ELECTRIFY VIRGINIA FLEET ANALYSIS

Prepared by Virginia Clean Cities for the Fredericksburg Police Department

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Executive Summary

The Fredericksburg Police Department ("FPD") could realize significant emission reductions and fuel cost savings through the use of alternative fuel vehicles and gasoline hybrid technology. Utilizing FPD vehicle data, Virginia Clean Cities (VCC) conducted an Alternative Fuel Life-Cycle Environmental and Economic Transportation analysis of the agency's light-duty vehicles. This analysis found that FPD could significantly reduce its greenhouse gas emissions (GHG) by 62% through the use of existing hybrid-electric vehicles (HEV). The addition of electric vehicles (EV) to the fleet where feasible could result in even greater GHG emission reductions. The FPD could also realize operational cost savings from the increased efficiency, higher miles per gallon, and lower maintenance costs associated with hybrids, plug-in hybrids (PHEV), and electric vehicles.

Fleet Analysis Background

At the request of Captain Patrick Reed in November 2020, Virginia Clean Cities and Fredericksburg Police Department initiated a fleet analysis through VCC's Electrify Virginia Project. This report is an analysis of emissions and potential cost savings from replacing gasoline police vehicles with gasoline-hybrid, plug-in hybrid (PHEV), and electric vehicles (EV).

The analysis run with Argonne National Laboratories AFLEET calculator, full spreadsheet presented to Fredericksburg and the tool is online at https://afleet-web.es.anl.gov/afleet/

The City's annual vehicle mileage duty cycle for police vehicles ranges from 3,506 for Administration vehicles, 6,533 for Patrol passenger vehicles and 8,327 for Patrol sport-utility vehicles (SUV). The vehicles when running air conditioning and heat could benefit from an idle-reduction strategy. In a hybrid or PHEV the engine programming allows the engine to idle less because the battery can power radio, computer, climate control and other functions that keep a gasoline car's engine running when the vehicle is stationary.

The vehicle costs range from $22,000 for a gasoline passenger vehicle to $65,000 for an electric SUV. The Ford Explorer Hybrid Interceptor will likely cost $37,155 to purchase and likely operate at 24 miles per gallon. This cost is closely comparable to the cost of a similar gas powered vehicle. The City fuel costs average $1.53 per gallon for gasoline during reporting period while electricity is 9.7 cents per kWh with very low volatility due to Virginia's regulated electricity sector. For comparison, $0.10 per kwh equates to about $1.00 per gallon of gasoline.

After analyzing options and Police department requirements, it is recommended at this time that the City of Fredericksburg pursue Hybrid Electric Vehicles (HEV). This type of vehicle, and others, are described in the "Additional Background" section of this report. The table below presents the four types of vehicles analyzed and described in the "Additional Background."

Vehicle-Type	Acronym	Brief Description
Gasoline	-	Gasoline powered – current fleet
Hybrid-Electric	HEV	Gasoline & Battery powered – battery re-charge from gasoline engine & regenerative braking
Plug-In Hybrid	PHEV	Gasoline & Battery powered – battery re-charge from gasoline engine & regenerative braking or plug-in charging
Electric Vehicle	EV	Battery powered - requires plug-in charging

Emissions Reductions

A significant reduction in greenhouse gas emissions, petroleum use, and air pollutants is possible from a transition to an electric or gas-hybrid fleet. The replacement of gasoline vehicles with hybrid vehicles results in an estimated 62% lifetime reduction in petroleum use and a 62% lifetime reduction in greenhouse gas emissions from these vehicles.

Idle Reduction

One of the benefits of a PHEV or HEV is the operational savings and emissions reductions that can be achieved through idle reduction. When the vehicle is parked the engine switches to a battery as the source of its energy. This enables the vehicle's systems to continue operation. Current data shows that the patrol fleet vehicles have and average idle rate of 50.35%. On a standard 11-hour shift that represents more than 5.5 hours of idling per Patrol vehicles. The average Patrol vehicle consumes 663 gallons of gasoline per year, half of which are consumed while idling. For the 27 Patrol SUVs and the 12 Patrol sedans this idling generates 138 tons of CO2, consumes more than 13,833 gallons of gasoline, and costs the department $21,165 in fuel expenses.

