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Memorandum

To: Paul Conner and Lou Bresee, City of South Burlington
From: David Roberts and Philip Picotte, VEIC
Re: South Burlington City Fleet Vehicle Efficiency Research

This memorandum responds to a request from the City of South Burlington's energy committee to investigate fleet efficiency options for the City. VEIC received funding from the Chittenden County Regional Planning Commission (CCRPC) to assist communities interested in advancing the efficiency of municipal fleet operations. A summary of fleet efficiency options and brief analysis of potential costs and benefits of switching out to more efficient vehicles, including plug-in electric vehicle (EV) options, is included below.

Overview

Electric vehicles are one of the best ways to improve fleet energy efficiency. There are already many EV models available for light duty vehicles, especially sedans. The medium and heavy duty markets are less mature but options are expected to grow in these segments over the next five years. Traditional hybrids that do not plug-in are not EVs, but also offer improved efficiency compared to fossil fueled vehicles.

EVs typically cost more than conventionally fueled vehicles to purchase but offer lower operating costs and significant environmental benefits as the current electricity mix serving the city is 60% renewable and 90% carbon free.[1] EVs that lack an internal combustion engine require less maintenance, such as no oil changes and reduced brake wear.

EV adoption is increasingly rapidly, both among private owners and in the public sector. The State of Vermont's fleet currently consists of 7% EVs and hybrids. Beginning in July 2019, at least 50% of vehicles purchased or leased by the State's Department of Buildings and General Services must be hybrid or electric vehicles, rising to 75% in 2021. South Burlington already has one EV in the fleet, and other

[1] Green Mountain Power 2018 Fuel Mix

Vermont municipal fleets include electric vehicles, such as the City of Winooski, the Town of Hartford, and CCRPC.

South Burlington Municipal Vehicle Fleet

The municipal fleet consists of vehicles of many sizes and purposes. This includes: light duty vehicles, such as sedans and SUVs; medium duty vehicles, such as pickup trucks and work vans; and, heavy duty vehicles—including specialty vehicles such as dump trucks used for plow operations, street sweepers and stormwater catch basin cleaning trucks. Vehicle replacement rates vary. According to city officials, the Police Department generally replaces three vehicles each year, while the rest of the city replaces one vehicle every three years. According to City officials, each department would consider EVs suited to their needs.

Efficient Vehicle Options

The most efficient vehicles available are all-electric vehicles (AEVs), which are powered exclusively by electricity and do not have an internal combustion engine. Plug-in hybrid electric vehicles (PHEVs) use a combination of electricity and gasoline for vehicle power to offer greater total range and faster refueling and operate at somewhat lower efficiency depending on the specific model range and driving/charging patterns.

Traditional hybrid models lacking plug-in capability are worth considering when suitable EV models are not yet available or where other issues preclude their use. Hybrid vehicles, such as the Toyota Prius, have electrified drivetrains but rely entirely on gasoline for charging. Hybrids cannot draw electric power from an external source so are still heavily reliant on fossil fuels.

School vehicles fall outside the scope of this memo. However, recommendations for light duty vehicles (such as sedans) are also applicable to the school district fleet. In addition, electric school buses are available from multiple manufacturers and currently operate in New England, New York, and Quebec. Electric school bus resources are available at https://www.veic.org/electric-school-buses. The Vermont Agency of Natural Resources (ANR) has contracted with VEIC to administer an electric school and transit bus pilot program which will offer interested school districts an opportunity to express interest in participating in late summer 2019.

Light Duty Vehicles

Light duty electric vehicle adoption is growing rapidly. In 2018, there were more than 328,000 electric vehicles (EVs) registered in the US and 16,000 EVs sold in in New England. Drive Electric Vermont has identified more than 40 EV models available in Vermont. Many of these are sedans and small SUVs well suited to the City's light duty needs.

