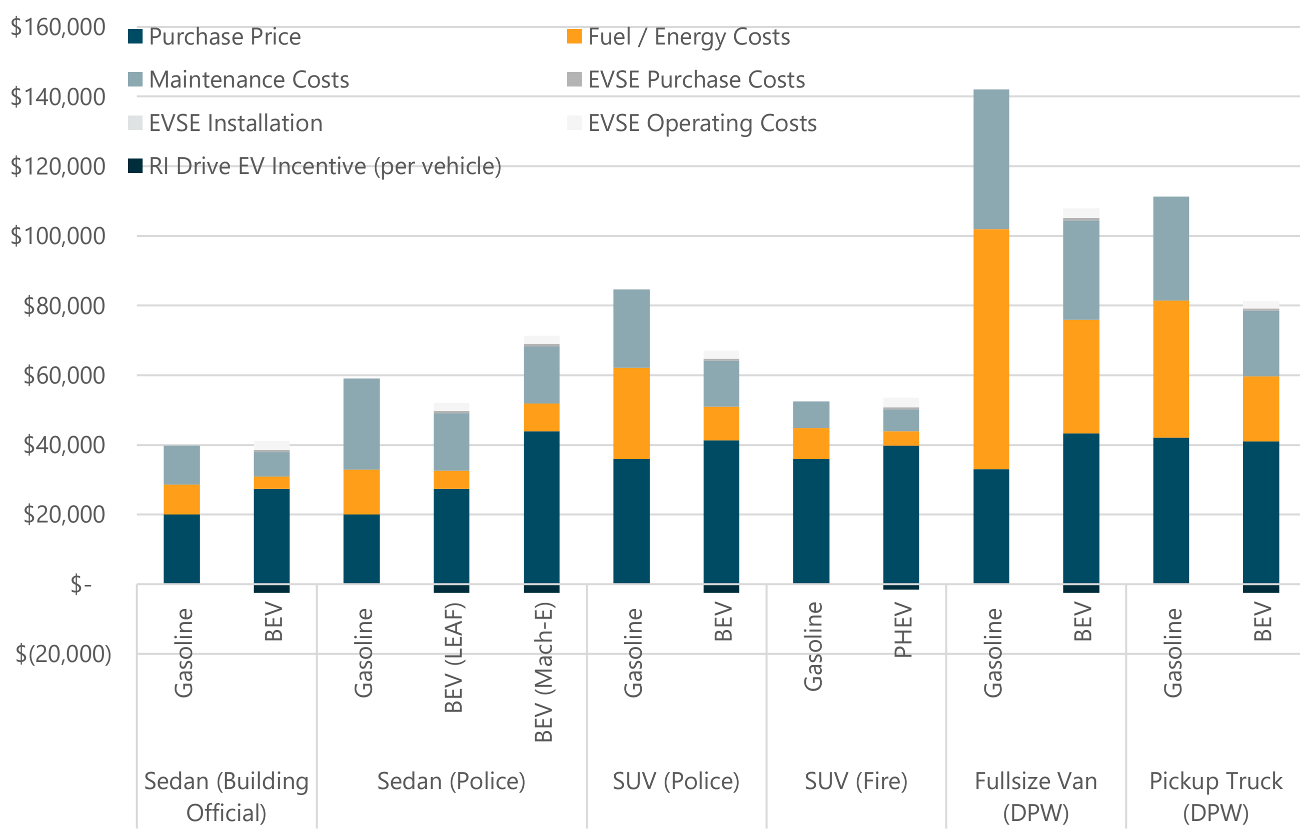

Figure 2. Lifetime total cost of ownership for Nissan LEAF, Ford Mustang Mach-E, Volkswagon ID.4, Ford E-Transit, and Ford F-150 Lightning compared to gasoline-powered sedan, SUV, fullsize van, and pickup truck equivalents.

Figure 2 demonstrates that for Barrington's identified sedans, SUVs, pickup trucks and cargo vans, operational savings with replacement PHEV and BEVs are expected to provide a wide range of positive overall lifetime cost savings (ranging from roughly $400 to $36,600, depending on specific vehicles and estimated annual mileage). Projected lifetime savings are highest with cargo vans and fullsize pickup trucks due to high annual mileage (which increases operational cost savings) and lower incremental cost between gasoline and BEV models.

As noted previously, the Mustang Mach-E costs an additional $9,655 per vehicle over its anticipated lifetime after incentives compared to an equivalent gasoline sedan. These additional costs can be offset by anticipated EV SUV, cargo van and pickup truck lifetime savings, resulting in an **overall net-project savings of $142,795 after applicable incentives.**

Emission Reductions

An important goal for Barrington is to reduce greenhouse gas emissions associated with their fleet. If all 14 vehicles are replaced with recommended PHEVs and BEVs, there is the potential to reduce GHG emissions by 975 short tons (or 2,270 barrels of oil) over the lifetime of the vehicles, a reduction of 75%.

The magnitude of greenhouse gas emissions reductions is most dramatic with the BEV cargo van and pickup deployments, accounting for nearly two-thirds of Barrington's projected emissions savings. This is due mostly to the relatively high annual mileage and low fuel economy of existing gasoline-powered cargo vans and pickups compared to other vehicle types.

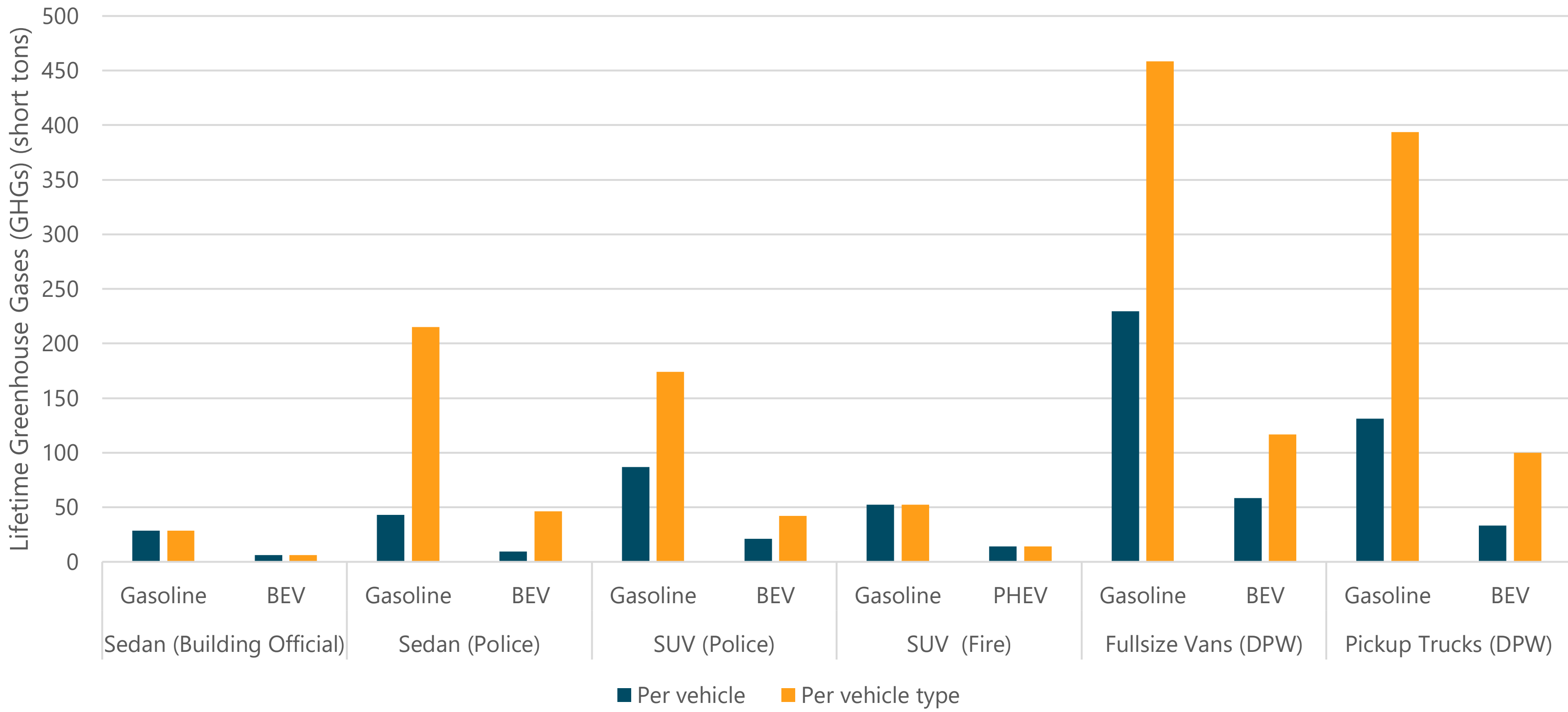

Figure 3. Lifetime greenhouse gas emissions for EV sedans, SUVs, fullsize vans, and pickup trucks compared to gasoline-powered equivalents (on a per vehicle basis (blue) and total by vehicle type (orange)).

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 4). A PHEV SUV is estimated to reduce CAPs by roughly 57% compared to gasoline, and BEV sedans, SUVs, pickups and cargo vans should reduce CAPs by approximately 98% compared to gasoline. Note that tire and brake wear (TBW) produces PM emissions for all vehicles.