Figure 1: Patrol Fleet Data and Project Cost Savings using Hybrids

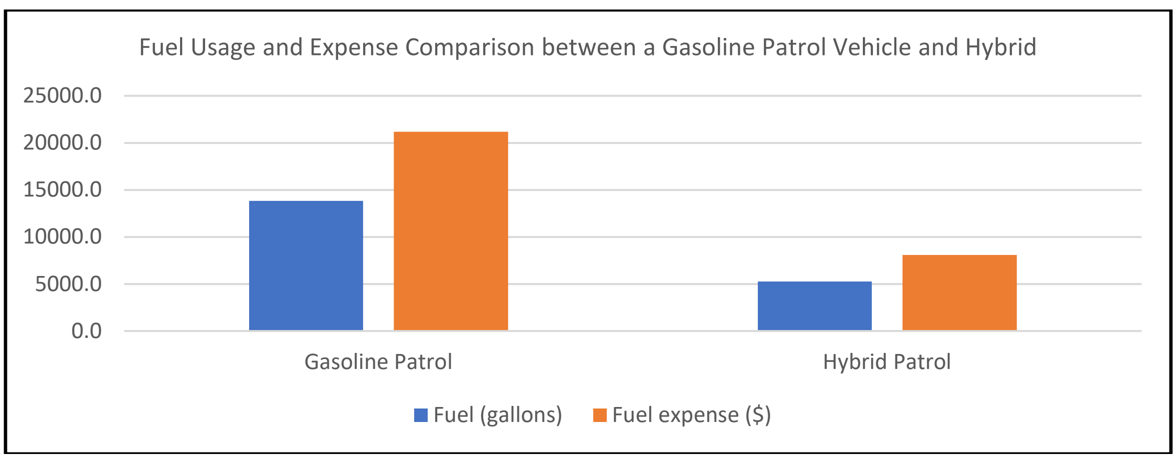
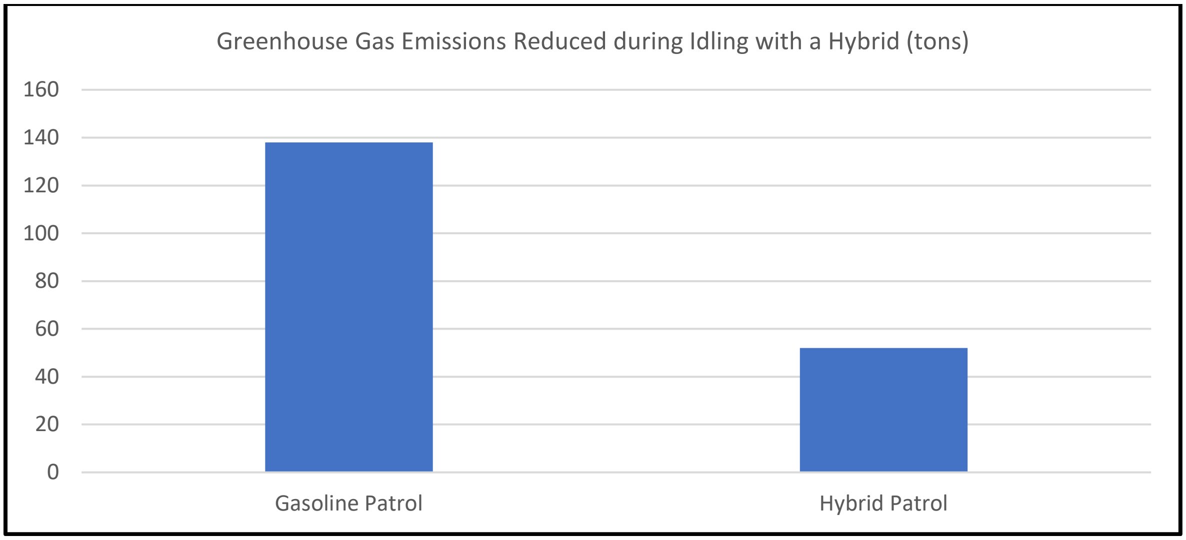


Figure 2: Patrol fleet Emissions Reductions using Hybrids



By switching to hybrid technology, the Department could save an estimated 128 gallons of fuel per vehicle annually, reducing wear and tear on the vehicle, and reducing harmful greenhouse gas emissions.

Balancing the Needs of the Fleet

Police vehicles need to be available 24 hours a day, 7 days a week. Additionally, police vehicles may go home with officers, making charging stations more difficult and costly to install. Because of this unique duty cycle, hybrid electric vehicles for now may provide the desired balance of readiness, reliability and emission reductions.

Additional Background

Hybrid Electric Vehicles

Today's hybrid electric vehicles (HEVs) are powered by an internal combustion engine in combination with one or more electric motors that use energy stored in batteries. HEVs combine the benefits of high fuel economy and low tailpipe emissions with the power and range of conventional vehicles.

Help from an Electric Motor

In an HEV, the extra power provided by the electric motor may allow for a smaller combustion engine. The battery can also power auxiliary loads and reduce engine idling when the vehicle is stopped. Together, these features result in better fuel economy without sacrificing performance.

An HEV cannot plug in to off-board sources of electricity to charge the battery. Instead, the vehicle uses regenerative braking and the internal combustion engine to charge. The vehicle captures energy normally lost during braking by using the electric motor as a generator and storing the captured energy in the battery.