PHEVs generally use electricity until the battery is discharged, and then switch to gasoline. PHEV battery range is officially reported at 14 to 53 miles for current models which offer total vehicle ranges of 180 – 610 miles when the electric range is combined with a full tank of gasoline. PHEVs offer greater flexibility and vehicle range than AEVs and are often less expensive to purchase. However, with limited electric range there is less of an opportunity to save on fuel costs and reduce emissions. Among the most affordable PHEVs available are the Ford Fusion Energi (electric range of 21 miles, MSRP $31,400) and Toyota Prius Prime (electric range of 25 miles, $27,600).

AEVs currently on the market provide 58 to more than 300 miles of electric range. The longer range options tend to have higher purchase prices but are often less expensive to operate than PHEVs or conventional vehicles because they only require mechanical components for a single fuel source, eliminating the need for internal combustion engines, fuel tanks and related components. Some of the more affordable AEVs include the Nissan Leaf with a range of 151 miles ($29,990), Chevrolet Bolt ($37,495), and Hyundai Kona ($37,495). EV battery is expected to decrease over time, but are commonly warrantied for 8 years or 100,000 miles, with some warranties available for 10 years. As modern electric vehicles haven't been around too long we don't yet have data to understand when and under what conditions battery replacement or servicing might be needed, but a somewhat conservative estimate would be to expect a reduction in range of up to 25% over a 10 year period.

EV electric range can be significantly reduced by cold temperatures over winter months. Research conducted by AAA, Consumer Reports, and the US Department of Energy has found that cold temperatures can reduce EV range by 25-50%. In Vermont, drivers report electric range is almost cut in half when temperature drops below 0° Fahrenheit. Charging speed can also be reduced in cold conditions.

The electric vehicle market is rapidly evolving and automakers have announced dozens of additional AEV and PHEV models expected to be available by 2022, from

sedans (such as VW's complete line) to SUVs and trucks (such as the Ford Escape and F-150).

Police Vehicles

Police vehicles are a major element of the City's fleet. EVs are already in use by law enforcement agencies around the country, although mostly for administrative and traffic enforcement purposes, not as "pursuit" vehicles. The three automakers producing patrol vehicles—Ford, Chevrolet, and Fiat-Chrysler's Dodge brand—are all moving towards more efficient vehicles, including hybrid vehicles.

Ford's Police Responder Hybrid Sedan[2] uses a traditional hybrid engine to offer improved fuel efficiency (38 MPG) over the standard Police Interceptor Sedan (18 MPG). The model is pursuit-rated, allowing unrestricted use for day-to-day patrol operations. A plug-in hybrid sedan is also available, offering 25 miles of electric-only power and more than 600 miles of total range. The plug-in hybrid is not pursuit-rated but is intended for investigator or administrator use; the vehicle takes 2.5 hours to charge using a Level 2 charger, and 7 hours using a standard 110-volt cord.

Beginning with the 2020 model year, a hybrid engine is standard on Ford's all-wheel drive SUV for law enforcement, the Police Interceptor Utility[3]. Fuel efficiency is raised from 17 to 24 mpg with no impact to performance or cargo space.

[2] https://www.ford.com/police-vehicles/hybrid-police-responder/
[3] https://www.ford.com/police-vehicles/hybrid-utility/

Medium Duty

Medium duty vehicles include vans and pickup trucks used by the Public Works, Stormwater, and Recreation departments. The medium duty EV market has fewer options than the light duty market. VEIC has identified 33 plug-in medium duty EVs, but of these only 18 are presently available for purchase in the US. Seven more offer pre-orders but manufacturers have not announced firm dates of delivery to non-partner fleets. The majority are all-electric AEVs from a mix of automakers and specialty vehicle manufacturing companies specializing in fleet EVs like BYD and Workhorse. Several aftermarket companies add electric drive trains to a traditional automaker's chassis, or "glider" (Motiv, Lightning Systems).

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

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 cold temperature. Batteries are typically affixed along the chassis, resulting in no impact on available storage space compared to equivalent diesel vehicles. Many vehicles lack transparent prices due to their limited availability but range in price from $39,995 for a Chrysler Pacifica Minivan to $52,000 for a plug-in hybrid pick-up truck.