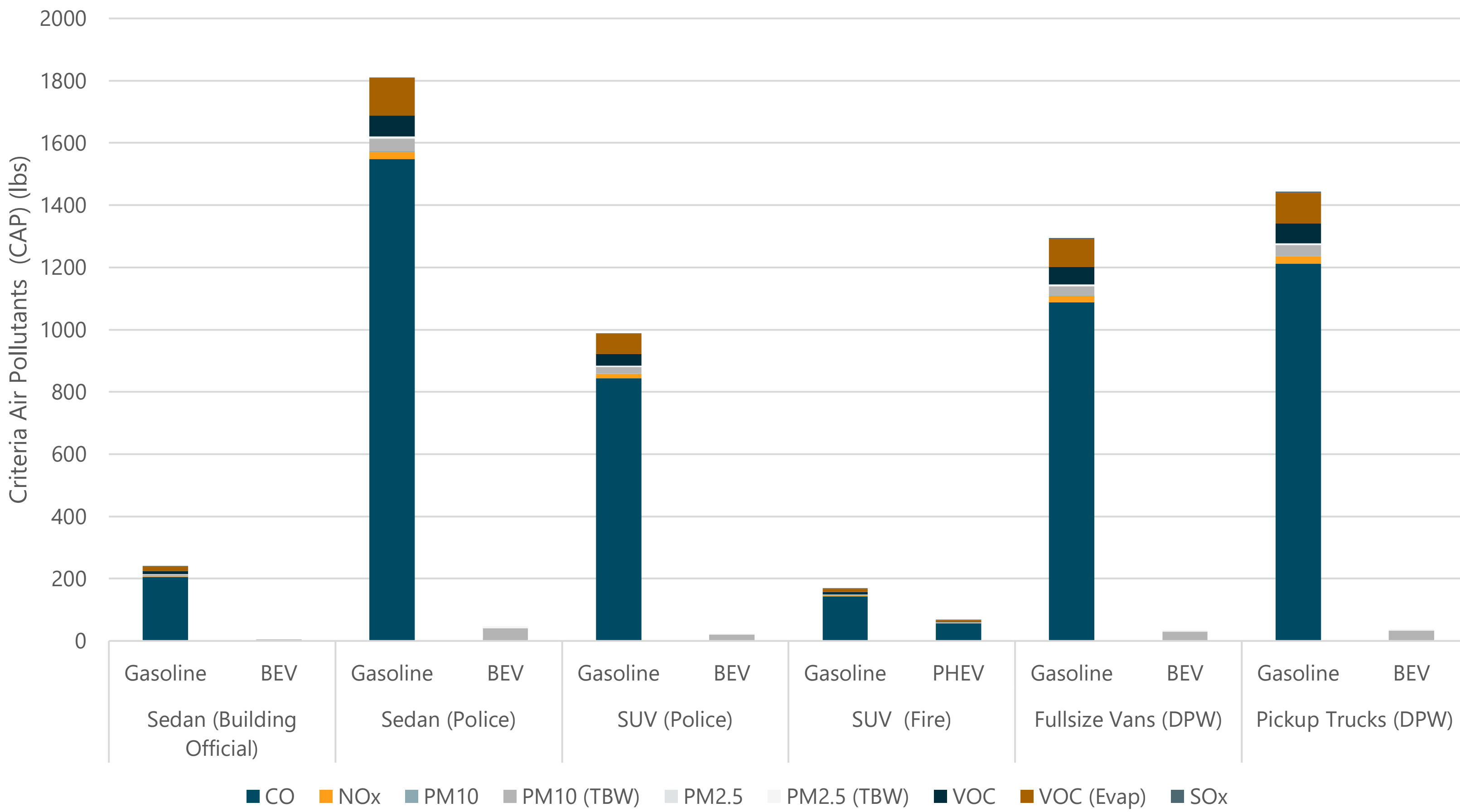

Figure 4. Lifetime criteria air pollutant emissions for EV sedans, SUV, fullsize vans, and pickup trucks compared to gasoline-powered equivalents (total by vehicle type).

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.

Appendices

Appendix A – EV Candidates

Recommended EV Candidates: Vehicles to be replaced by 2026

EV cost savings below are based on simple payback and include all costs associated with installation and operation of EVSE, after incentives.

Table A-1: Sedan candidate for Building Official

Overnight Parking Location	Department	Vehicle Type	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime BEV Sedan Savings	Lifetime Savings without RI Drive BEV Incentive
Town Hall	Building Official	Sedan - building official	Ford	Fusion	2012	1	6,250	Less than 50	$1,155	$(1,345)
Total						**1**	**6,250**	**Less Than 50**	**$,155**	**$(1,345)**

Table A-2. Sedan candidates for Police department

Overnight Parking Location	Department	Vehicle Type	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	EV Replacement: Nissan LEAF		EV Replacement: Ford Mustang Mach-E	
									Lifetime BEV Sedan Savings	Lifetime Savings without RI Drive BEV Incentive	Lifetime BEV Sedan Savings	Lifetime Savings without RI Drive BEV Incentive
Take Home	Police (Car 13 Ptl. Lt. Car)	Sedan	Dodge	Charger	2012	1	8,500	Less Than 50	$9,581	$7,081	$(9,655)	$(12,155)
PD	Police (Detectives)	Sedan	Dodge	Charger	2012	1	11,128	Less Than 50	$9,581	$7,081	$(9,655)	$(12,155)
PD	Police (Car 10 Detail)	Sedan	Ford	Interceptor AWD	2013	1	10,622	Less Than 50	$9,581	$7,081	$(9,655)	$(12,155)
PD	Police (Car 8 Detail)	Sedan	Ford	Interceptor AWD	2013	1	10,827	Less Than 50	$9,581	$7,081	$(9,655)	$(12,155)
PD	Police (Car 16 Detail)	Sedan	Dodge	Charger	2015	1	12,340	Less Than 50	$9,581	$7,081	$(9,655)	$(12,155)
Total						**5**	**10,683**	**Less Than 50**	**$47,904**	**$35,404**	**$(48,275)**	**$(60,775)**

Table A-3. BEV SUV Candidates for Police Department

Overnight Parking Location	Department	Vehicle Type	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime BEV Savings	Lifetime Savings without RI Drive BEV Incentive
PD	Police (ACO)	SUV, Medium	Ford	Explorer	2014	1	11,950	Less Than 50	$20,059	$17,559
PD	Police (Car 9)	SUV, Medium	Ford	Explorer	2016	1	13,159	Less Than 50	$20,059	$17,559
Total						**2**	**12,554**	**Less Than 50**	**$40,118**	**$35,118**

Table A-4. PHEV SUV Candidates for Fire Department

Overnight Parking Location	Department	Vehicle Type	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime PHEV SUV Savings	Lifetime Savings without RI Drive PHEV Incentive
In Station	Fire	SUV Utility Vehicle	Ford	Explorer	2012	1	3,609	Less than 50	$428	$(1,072)
Total						**1**	**3,609**	**Less Than 50**	**$428**	**$(1,072)**

Table A-5. BEV Van Candidates for DPW department

Overnight Parking Location	Department	Vehicle Type	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime BEV Van Savings	Lifetime Savings without RI Drive BEV Incentive
DPW	DPW	Van, Full Size	Ford	Transit Van	2005	1	15,000	Less than 20	$36,636	$34,136
DPW	DPW	Van, Full Size	GMC	Savana 1500 Cargo Van	2013	1	15,000	Less than 20	$36,636	$34,136
Total						**2**	**15,000**	**Less than 20**	**$73,273**	**$68,273**

Table A-6. BEV Pickup Candidates for DPW department

Overnight Parking Location	Department	Vehicle Type	Make	Model	Year	Qty	Average Annual Mileage	Estimated Maximum Daily Mileage	Lifetime BEV Pickup Truck Savings	Lifetime Savings without RI Drive BEV Incentive
Home	DPW	Pickup, Regular Duty	Chevrolet	Colorado	2018	1	15,000	Less than 50	$32,532	$30,032
Home	DPW	Pickup, Regular Duty	Chevrolet	Colorado	2019	1	15,000	Less than 50	$32,532	$30,032
Home	DPW	Pickup, Regular Duty	Chevrolet	Colorado	2012	1	15,000	Less than 50	$32,532	$30,032
Total						**3**	**15,000**	**Less than 50**	**$97,596**	**$90,096**

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Appendix B – Vehicle Lifetime Total Cost of Ownership and Emissions

Table B-1. BEV/PHEV Sedans: Lifetime total cost of ownership for Nissan Leaf, Ford Mustang Mach E, and Hyundai Ioniq PHEV compared to a gasoline-powered sedan for Police department vehicles.

	Gas Sedan	Nissan Leaf	Ford Mustang Mach E	Hyundai Ioniq PHEV
Purchase Price	$20,000	$27,400	$43,895	$26,800
Fuel / Energy Costs	$12,932	$5,189	$7,930	$7,704
Maintenance Costs	$26,160	$16,493	$10,781	$ 22,833
EVSE Purchase Costs		$650	$650	$650
EVSE Installation		$ -	$ -	$ -
EVSE Operating Costs		$2,279	$2,279	$2,279
RI Drive EV Incentive (per vehicle)		$(2,500)	$(2,500)	$(1,500)
Total	$59,091	$49,511	$63,035	$58,766

Table B-2. BEV/PHEV Sedans: Lifetime total cost of ownership for Nissan Leaf, Chevy Bolt, and Hyundai Ioniq PHEV compared to a gasoline-powered sedan for Building Official department vehicles.