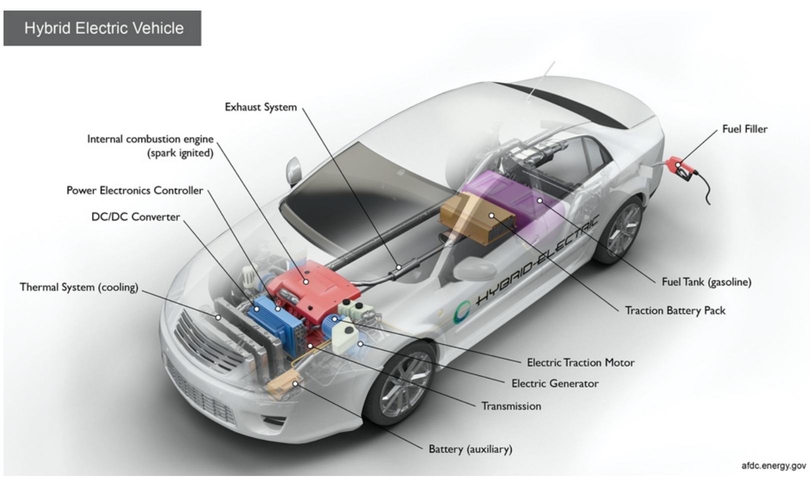


Figure 3: Key Components of a Hybrid Electric Car

HEVs can be either mild or full hybrids, and full hybrids can be designed in series or parallel configurations.

- **Mild hybrids**—also called micro hybrids—use a battery and electric motor to help power the vehicle and can allow the engine to shut off when the vehicle stops (such as at traffic lights or in stop-and-go traffic), further improving fuel economy. Mild hybrid systems cannot power the vehicle using electricity alone. These vehicles generally cost less than full hybrids but provide less fuel economy benefit than full hybrids.

- **Full hybrids** have larger batteries and more powerful electric motors, which can power the vehicle for short distances and at low speeds. These vehicles cost more than mild hybrids but provide better fuel economy benefits.

Plug-in Hybrid Electric (PHEV)

Plug-in hybrid electric vehicles (PHEVs) use batteries to power an electric motor, as well as another fuel, such as gasoline or diesel, to power an internal combustion engine or other propulsion source. PHEVs can charge their batteries through charging equipment and regenerative braking. Using electricity from the grid to run the vehicle some or all of the time reduces operating costs and fuel use, relative to conventional vehicles. PHEVs may also produce lower levels of emissions, depending on the electricity source and how often the vehicle is operated in all-electric mode. For the purposes of this analysis, the AFLEET default assumptions were selected because of the lack of comparable vehicles to the Ford Explorer SUV.

PHEVs have an internal combustion engine and an electric motor, which uses energy stored in batteries. PHEVs generally have larger battery packs than hybrid electric vehicles. This makes it possible to drive moderate distances using just electricity (about 15 to 60-plus miles in current models), commonly referred to as the "electric range" of the vehicle.

During urban driving, most of a PHEV's power can come from stored electricity. For example, a light-duty PHEV driver might drive to and from work on all-electric power, plug the vehicle in to charge at night, and be ready for another all-electric commute the next day. The internal combustion engine powers the vehicle when the battery is mostly depleted, during rapid acceleration, or when intensive heating or air conditioning loads are present.

PHEV batteries can be charged by an outside electric power source, by the internal combustion engine, or through regenerative braking. During braking, the electric motor acts as a generator, using the energy to charge the battery, thereby recapturing energy that would have been lost.

PHEV fuel consumption depends on the distance driven between battery charges. For example, if the vehicle is never plugged in to charge, fuel economy will be about the same as a similarly sized hybrid electric vehicle. If the vehicle is driven a shorter distance than its all-electric range and plugged in to charge between trips, it may be possible to use only electric power. Therefore, consistently charging the vehicle is the best way to maximize the electric benefits.

Because of their less strenuous duty-cycle the FPD may find opportunities to replace some of its Administration vehicles with PHEVs.

Battery Electric Vehicles (EV)

All-electric vehicles (EVs), also referred to as battery electric vehicles, use a battery pack to store the electrical energy that powers the motor. EV batteries are charged by plugging the vehicle in to an electric power source. Although electricity production may contribute to air pollution, the U.S. Environmental Protection Agency categorizes all-electric vehicles as zero-emission vehicles because they produce no direct exhaust or tailpipe emissions.

Light-duty EVs are commercially available. EVs are typically more expensive than similar conventional and hybrid vehicles, although some cost can be recovered through fuel savings, a federal tax credit, or state incentives. A Chevrolet Bolt EV, Nissan LEAF or Ford Mach-E could be good candidates for police administration EV.