Medium Duty Cargo Vehicles & Work Vans

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.

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

The full-size cargo van category is the most active market among electric medium duty vehicles. Multiple modifiers offer all-electric vans by adding their own electric drive trains to Ford and Chevrolet van gliders. Many electric cargo vans are not yet available in North America. Nissan has offered the e-NV200 for many years in Europe, but has not introduced it to the US market. Ford has announced a 2021 Europe launch for the Transit and smaller Transit Connect. Similarly, GM has announced plans to create an electric replacement for its full-size vans (the Chevrolet Express and GMC Savannah). No release dates are known for either Ford or GM versions in the US.

All-electric pickup trucks are not widely available, but more models are expected over the next few years. Rivian is a new automaker following Tesla's lead with the introduction of a high end electric pickup truck expected to arrive in 2020 the anticipated expense of this option likely means it will be of limited value to fleet customers. Given the variety of loads (e.g. gravel) and purposes (e.g. plowing) for Public Works trucks, it is unlikely these will be well served by EVs in the next few years, but new options are appearing all the time so market conditions should be monitored.

Medium Duty Passenger Vehicles

Medium duty all-electric passenger vehicles include passenger vans and shuttle buses using medium duty chassis. Small school and transit buses may use the same "cutaway" truck chassis as shuttle buses but are subject to additional regulatory requirements. 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 similar to their cargo-carrying equivalents, offering 60- to 120-mile ranges.

Heavy Duty & Specialty Vehicles

On the heavy duty side, electric transit and school buses are relatively well developed with multiple manufacturers and active deployments in fleets across the country. Electric refuse trucks are now available and in use in the US. However, other large vehicle categories are still in the early stage of EV development. This segment is expected to grow over the next five years. For example, all-electric street sweepers are now available in Europe but are rare in the US. While all-electric snowplows are not expected in the next five years, greater efficiency is possible with hybrid diesel-electric engines.

Electric Vehicle Charging

EV chargers, formally called Electric Vehicle Supply Equipment (EVSE), is divided into three levels based on charging method and the resulting speed of charging. Charging capability ranges widely; DC Fast chargers can recharge vehicles up to 60 times faster than a standard Level 1 charger. A summary of charging options is below. Drive Electric Vermont offers additional resources to explore charging levels and installation options at:
https://www.driveelectricvt.com/charging-stations/installation-guide

Level 1 Charging

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 most EVs come with along with 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 other 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, with potential economies of scale when charging can

be installed as part of a larger project or multiple ports are retrofitted in an existing parking facility.

Level 2 Charging

Level 2 charging uses SAE J1772 connectors.

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. 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 are considerably more expensive than Level 1 EVSE to purchase and install.

Hardware costs (not including any additional costs to track usage or charge a fee) range from $400-$6,500, depending on equipment and networking capability. Installation costs range from $600 to $12,000 or more. The higher cost range accounts for locations where extensive site work and power infrastructure upgrades are necessary to serve the EVSE hardware.[4]

DC Fast Charging

A DC Fast Charger with two charging plug types, one on each cable.

DC Fast Charging (DCFC, sometimes referred to as "level 3") 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. Not all EVs can utilize DCFC.

DC fast chargers dramatically reduce charging time. However, these chargers are significantly more expensive than Level 1 or 2 chargers and generally

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

require access to three-phase power. Equipment costs can range from $10,000 to $40,000 or more, depending on number of ports, power level, and display capabilities. Installation costs can range from $4,000 to $51,000 or more.

Charging Installation Considerations

Fleets typically rely on Level 2 charging at depots 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 take as long to charge. For larger fleets with many chargers, an interconnected charging management system can help to schedule and moderate flow to charging to reduce peak power expenses and help avoid expensive electrical infrastructure upgrades in certain applications.

The City of South Burlington was recently awarded a grant from the State of Vermont for several "Level 2" 240 volt charging installations as part of the new municipal facilities under construction in the new City Center. These may help to streamline opportunities to add more EVs to the light duty municipal fleet.