	Gas Sedan	Nissan Leaf BEV	Chevy Bolt BEV	Hyundai Ioniq PHEV
Purchase Price	$20,000	$27,400	$31,500	$26,800
Fuel / Energy Costs	$8,565	$3,436	$3,436	$37,184
Maintenance Costs	$11,250	$7,093	$7,093	$9,819
EVSE Purchase Costs		$650	$650	$650
EVSE Installation		$ -	$ -	$ -
EVSE Operating Costs		$2,580	$2,580	$2,580
RI Drive EV Incentive (per vehicle)		$(2,500)	$(2,500)	$(1,500)
Total	$39,815	$38,659	$42,759	$75,533

Table B-3. BEV/PHEV SUVs: Lifetime total cost of ownership for Volkswagen ID.4, Toyota Rav 4, Hyundai Sante Fe, and Jeep Grand Cherokee PHEV compared to a gasoline-powered SUV for Police department vehicles.

	Mid/Full Gas SUV	Volkswagen ID.4	Toyota RAV4 PHEV	Hyundai Santa Fe PHEV	Jeep Grand Cherokee PHEV
Purchase Price	$36,000	$41,230	$39,800	$39,500	$58,095
Fuel / Energy Costs	$26,111	$9,670	$12,251	$12,251	$15,659
Maintenance Costs	$22,510	$13,147	$18,201	$18,201	$19,647
EVSE Purchase Costs		$650	$650	$650	$650
EVSE Installation		$ -	$ -	$ -	$ -
EVSE Operating Costs		$2,365	$2,365	$2,365	$2,365
RI Drive EV Incentive (per vehicle)		$(2,500)	$(1,500)	$(1,500)	MSRP too high for incentive
Total	$84,621	$64,562	$71,767	$71,467	$96,416

Table B-4. BEV/PHEV SUVs: Lifetime total cost of ownership for Volkswagen ID.4, Toyota Rav 4, Hyundai Sante Fe, and Jeep Cherokee compared to a gasoline-powered SUV for Fire department vehicle

	Mid/Full Gas SUV	Volkswagen ID.4	Toyota RAV4 PHEV	Hyundai Santa Fe PHEV	Jeep Grand Cherokee PHEV
Purchase Price	$36,000	$44,910	$39,800	$39,500	$58,095
Fuel / Energy Costs	$8,871	$3,285	$4,162	$4,162	$5,320
Maintenance Costs	$7,647	$4,467	$6,183	$6,183	$6,675
EVSE Purchase Costs		$650	$650	$650	$650
EVSE Installation		$ -	$ -	$ -	$ -
EVSE Operating Costs		$2,795	$2,795	$2,795	$2,795
RI Drive EV Incentive (per vehicle)		$(2,500)	$(1,500)	$(1,500)	MSRP too high for incentive
Total	**$52,519**	**$53,607**	**$52,091**	**$51,791**	**$73,535**

Table B-5. BEV Vans: Lifetime total cost of ownership for Ford E-Transit compared to a gasoline-powered Fullsize Cargo Van for DPW department vehicles.

	Gas Fullsize Cargo Van	Ford E Transit
Purchase Price	$33,000	$43,295
Fuel / Energy Costs	$68,874	$32,645
Maintenance Costs	$40,170	$28,522
EVSE Purchase Costs		$650
EVSE Installation		$ -
EVSE Operating Costs		$2,795
RI Drive EV Incentive (per vehicle)		$(2,500)
Total	$142,044	$105,408

Table B-6. BEV/PHEV Pickup Trucks: Lifetime total cost of ownership for Ford Lightning 150 (extended range included), Chevrolet Silverardo, Lordstown Endurance, and XL Fleet Ford 150 PHEV for DPW department vehicles.

	Gas Pickup Truck	Ford 150 Lightning	Ford 150 Lightning (extended range)	Chevrolet Silverado	Lordstown Endurance	XL Fleet Ford 150 PHEV
Purchase Price	$42,000	$41,000	$51,000	$40,000	$52,000	$64,000
Fuel / Energy Costs	$39,395	$18,673	$18,673	$18,673	$18,673	$22,019
Maintenance Costs	$29,870	$18,832	$18,832	$18,832	$18,832	$26,071
EVSE Purchase Costs		$650	$650	$650	$650	$650
EVSE Installation		$ -	$ -	$ -	$ -	$ -
EVSE Operating Costs		$2,078	$2,078	$2,078	$2,078	$2,078
RI Drive EV Incentive (per vehicle)		$(2,500)	$(2,500)	$(2,500)	$(2,500)	$(1,500)
Total	$111,265	$78,733	$88,733	$77,733	$89,733	$113,319

Emissions: Total lifetime greenhouse gas and criteria air pollutant emissions for BEV, PHEV and gasoline or diesel-powered SUV, Full-size Truck, Utility Truck, Minivan, and Compact Cargo Van equivalents. Note that tire and brake wear (TBW) produces PM emissions for all vehicles.

Table B-7: Lifetime emissions per vehicle

		Sedan (Building Official)		Sedan (Police)		SUV (Police)		SUV (Fire)		Fullsize Van (DPW)		Pickup Truck (DPW)	
	Units	Gasoline	BEV	Gasoline	BEV	Gasoline	BEV	Gasoline	PHEV	Gasoline	BEV	Gasoline	BEV
Greenhouse Gases (GHGs)	Short Tons	28.5	6.1	43.1	9.3	86.9	20.9	29.5	12.6	229.3	58.3	131.2	33.3
CO	lbs	205.0	0.0	309.5	0.0	422.4	0.0	143.5	55.9	543.7	0.0	404.3	0.0
NOx	lbs	2.9	0.0	4.4	0.0	6.9	0.0	2.4	0.8	10.3	0.0	7.7	0.0
PM10	lbs	0.3	0.0	0.5	0.0	0.5	0.0	0.2	0.1	0.7	0.0	0.5	0.0
PM10 (TBW)	lbs	5.5	5.5	8.2	8.2	10.4	10.4	3.5	3.5	15.0	15.0	11.2	11.2
PM2.5	lbs	0.3	0.0	0.5	0.0	0.6	0.0	0.2	0.1	0.7	0.0	0.5	0.0
PM2.5 (TBW)	lbs	0.7	0.7	1.0	1.0	1.5	1.5	0.5	0.5	2.1	2.1	1.6	1.6
VOC	lbs	8.8	0.0	13.3	0.0	18.4	0.0	6.2	1.3	28.3	0.0	21.0	0.0
VOC (Evap)	lbs	16.2	0.0	24.4	0.0	32.7	0.0	11.1	4.3	44.5	0.0	33.1	0.0
SOx	lbs	0.3	0.0	0.4	0.0	0.8	0.0	0.3	0.1	2.2	0.0	1.3	0.0
GHG Emission Reduction	%	78%		78%		76%		57%		75%		75%	
CAP Emission Reduction	%	97%		97%		98%		60%		97%		97%	

Appendix C – Methodology

Fuel Costs

Average fuel prices used to estimate fuel costs by vehicle type. Fuel prices based on AAA's RI State Average State Fuel Prices[31] in March 2022: approximately $3.53 per gallon for gasoline and $3.55 per gallon for diesel.

Electricity Costs

Barrington's electric rate class was assumed to be G-02 for their various buildings and parking facilities, with electric rates estimated at $0.146 per kWh. The G-02 rate class includes users that have a potentially wide range of electricity power demand (between 10 kW and 200 kW), with demand charges of $12.09 per kW. Demand charges associated with EV charging were not estimated.

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 BEVs and 13% for PHEVs, fleetwide. Vehicles are assumed to be replaced at vehicle type-specific lifetime mileage thresholds based on Barrington'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[32], which also provided additional defaults for replacement vehicles.

Emissions

Gasoline pollutant emissions are from Argonne National Laboratory's GREET model.[33] Electricity greenhouse gas data is from the EPA's Emission Factors for Greenhouse Gas Inventories[34]

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[31] AAA Gas Prices

[32] https://greet.es.anl.gov/afleet_tool

[33](24 lbs CO_{2eq} /gallon gasoline) https://greet.es.anl.gov/

[34] (981 lbs CO_{2eq} / MWh electricity for the New England Region) https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

Appendix D - Funding Opportunities

All financial analysis in this report is based on MSRP of replacement vehicles (or estimates for upfit vehicles without set MSRPs). No discounts, incentives, or tax credits have been included unless stated.