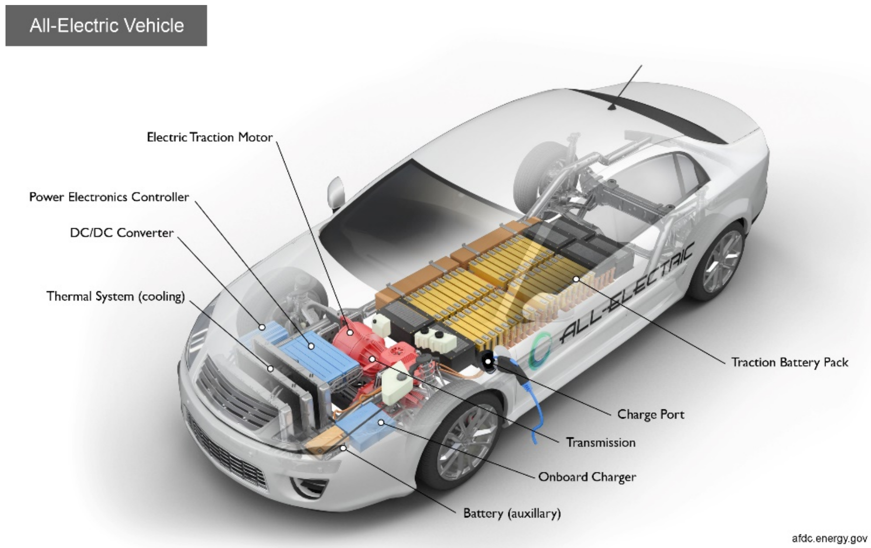


Figure 4: Key Components of an Electric Vehicle

Today's EVs generally have a shorter range (per charge) than comparable conventional vehicles have (per tank of gas). However, the increasing range of new models and the continued development of high-powered charging equipment is reducing this gap. The efficiency and driving range of EVs varies substantially based on driving conditions. Extreme outside temperatures tend to reduce range, because more energy must be used to heat or cool the cabin. EVs are more efficient under city driving than highway travel. City driving conditions have more frequent stops, which maximize the benefits of regenerative braking, while highway travel typically requires more energy to overcome the increased drag at higher speeds. Compared with gradual acceleration, rapid acceleration reduces vehicle range. Hauling heavy loads or driving up significant inclines also has the potential to reduce range. For the purposes of this analysis, the AFLEET default assumptions were selected because of the lack of comparable vehicles to the Ford Explorer SUV.

The FPD may find opportunities to replace some of its Administration vehicles with EVs. Because of their less strenuous duty-cycle and the ability to return home each day to re-charge these vehicles may be the best candidate for electrification.

For PHEVs and electric vehicles additional infrastructure will be necessary. These electric police vehicles are designed to charge on a J1772 standard electric vehicle chargers operating at medium amperage. While equipment for medium amp electric vehicle chargers are currently listed at between $200 to $1,200 from many vendors, the installation, wiring, conduit, and appropriate siting of the charger may represent a project of far greater cost. For pilot projects, ease of installation of equipment and lowering costs with close proximity to available electrical equipment and limited trenching should be considered. A rule of thumb is 1 charging station for every 3 or 4 vehicles, but due to the unique duty cycle of police vehicles more charging stations may be required.

An example of a portable 15-amp level 1 electric vehicle charger which would charge vehicles at up to 1 kWh. All EVs come equipped with this equipment.

An example of a wall or pedestal mounted 40-amp level 2 electric vehicle charger capable of charging vehicles at up to 7.7 kWh.

Electricity Sources and Emissions

EVs and PHEVs running only on electricity have zero tailpipe emissions, but emissions may be produced by the source of electrical power, such as a power plant. In geographic areas that use relatively low-polluting energy sources for electricity generation, PHEVs and EVs typically have a well-to-wheel emissions advantage over similar conventional vehicles running on gasoline or diesel. Fredericksburg electricity profile is 37% nuclear, 35% natural gas, 19% in coal. The production of Fredericksburg's electricity produces 21.5% less carbon dioxide than the national average, making transportation electrification even more attractive.

Figure 5: Electricity Fuel Mix & Emissions, Fredericksburg, EPA Power Profiler.

About VCC

Virginia Clean Cities at James Madison University (VCC-JMU) is a university hosted government- industry partnership designed to promote healthful air through the reduction of petroleum consumption in the transportation sector by advancing the use of alternative fuels and vehicles, idle reduction technologies, hybrid electric vehicles, fuel blends, and fuel economy. Virginia Clean Cities is one of nearly 100 Department of Energy (DOE) sponsored coalitions across the U.S. that help meet the objectives of improving air quality, developing regional economic opportunities, and reducing the use of imported petroleum. Virginia Clean Cities was incorporated in November 2001 as a 501 (c) (3) non-profit corporation.