Commercial electricity customers—such as the City—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. 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. Improving efficiency of buildings or other power uses on the same site may also help lower these costs. As additional EVs are added to the City's fleet, demand charge mitigation and ensuring transformer capacity become more important considerations.

Fleet Efficiency Costs and Benefits

Electric or hybrid vehicles typically have higher prices than equivalent conventional vehicles but offer operational and maintenance savings over the vehicle's lifespan. However, in some cases the increased costs can be minimal. Toyota offers the Prius Prime PHEV version at a base price of $27,600 – less than $4,000 more than the standard version. Entities able to take advantage of the federal tax credit for EV purchases can more than make up this difference.

Hybrid Police Vehicles

Ford offers an online calculator[5] to estimate the fuel savings in switching from a standard police SUV (17 mpg) to a hybrid version (24 mpg). The calculator includes savings from idling. Assuming idling time of 4.9 hours per day, annual mileage of 20,000 miles per year (an average of 55 miles per day), and fuel prices of $2.65 per gallon, Ford estimates annual fuel savings of $2,103 per vehicle per year. The hybrid also cuts emissions by 7.15 tons of carbon annually. Additional idling (such as adding a second daily shift) would increase annual savings to $3,318 per year.

Electric Sedans

Comparing a gasoline and AEV sedan driving 15,000 miles per year, using the AEV would reduce greenhouse gas emissions at least 4.1 tons per year, from 5.4 to 1.3 tons. In fact, the emissions reductions would likely be even greater given that Vermont's electricity mix is cleaner than Northeast estimate used in modeling.

Using current electricity and fuel prices, the EV would save around $650 in fuel costs per year. With a price premium of $10,900, this would provide a simple payback of 17 years.[6] However, factoring in the value of a $7,500 tax credit, the payback is reduced to 5 years. While the City is a non-taxable entity, it can benefit from the value of the tax credit by leasing the vehicle. This allows the lessor to utilize the tax credit while the City pays a lower monthly payment. More information on municipal EV leasing options is available in this Georgetown Climate Center report:
https://www.georgetownclimate.org/files/report/Capturing-the-Federal-EV-Tax-Credit-for-Public-Fleets.pdf.)

Higher mileage, more idling, or a lower price premium all improve the financial case for switching to an EV option.

Fleet Efficiency Recommendations

- Plan for electric vehicle growth in all municipal infrastructure projects and site work; this includes providing for electric circuits and conduits in or near parking areas. The Capital Improvement Plan indicates the Public Works garage will be expanded with additional bays in FY20-21, so this could be a consideration in planning and design of this project.

[5] https://www.ford.com/police-vehicles/police-interceptor/hybrid-utility/calculator/
[6] Modeled using Argonne National Laboratory's AFLEET tool for a 33-mpg gasoline vehicle and 112-mpge EV, using fuel prices of $2.60 per gallon and 18 cents per kWh.

- Prioritize AEVs and/or PHEVs for high mileage and high idling vehicle roles.
- Consult Green Mountain Power for potential customer incentives and rate options for EV fleet customers.
- Review opportunities for joint purchases of EVs using pricing negotiated by the State of Vermont or other entities the City can work with.
- Consider leasing vehicles to leverage the federal tax credit for electric vehicles (value of $2,500 to $7,500 per vehicle, depending on manufacturer and vehicle details).
- Monitor EV market development for medium and heavy-duty options suitable for the City's needs.
- Consider non-EV hybrid vehicles when EV options are limited or do not exist.
- Pending data availability, consider undertaking a more detailed fleet transition plan based on vehicle inventory and use data. This could develop more accurate costs and savings information with phasing recommendations based on current and future vehicles.

Additional Resources

Drive Electric Vermont
https://www.driveelectricvt.com
Fleets for the Future Best Practices
http://www.fleetsforthefuture.org/f4f-best-practices
Climate Mayors Electric Vehicle Purchasing Collaborative
https://driveevfleets.org