Vehicles

- Federal Tax Credits: The amount of the federal tax credit varies with battery size between $3,750 and $7,500. The federal tax credit, while generous in some instances, is only available to those entities with adequate tax liability and thus not available to Barrington directly for vehicle purchase. If leasing the EV, Barrington *may* see some of the tax credit passed through in a reduced lease cost. In practice, leasing is usually still less cost-effective than outright purchase.
  - Leasing is complex, and the specific terms of any lease agreement, *especially the buyout price at the end of the agreement*, must be carefully considered. Many leasing programs do not present a good value proposition when compared to outright ownership, even after accounting for the tax credit.
- RI Master Purchase Agreements for Vehicles (MPA 563) which offers discounts of roughly 5-10% off the MSRP purchase costs of covered vehicles. Barrington is eligible to purchase from this agreement, which are in effect through 1/31/24.[35]
- This summer, Rhode Island will launch its D**RI**VE EV incentive which offers $2,500 for BEVs and $1,500 for PHEVs. This is per vehicle and there is a limit of 5 vehicles per fleet and for vehicles with an MSRP of less than $50,000.[36]
- Climate Mayors Electric Vehicle Purchasing Collaborative[37], which offers competitive pricing on electric light, medium and heavy duty vehicles and associated charging stations for public entities, and is managed by Sourcewell.[38]

[35] MPA 563 – Passenger Vehicles - https://www.ridop.ri.gov/contract-board/
[36] http://www.drive.ri.gov/
[37] Offerings | Drive EV Fleets
[38] Fleet | Sourcewell (sourcewell-mn.gov)

Charging Stations (EVSE)

- Rhode Island Energy Electric Charging Station Program: Rhode Island Energy offers incentives for EV charging stations and related electrical upgrades for use by Barrington's fleet. For approved projects, the program[39] funds 100% of:
  - New service upgrades and upgrades to Barrington's electric panel(s) (if existing electrical service is inadequate).
  - Electric infrastructure to the charging station stub ("make ready" work), including trenching. Rhode Island Energy will own and maintain the electrical infrastructure upgrades.
  - In addition, Rhode Island Energy offers a 50% rebate towards the cost of the Level 2 charging station unit itself. Barrington, as the station's owner, would pay the remaining 50% of the station purchase cost, as well as the station electricity, network and maintenance fees, and agrees to maintain it for a minimum of 5 years. Under the program, Rhode Island Energy gains access to charger use information such as charging time and total electricity consumed. The utility maintains a list of qualified chargers eligible for Rhode Island Energy incentives[40] that Barrington can select from based on Barrington's needs.
- RI Master Purchase Agreement for Electric Vehicle Charging Stations and Related Services (MPA 509), which offers discounts of roughly 20-30% off the MSRP purchase costs of covered charging stations (though not network fees). Barrington is eligible to purchase from this agreement, which is in effect through 7/31/2022.[41]
- Climate Mayors Electric Vehicle Purchasing Collaborative[42], which offers competitive pricing on electric light, medium and heavy duty vehicles and associated charging stations for public entities, and is managed by Sourcewell.[43]

[39] https://www.rienergy.com/RI-Business/Energy-Saving-Programs/Electric-Vehicle-Charging-Station-Program
[40] https://www.rienergy.com/media/ri-energy/pdfs/energy-efficiency/rie7387-mass-ri-evse-list.pdf
[41] MPA 509 - Electric Vehicle Charging Stations and Related Services - https://www.ridop.ri.gov/contract-board/
[42] Offerings | Drive EV Fleets
[43] Fleet | Sourcewell (sourcewell-mn.gov)

Appendix E – Technical Memo

Review of Existing Conditions: Quonset Development Corporation

Barrington Electric Vehicle Fleet Study - Existing Conditions

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Background

- National Grid Electric Transportation & Charging Programs
  - EV Charging Station Purchase/Installation Incentives
  - Fleet Advisory Services Program
- Study of Barrington's fleet for EV deployment over next ~3 years

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Study Approach

Vehicle Fleet

- Observed: Fleet composition, age, annual mileage, daily max mileage
- Estimated: vehicle lifetime, fuel consumption
- Defaults: fuel economy and per-mile maintenance costs
- Operational needs
- Vehicles identified for near-term replacement

Facilities

- Parking Locations

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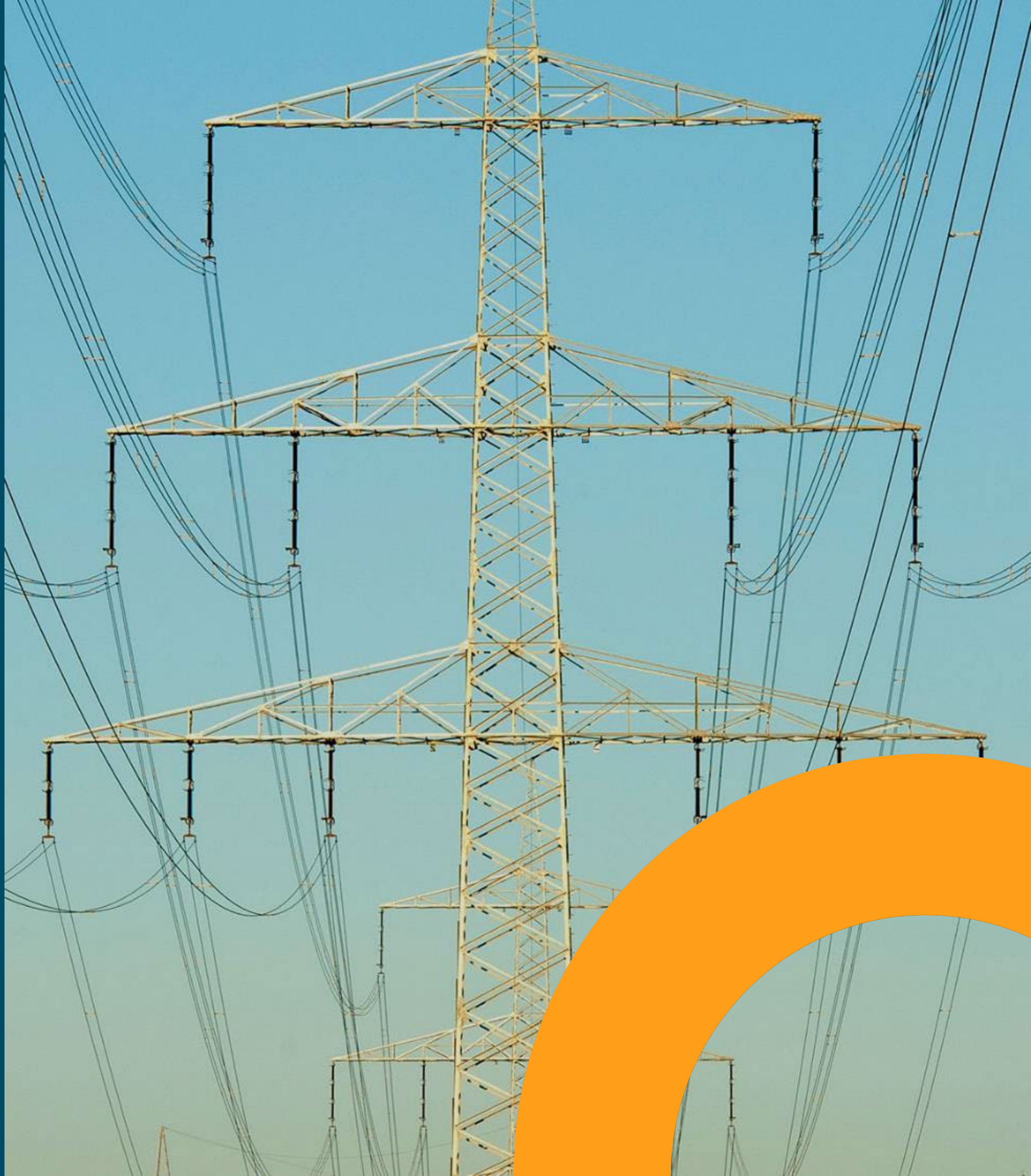
Existing Conditions Findings



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Overview

Current Fleet

- 37 vehicles identified by Barrington for inclusion in fleet analysis
- Five overnight parking locations (Town Hall, DPW, Fire, PD, and Home)
- Barrington owns entire fleet

14 light and medium-duty vehicles are preliminary candidates for electrification using the following criteria:

- Availability of comparable plug-in options, and
- Anticipated vehicle replacement by end of 2026

Fleet Replacement Information

Vehicle Type/Subclass	Department	Fuel Type	Anticipated vehicle replacement year
Sedan - building official	Building Official	Gas	Probably by 2024
Pickup, Regular Duty	DPW	Gas	By 2026
Pickup, Regular Duty	DPW	Gas	By 2026
Cargo Van, Full Size	DPW	Gas	By 2026
Cargo Van, Full Size	DPW	Gas	By 2026
SUV Utility Vehicle	Fire	Gas	used as a spare vehicle - yes would consider replacing with electric vehicle
Sedan	Police (Car 13 Ptl. Lt. Car)	Gas	By 2026
Sedan	Police (Detectives)	Gas	By 2026
Sedan	Police (Car 10 Detail)	Gas	2022
Sedan	Police (Car 8 Detail)	Gas	2022
SUV, Medium	Police (ACO)	Gas	By 2026
Sedan	Police (Car 16 Detail)	Gas	2022
SUV, Medium	Police (Car 9)	Gas	By 2026

Vehicle Lifetime Assumptions

Model Type and Department	Assumed Vehicle lifetime (years)	Assumed Vehicle lifetime mileage (miles)
Building Official		
Sedan	12	75,000
DPW		
Pickup, Regular Duty	10	145,000
Cargo Van, Full Size	15	225,000
Fire		
SUV, Medium	13*	108,069
Police		
Sedan	11	110,844
SUV, Medium	11	137,492

*no specific replacement year was listed (assumed 2025 for replacement year)

Light-Duty Fleet - EV Candidates Due for Replacement by Department & Model Type

Model Type and Department	Number of Vehicles
Building Official	**1**
Sedan	1
DPW	**5**
Pickup, Regular Duty	3
Cargo Van, Full Size	2
Fire	**1**
SUV, Medium	1
Police	**7**
Sedan	5
SUV, Medium	2

Certain vehicle types (such as shuttle buses and dump trucks) were not included as candidates due to limited comparable (or likely cost-effective) plug-in options.

Most other vehicles in Barrington's fleet are not expected to be replaced within the next 3-4 years and were not included.

Light-Duty Fleet - EV Candidate Operating Costs

Average fuel prices used to estimate fuel costs by vehicle type.
Fuel prices based on AAA's RI State Average State Fuel Prices in March 2022:

- $3.55/gallon for diesel
- $3.53/gallon for gasoline

Vehicle Type	Vehicle Count	Average Annual mileage	Estimated Fuel Economy (mpg)	Annual Fuel Cost per Vehicle (estimated)	Annual Maintenance Cost Per Vehicle (estimated)	Operating Cost per Mile ($/mile) (default)
Sedan-Building official	1	6,250	31	$714	$938	$0.26
Sedan (Police)	5	10,683	31	$1,220	$2,468	$0.35
SUV, Medium (Police)	2	12,554	19	$2,374	$2,046	$0.35
SUV, Medium (Fire)	1	8,313	19	$1,572	$1,355	$0.35
Fullsize Cargo Vans (DPW)	2	15,000	10	$5,298	$3,480	$0.59
Pickup, Regular (DPW)	3	15,000	13	$4,075	$3,090	$0.48

Operational Details and Considerations

- Most vehicles are parked at Barrington facilities each night. Three potential EV candidates are parked at employees’ homes.
- Vehicles are assigned to individual staff at the start of each day.
- Vehicle travel is almost exclusively in-state.
- All police vehicles identified as potential EV candidates are used for a single shift per day. Sedans are used for either administrative purposes or as on local detail assignments. The two Police medium SUVs identified are not specifically designated.
- All DPW vehicles identified as potential EV candidates are typically used for a single shift per day. However, under extreme weather conditions (snow removal, hurricanes and bad storms) the three pickups and transit vans may be utilized continuously and are considered essential (in addition to other DPW vehicles)
- The Fire medium SUV is considered a spare vehicle and is used sporadically for both emergency and non-emergency purposes

Preliminary EV Candidates Due for Replacement by Department and Model

Model	Vehicle Type	Department (Assignment)	Annual Mileage	Max Daily Mileage	Model Year	AWD Required?	Overnight Parking Location
Fusion	Sedan - building official	Building Official	6,250	Less than 50	2012	NO	Town Hall
Charger	Sedan	Police (Car 13 Ptl. Lt. Car)	8,500	Less Than 50	2012	blank	Take Home
Charger	Sedan	Police (Detectives)	11,128	Less Than 50	2012	blank	PD
Interceptor AWD	Sedan	Police (Car 10 Detail)	10,622	Less Than 50	2013	AWD	PD
Interceptor AWD	Sedan	Police (Car 8 Detail)	10,827	Less Than 50	2013	AWD	PD
Charger	Sedan	Police (Car 16 Detail)	12,340	Less Than 50	2015	blank	PD
Explorer	SUV, Medium	Police (ACO)	11,950	Less Than 50	2014	blank	PD
Explorer	SUV, Medium	Police (Car 9)	13,159	Less Than 50	2016	blank	PD
Explorer	SUV Utility Vehicle	Fire	3,609	Less than 50	2012	AWD	In Station
Transit Van	Van, Full Size	DPW	15,000	Less than 20	2005	NO	DPW
Savana 1500 Cargo Van	Van, Full Size	DPW	15,000	Less than 20	2013	NO	DPW
Colorado	Pickup, Regular Duty	DPW	15,000	Less than 50	2018	4WD	DPW
Colorado	Pickup, Regular Duty	DPW	15,000	Less than 50	2019	4WD	DPW
Colorado	Pickup, Regular Duty	DPW	15,000	Less than 50	2012	4WD	DPW

Appendix F – Technical Memo

State of Technology: Light and Medium-Duty Electric Vehicles and Charging Equipment

State of Technology: Light and Medium-Duty Electric Vehicles and Charging Equipment

December 2020

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Rhode Island Energy™
a PPL company

Background

In 2018, National Grid (now known as Rhode Island Energy) received approval from the Rhode Island Public Utilities Commission to support electrification of customer vehicle fleets. These activities will support Rhode Island Energy's overall transportation electrification initiatives including programs supporting charging infrastructure development. VEIC is leading the fleet electrification initiative for Rhode Island Energy, working with fleets to assess near-term opportunities for electrification.

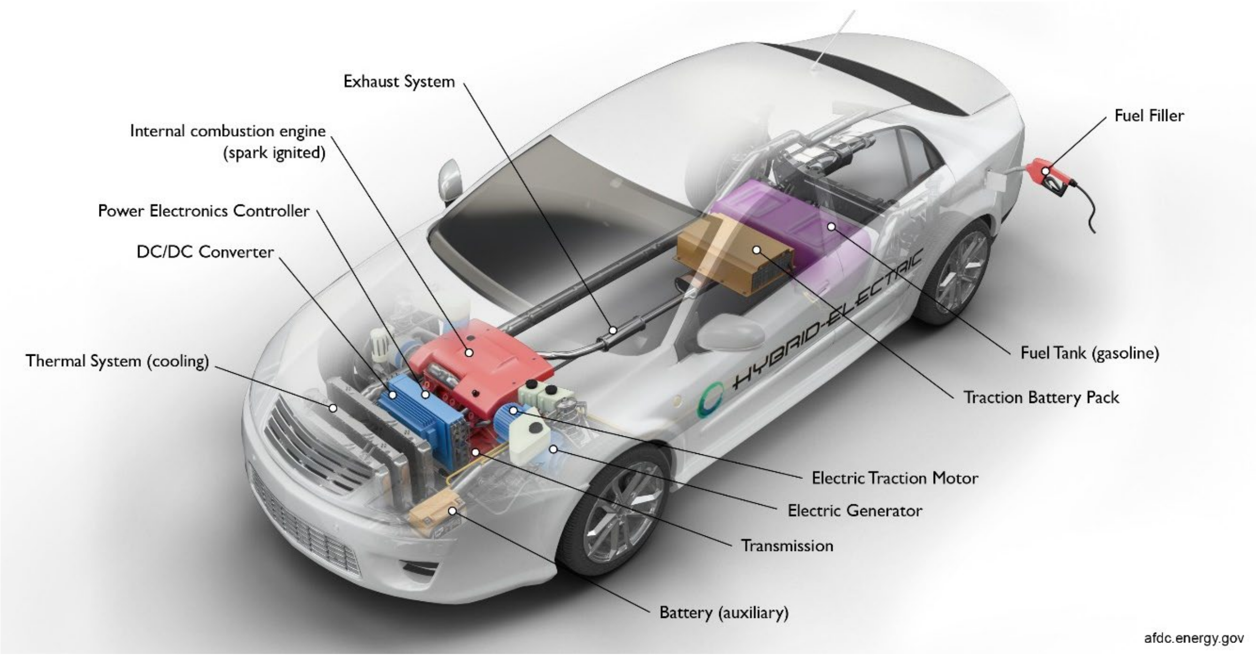
This technical memo is an overview of the state of light and medium-duty electric vehicles (EVs), including electric school buses and low-speed electric vehicles, and charging equipment technology.

State of Electric Vehicle Technology

Light Duty

Nationally and regionally, electric vehicle adoption is growing. In 2018 there were more than 328,000 electric vehicles (EVs) registered in the US and 16,000 EVs sold in in New England. The Electric Power Research Institute (EPRI) estimates that as of 2019, there were 41 light duty models available nationwide (light duty vehicles are those with a gross vehicle weight rating less than 8,500 lbs.; see accompanying spreadsheet for a full list of light duty EV models available in Rhode Island as of December 2020).[1] Light-duty plug-in vehicles include both plug-in hybrids (PHEVs), which use a combination of electricity and gasoline for vehicle power, and battery electric vehicles (BEVs), which are powered exclusively by electricity and do not have an internal combustion engine.

Hybrid vehicles, such as the conventional Toyota Prius, have electrified drivetrains but rely entirely on gasoline for charging. Hybrids cannot draw electric power from an external power source. Electric vehicles of any type can be more expensive to purchase than their conventional gas or diesel counterparts, although they are generally less expensive to operate with lower maintenance[2] and fueling costs[3].

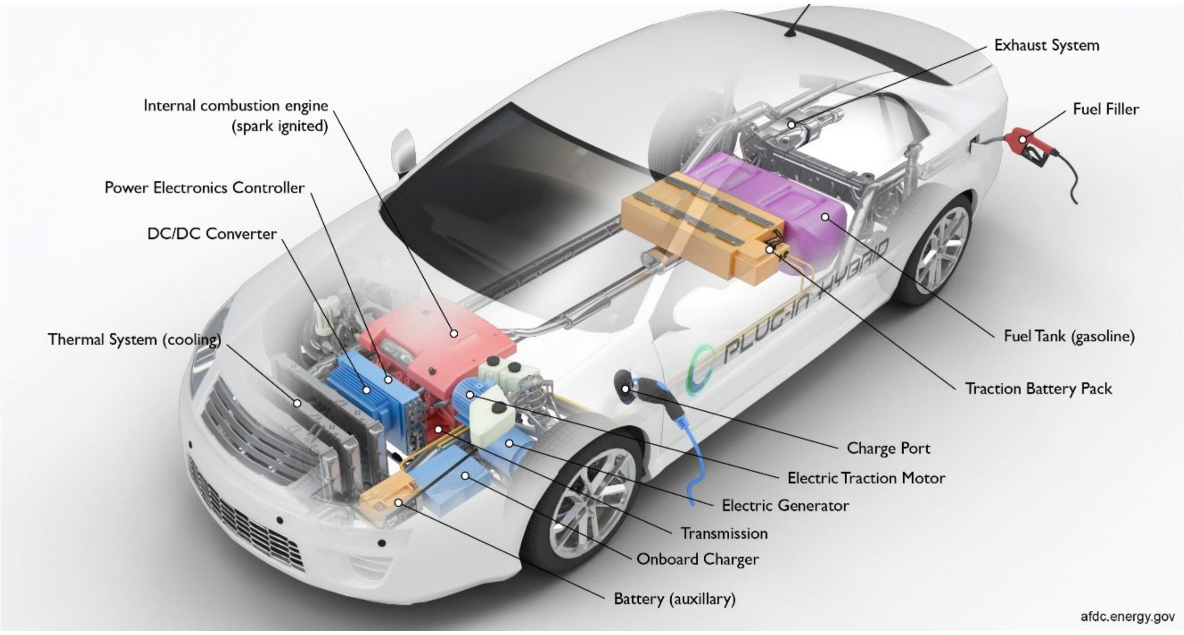


Hybrid Electric Vehicle Diagram

PHEVs generally use electricity until the battery is discharged, and then switch to gasoline. PHEV battery range is 14 to 53 miles for models currently available in New England and have a total vehicle range of 180 – 610 miles. PHEVs offer greater flexibility and vehicle range than BEVs. However, with limited electric range there is less of an opportunity to save on fuel and maintenance costs and reduce emissions. Among the most affordable PHEVs available in New

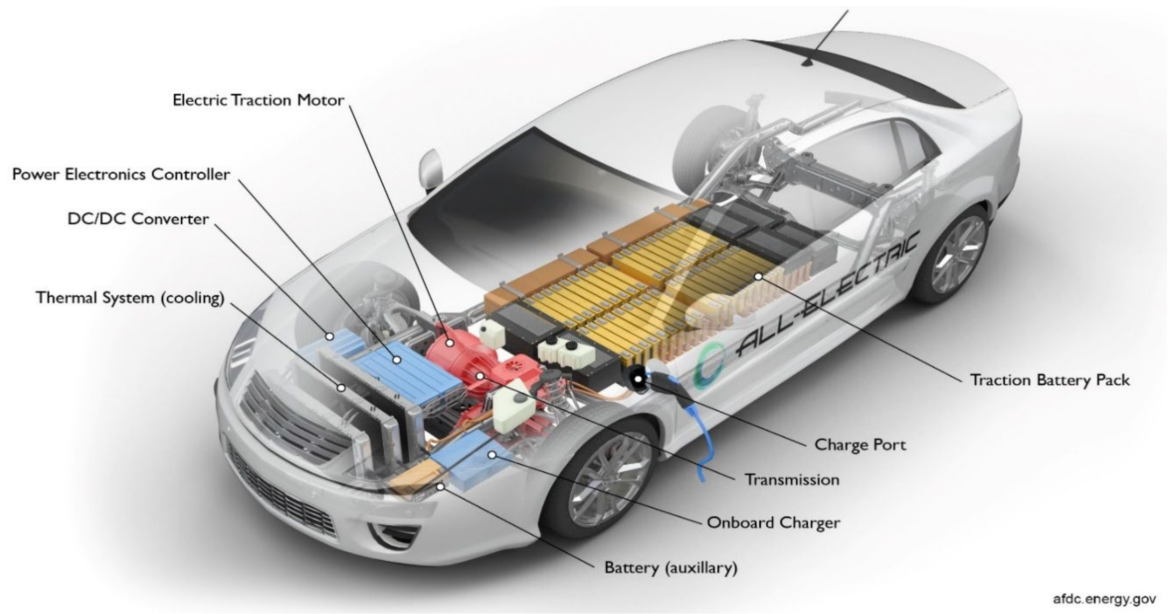
[1] EPRI Consumer Guide to Electric Vehicles, March 2019.
[2] US Department of Energy (DOE) Alternative Fuels Data Center (AFDC), **https://afdc.energy.gov/vehicles/electric_maintenance.html**
[3] US DOE AFDC, **https://www.energy.gov/eere/electricvehicles/saving-fuel-and-vehicle-costs**

England are the Hyundai Ionic PHEV (electric range of 29 miles, MSRP $25,350) and Toyota Prius Prime (electric range of 25 miles, MSRP $27,750).



Plug-in Hybrid Electric Vehicle Diagram

In contrast, BEVs currently on the market provide between 110 to more than 250 miles of electric range. BEVs are often less expensive to operate than PHEVs because the vehicles only require mechanical components for a single fuel source, eliminating the need for maintenance of gas engines, coolants, exhaust systems, or oil changes. Some of the more affordable BEVs



Battery Electric Vehicle Diagram

available in New England include the Hyundai Ioniq EV, which has a range of 124 miles (MSRP $33,045), and the Nissan LEAF, which has a range of 151 miles (MSRP $31,600).

Note that this range can be significantly reduced during the winter months. Research conducted by AAA[4], Consumer Reports,[5] and the US Department of Energy[6] has found that cold temperatures can reduce light duty EV range by 25-50%. In VEIC's experience driving light duty electric vehicles and in speaking with other EV owners, electric range can be almost cut in half when temperature drops below 0° Fahrenheit. Charging can also be slower in cold weather.

However, coastal Rhode Island averages only one day per year with minimum temperatures below zero (and only 5 days/year inland). The average daily minimum temperature in January and February is 19 to 20° F over about two- thirds of the State, increasing to near 25° F in immediate coastal sections.[7] Consequently, RI-based fleets would be more likely to encounter moderate cold-related range decreases (closer to 30%). Steps can be taken to help mitigate cold-related range decreases, such as parking and charging vehicles in heated garages where available, preheating the vehicle cabin while still plugged in, and selecting vehicles with heated seats to reduce need for cabin heating (which reduces energy draw from the propulsion battery).

The electric vehicle market is rapidly evolving, and automakers expect to introduce dozens of additional BEV and PHEV models by 2022, from sedans (such as VW's complete line) to SUVs (such as the Ford Escape and Explorer) to pickup trucks (the Ford F-150).

An important consideration with any plug-in vehicle is when and where the vehicle can charge. Opportunities to charge throughout the day effectively increase vehicle range, although most fleets with limited daily mileage can rely entirely on nighttime-only charging. A State of EV Charging Technology section is provided later in the memo.

Rhode Island Light Duty EV Landscape

Similar to national trends, sales of light duty electric vehicles are increasing in Rhode Island. Between 2015 and 2018, the Rhode Island Division of Motor Vehicles registered 592 BEVs and

[4] See **https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range/**.
[5] See **https://www.consumerreports.org/hybrids-evs/buying-an-electric-car-for-a-cold-climate-double-down-on-range/**.
[6] See **https://www.energy.gov/eere/electricvehicles/maximizing-electric-cars-range-extreme-temperatures**.
[7] RI Dept. of Environmental Management - **http://www.dem.ri.gov/climate/climate-overview-ri.php**

902 PHEVs.[8] Notably, 47% of BEV and 38% of PHEV registrations occurred in 2018 alone, with annual growth rates of 67% and 28% over the prior year, respectively. Combined BEV and PHEV new vehicle market share increased from 0.9% of all vehicles in 2017 to 1.3% in 2018.[9] EV sales are also increasing in adjoining states, where EV market share is 2.5% in Massachusetts and 2.0% in Connecticut. Continued sales of new EVs will expand the used EV market in coming years. As of December 2020, we are aware of 131 public, non-Tesla charging stations (with a total of 406 outlets) for EV users in Rhode Island, including at least 16 DC fast charging stations[10] (see State of EV Charging Technology later in this memo for an overview of charging types). Additional non-public charging stations are located at private employers.

There are a variety of EV incentives available, from the federal tax credits to utility-specific incentives. The amount of the federal tax credit varies with battery size (up to $7,500 for most BEVs). In addition, incentives decline once a manufacturer has sold 200,000 units. Tesla has reached this limit and tax credits have been reduced to $1,875 as of July 1, 2019 (and will be eliminated entirely January 1, 2020). Federal tax credits are also set to sunset for EVs manufactured by General Motors, reducing to $1,875 October 1, 2019 (and will be eliminated entirely March 1, 2020). There are Congressional efforts to extend these tax credits, but no changes have yet been made to the current manufacturer limits. Current incentive levels are included in the attached light-duty spreadsheet and vary between $3,750 and $7,500.

The federal tax credit, while generous in some instances, is only available to those entities with adequate tax liability. However, if a non-profit leases a new EV, the dealership may have the ability to claim the tax credit and roll those savings into the lease cost.

Financial and technical assistance for non-residential EVSE infrastructure and installation in Rhode Island is also available through Rhode Island Energy's EVSE program (see: **Electric Transportation and Charging Programs (rienergy.com)**). This program funds upgrades to Rhode Island Energy's distribution network and transformers, as well as sitework to prepare for charger installation. In addition, Rhode Island Energy offers a 50% rebate towards

[8] Alliance of Automobile Manufacturers and HIS Markit, 2019. **https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard**

[9] EVAdoption, 2019. **https://evadoption.com/ev-market-share/ev-market-share-state**.

[10] US DOE AFDC Station Locator - **https://afdc.energy.gov/stations/#/find/nearest**

the cost of the charger itself if a qualified charging station is installed. The list of qualified charging stations is available here: **Qualified Electric Vehicle Supplier List (rienergy.com)**

Lease vs. Purchase

When light duty EVs first became available in the early 2010's, it was much more common for customers to lease rather than purchase, in large part because battery technology was improving rapidly on an almost annual basis, lowering costs and increasing vehicle range. As ranges have plateaued, purchase of EVs has become more common. As EV prices and battery ranges have stabilized, purchase of vehicles is a viable long-term option. One advantage that leasing could provide is ability to access the federal tax credit (as described above).

Medium Duty

Because medium duty vehicles are common in many fleets, VEIC conducted a survey of available medium duty EV models. Medium duty vehicles encompass a range of vehicle sizes and purposes, such as moving goods to work sites, delivering goods, and moving people. Medium duty commercial vehicles are categorized in different ways. Federal Highway Administration classifications account for axles or gross vehicle weight rating (GVWR). Medium duty is often categorized as 10,001 to 26,000 lbs. GVWR. Body type, cargo space, and payload capacity are also characteristics that categorize medium-duty vehicles and are critical to meeting a fleet's functional needs.

A 150-mile range cargo van with an after-market electric powertrain. Manufacturer photo.

The light duty EV market is far more developed than the medium duty market. VEIC identified 33 plug-in medium duty vehicles. Of these, 18 are available for purchase in the US, seven can be pre-ordered but the manufacturers have not announced firm dates of delivery to non-partner fleets, and five lack a firm date for production or sale in North America. Only four of the 33 vehicles are PHEVs; the vast majority are all-electric BEVs. These BEVs are available (or will be available) from a mix of large automakers (Ford, Chrysler), specialty companies (BYD, Workhorse), and aftermarket companies that add electric drive trains to a traditional automaker's chassis, or "glider" (Motiv, Lightning Systems, XL Hybrids).

Electric vehicle range is determined by equipment (e.g. battery size), operational factors (such as load weight and driving habits), and environmental factors (e.g. temperature and terrain). Most medium duty equipment offers a range of 40 to 120 miles, subject to some reduction in extreme cold. Batteries are typically affixed along the chassis, resulting in no impact on available storage space compared to equivalent gasoline or diesel vehicles. VEIC compiled a list of medium duty plug-in vehicles that includes vehicles from small vans to step trucks and box trucks, as well as passenger vans and shuttle buses, plus pickup trucks and minivans (attached to this memo as an Excel spreadsheet). VEIC is not aware of any medium duty EVs currently in use in Rhode Island.

Many vehicles lack transparent prices due to their novelty, specialty markets, and small production runs but range in price from $39,995 for a Chrysler Pacifica Minivan to $57,000 for a plug-in hybrid pick-up truck, to $120,000 for an aftermarket-electrified full-sized cargo or passenger van.

Delivery companies are leading the way in deployment of medium duty electric vehicles in the US, especially DHL and FedEx. It is our understanding that interest in electric vehicles among these fleets is driven by the opportunity to save money on fuel costs and ensure lower maintenance costs by avoiding gasoline or diesel engines altogether.

Cargo Vehicles

Cargo vehicles include both vans (with the cab fully integrated into the body) and trucks (where the cargo area is mostly or entirely separated from the cab, and often have a roll-up rear door). The largest medium duty plug-in cargo trucks are low cab forward trucks with up to 14,000 pounds of payload capacity, which is comparable to an equivalent diesel truck. These models have all-electric drivetrains added to standard truck chassis (such as the Ford F-59 and Chevrolet 6500XD) and offer 60 to 120 miles of range on a full charge.

The full-size cargo van category is the most active market among electric medium duty vehicles. Multiple modifiers offer all-electric vans based on Ford and Chevrolet van gliders. Lightning Systems, for example, offers a Ford Transit-based electric van (capable of carrying up to 3,700 pounds) that retains Ford's standard warranty on the chassis and the modifier's 5-

An all-electric box truck adds an electric powertrain to a Ford E-450 chassis. Manufacturer photo.

year warranty on the powertrain and battery. Other manufacturers produce vans from scratch using lighter material (such as composite bodies in lieu of aluminum) to offer lighter vehicles and longer ranges. For example, one manufacturer, Chanje (pronounced as "change") has agreed to sell 100 and lease 900 full size cargo vans to FedEx for use in the US.

Ford recently announced the E-Transit van, expected mid-2021. Preliminarily, this vehicle would have a range of 126 miles, be available in three different lengths and heights in both chassis cab and cutaway models, at a base cost of $45,000 before incentives. This would make it more cost-effective than a conventional van in many applications.

The 126-mile range 2022 Ford E-Transit. Manufacturer photo.

Similarly, GM has announced plans to create an electric replacement for its full-size vans (the Chevrolet Express and GMC Savannah).

Minivans are similar in cargo capacity to small cargo vans. One Chrysler PHEV minivan is currently available nationwide,. The Nissan e-NV200 is a small cargo van sold in Europe but currently limited to select customers in the US. However, Nissan cancelled further work of the diesel version, signaling the view that electric fleet vehicles will become commonplace.

All-electric pickup trucks are not widely available, but more models are expected over the next few years, including a plug-in Ford F-150. Electric pickups built by specialty firms such as Rivian or Tesla are focused on high-margin luxury models and do not appear to be an option for fleet customers at this time. One exception may be the fleet-focused Lordstown Endurance, a full-sized pickup which is projected to have a 250 mile-range, four-wheel drive and a starting price of $52,500.

Passenger Vehicles

Medium duty all-electric passenger vehicles include passenger vans and shuttle buses using medium duty chassis, as well as school buses using medium and heavy-duty chassis.

Three aftermarket manufacturers offer modified vans and shuttle buses based on automakers' bodies. In addition, one manufacturer sells an all-electric van with seating configurations ranging from 10 passengers to 16 passengers (including a single wheelchair). These passenger vehicles are typically similar to their cargo equivalents, with 60 to 120-mile ranges. A major market for electric shuttle buses and passenger vans are airport shuttles (connecting terminals with remote parking and rental car centers) and hotel shuttles. Frequent stops, predictable mileage, limited maximum speeds and highway miles, and reduced maintenance downtime make these markets well suited to electric vehicles.

School and Commercial Buses

All major school bus body manufacturers now offer a production model electric bus or plan to offer one by 2021. As with their conventional counterparts, types A, C and D bus bodies can be configured for pupil transportation or for specialized transit or commercial activities.

Type A and Type D electric models from Blue Bird

School bus or shuttle bus routes offer an attractive use-case for electric vehicles. Since daily mileage is often moderate and consistent, range (and expensive batteries) can be smaller than might be needed for other use-cases. With subsidies or grant funding, these vehicles can be cost-effective as replacements for diesel, gasoline, or propane buses when deployed on high-mileage routes.

Type A Buses

Type A school buses of 24 to 30 passenger capacity are available from at least six manufacturers, either purpose-built or on a chassis such as the E-450. Range starts at 80 to 100 miles and can be expanded in some cases to 150 miles. These vehicles are typically charged from 6 to 8 hours overnight using conventional light-duty EV-charging plugs that are supplied with higher-than typical power capacity. These high-power Level 2 chargers typically cost between $3,000 and $5,000, plus installation. Type A school bus pricing varies from $235,000 to $335,000.

Type C Buses

Type C school buses of 72 to 81 passenger capacity are available from at least five manufacturers. Range of these full-sized buses generally starts at 65 miles and can be optionally increased to 150 miles in some cases. Some Type C buses charge in 6 to 8 hours overnight using conventional light-duty Level 2 charging plugs that are supplied with higher-than typical power capacity. Some are configured with Level 3 DC charging as an added option. Some are designed only to accept Level 3 DC chargers, which are usually more expensive to purchase and operate, but which may allow for a full recharge in as little as two hours. Type C buses start at around $310,000 and may cost as much as $450,000 for very long-range configurations.

Lion type C electric school bus

Type D Buses

Type D school buses with capacities of 81 to 84 passengers are available from at least three manufacturers. As of 2020 no commercially-available electric replacement exists for a type D bus seating between 85 and 90 passengers. These vehicles are similar in most respects to Type C buses but come with a price premium for their increased size comparable to premium on a conventional type D bus.

Vehicle-To-Grid

Electric utilities are interested in vehicle-to-grid configurations of electric school buses. In theory, an electric school bus could partially discharge its battery to the grid while it sits idle and connected to a charger. Strategic timing of battery discharge could save money for the utility and still allow for a fully-charged vehicle when needed, while potentially providing utility financial incentives to the fleet to help offset the cost of the electric bus. However, these technologies are still nascent, and until more trials have been completed, school bus operators should not plan on extra cost savings from vehicle-to-grid.

Off-Highway Vehicles

Low Speed Electric Vehicles (LSEVs) are a small segment of the EV market, but may offer substantial benefits for on-campus operations. In general, LSEVs are the most cost-effective option for vehicles that always travel fewer than 15 miles per day and 4,000 miles per year, and never need to exceed 25 MPH.

Polaris GEM eL XD

LSEVs major advantages include significant vehicle registration, insurance and inspections cost savings, significant emissions savings, compact size and maneuverability, and ability to charge on a standard 110V outlet (and so do not require investments in separate charging infrastructure). Many universities around New England utilize LSEVs in their year-round operating fleets.

The National Highway Traffic Safety Administration (NHTSA) defines an Low-Speed Vehicle (LSV) as any four-wheeled motor vehicle with a gross vehicle weight rating of less than 2,500 lbs. whose top speed is greater than 20 miles per hour, but not greater than 25 miles per hour on a paved level surface.[11]

Configurations

Two major manufacturers (Polaris' "GEM" and Club Car) produce short-range, street-legal vehicles that are speed limited to 25mph or less. All these vehicles are highly customizable. Configurations include simple two-seat passenger carts, six-seat vans, or light pickups. They can be produced with or without an enclosed cab, ladder racks, van boxes, etc.

Charging

All LSEVs come standard with Level 1 charging. Typically, they can be recharged opportunistically throughout the day when used for on-campus work. They should always be

[11] See: **https://www.federalregister.gov/documents/2005/08/17/05-16323/federal-motor-vehicle-safety-standards-low-speed-vehicles**

plugged in at night or when not in use to maximize battery life. Certain LSEVs with more-expensive lithium-ion batteries may also include the option to charge with Level 2 stations for faster charging.

Range

Most LSEVs are available with a maintenance-free lead-acid battery. With these basic batteries, range is limited to about 15 miles between charges. To maximize battery life, these batteries will do best if they usually travel only 5 miles between charges. Extended range lithium-ion batteries are available that can allow range up to 70 miles or more. However, the added cost of these high-tech batteries can approach $10,000, and long range is usually not needed for low-speed vehicles.

Maintenance

With fewer parts than a traditional electric vehicle, the general maintenance on LSEVs is low. However, their inexpensive batteries may last only three to five years under good operating conditions. Battery replacement may cost $2,000. Overall, maintenance costs per mile may be high when battery replacements are considered.

Club Car Electric Carryall 510 LSV

Insurance and Registration

LSEVs may offer substantial savings (50% or more) on annual insurance premiums compared to conventional vehicles. Especially for low-mileage vehicles, insurance can easily be the single biggest operating cost.

Unfortunately, Rhode Island is currently the only state in New England that does not have a special registration classification for low-speed vehicles ("LSVs" whether electric or conventionally powered). While some fleets have reported success in registering these vehicles through their local municipality, others working with their municipalities or the Rhode Island Division of Motor Vehicles directly have been unable to do so. If LSVs are added to Rhode Island's vehicle registration classifications in the future the registration process should become much more straightforward. Until that time, fleets are advised to explore registration options with their local municipalities and/or the RI DMV in advance of any purchase decisions.

Note that LSEVs may also be utilized for applications on large private campuses that do not require vehicle use on public roads and therefore may not require vehicle registration.

Purchase Price

LSEV purchase price can be as low as $13,000 for an open-cab, two-seat model. However, for year-round use, an enclosed-cab model with a maintenance-free battery will cost about $17,000 for a two-seater, $21,000 for a four-seat or pickup, and $24,500 for a six-seat van. Because LSEVs use Level 1 charging, little or no extra investment is needed for charging infrastructure.

State of Light Duty EV Charging Technology

Light duty Electric Vehicle Supply Equipment (EVSE) is divided into three levels based on charging method and the resulting speed of recharging vehicles. Charging capability ranges widely; the fastest Level 3 chargers can recharge vehicles up to 60 times faster than a standard Level 1 charger.

Level 1 charging uses standard 120-volt outlets.

Level 1

Level 1 charging uses the same 120-volt current found in standard household outlets and can be performed using the power cord and equipment that come with most EVs. Using this type of charging requires only a dedicated 120-volt outlet. Installation costs of Level 1 charging are low and impacts on peak demand charges are minimal. However, charge times are considerably slower than Level 2 charging, typically 3-5 miles of range per hour of charging. Installation costs of a dedicated Level 1 charger generally range from $350-$1,500 for a single port unit.

Level 2

Level 2 charging uses 240-volt power to enable faster regeneration of an EV's battery system. Providing this type of charging requires installation of an EVSE unit and electrical wiring capable of handling higher voltage power. **Plug-in America's Accessory Tracker**[12] offers an updated list of Level 2 EVSE currently on the market. Using a Level 2 charger, vehicles gain between 10-20 miles of range per hour of charging. For shorter charge times, Level 2 is also more efficient than Level 1. These charge stations can be considerably more expensive than Level 1 EVSE to purchase and install.

A dual port Level 2 EVSE with standard SAE J1772 connectors.

Hardware costs (not including any additional costs to track usage or charge a fee) range from $600-$6,500, depending on equipment and networking capability (see Managed Charging later in this memo for an overview of Networked vs Non-Networked chargers). Installation costs range from $600 to $12,700. The highest costs reflect the need for extensive site work including installing power to serve the charging stations, which sometimes can run long distances and require trenching.[13]

Level 3 - DC Fast Charging

DC fast charging provides compatible vehicles with an 80% charge in 20-30 minutes by converting high voltage AC power to DC power for direct storage in EV batteries. Automakers currently have three specifications for DC fast charging plugs: the CHAdeMO, SAE Combined Charging System, and Tesla Supercharger standards. Nissan and Mitsubishi vehicles use CHAdeMO while many current and upcoming vehicles from US and European manufacturers have SAE CCS ports. Tesla's Supercharger equipment is only compatible with Tesla Model S or later vehicles, although they are developing an adapter which will allow Tesla owners to use CHAdeMO equipment. Several EVSE manufacturers offer equipment with both the CHAdeMO and SAE CCS port connectors to increase compatibility.

DC fast chargers dramatically reduce charging time. However, these chargers are significantly more expensive than Level 1 or 2 chargers and require three-phase supply power. Equipment

[12] Plug In America offers a database of equipment and software: **https://pluginamerica.org/get-equipped/.**

[13] See **https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf** for cost category details.

costs can range from $10,000 to $40,000, depending on number of ports, power level, and display capabilities. Installations costs range from $4,000 to $51,000. In most cases, the charging needs of light duty commercial fleets are adequately met with Level 2 EVSE.

Example Level 3 DC Fast Charging EVSE units.

Publicly accessible DC fast chargers are increasing in availability in metro areas around RI and the Northeast, and may be useful for fleets for occasional supplemental or backup charging, especially during longer-than-average electric vehicle trips. Public DC fast charging and Level 2 stations may be located on a variety of online and phone-based applications, including the AFDC Station Locator (**https://afdc.energy.gov/stations/#/find/nearest**) and PlugShare (**https://www.plugshare.com/**).

More information about the different types of EV charging infrastructure can be found through the Alternative Fuels Data Center: **https://afdc.energy.gov/fuels/electricity_infrastructure.html**.

Managed Charging

Light and medium-duty fleet vehicles typically rely on Level 2 charging at locations where vehicles can be parked overnight to ensure charging occurs during "off-peak" hours. Level 1 charging can also be used, particularly for PHEVs which tend to have smaller batteries and do not require as long to charge. For larger fleets with many chargers, an interconnected charging management system can help to schedule and moderate charging electricity load to reduce peak power expenses and help avoid expensive electrical infrastructure upgrades in certain applications.

Designation of EV-only parking at DC Fast Charging

Commercial electricity customers commonly have two primary costs associated with electric use. As with residential accounts, total energy use (measured in kilowatt-hours) is measured as it is consumed. However, commercial customers also pay demand charges based on each account's peak electricity power draw established during each month's 15-minute period of greatest demand. EV charging can increase electricity demand, sometimes significantly, especially in the case of DC fast chargers. However, the resulting impact on demand charges can be minimal if EV charging is managed to occur while other loads are low, such as overnight. Demand charge mitigation, transformer capacity, and time-of-use rates are key conversations with Rhode Island Energy as fleets begin to deploy and operate EVs.

Managed charging includes any strategy to control when charging occurs or the amount of charging at any given time. Generally, managed charging aims to minimize both costs, such as demand charges, and strain on the electric grid. For most light duty fleets, simply delaying charging until the late evening allows vehicles to be fully charged by morning and avoids drawing electricity during times of peak demand.

For high-demand electricity users, demand charges are only assessed during peak hours. Under Rhode Island Energy's current tariff for the Large Demand Rate (G-32), peak hours begin on weekdays at 8 am (March through November) or at 7 am (December through February). Peak hours end at 10 pm during winter (December through February) and summer (June through September) or at 9 pm during spring and fall (March through May, October, and November). There are no weekend peak hours; all weekends are off-peak. The 9 to 11 hours of off-peak time each day should be sufficient to charge most EVs using Level 2 EVSE. Note that for Rhode Island Energy's General Commercial (G-02) and Small Commercial (C-06) rates, demand charges are assessed equally 24-hours per day, with no peak or off-peak hours.[14]

Managed charging typically uses software to coordinate charging schedules among multiple networked chargers. EVSE must be networked to track when and how much charging occurs and by which vehicles, and can be used to charge end-users (like employees, departments or visitors) fees for charging based on electricity consumed, time spent charging, or other factors). Networked chargers can also provide access control (to prevent unauthorized use), data collection, station and energy use analysis and automated diagnostics. Depending on the location and intended use of future chargers, a fleet may or may not find each of these features necessary.

Networked chargers are typically considerably more expensive to purchase and operate than more basic, non-networked chargers. In addition to higher upfront purchase costs, networked chargers also typically require "networking fees" which range from $100 to $900 annually

[14] Rhode Island Energy Rhode Island Business Service Rates, **Service Rates | Rhode Island Energy (rienergy.com)**

depending on the manufacturer and provider.[15] (Fees include cellular data subscriptions.) Networked Level 2 chargers popular among fleets include models offered by ChargePoint (**https://www.chargepoint.com/**) and Greenlots (**https://greenlots.com/**), whereas non-networked models by ClipperCreek (**https://www.clippercreek.com/**) are commonly used by fleets for more basic applications.

[15] US Dept. of Energy (2015), **https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf**.

Appendix

Three spreadsheets accompany this report. The first spreadsheet details light-duty EVs currently on sale in New England. The second spreadsheet identifies medium-duty EVs, including vans, cargo trucks, and pickup trucks, that are available or have been announced for the North American market. The third spreadsheet identifies Type A, C and D electric school buses that are available or have been announced for the North American market.