Electrify GTPD

The Feasibility of Electric Pursuit and Patrol Vehicles

Ford Pro Mustang Mach-E AWD Pilot Vehicle

Electrify GT

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I. Introduction

As concerns over carbon emissions have grown over the last two decades, automakers have increased their low-emission vehicle offerings. The advent of high-performance, competitively-priced electric vehicles (EVs) has redefined the capabilities of commercially available vehicles. Notably, instant torque and a low center of gravity make some EV perfect for pursuit while the quiet, emissions-free driving lends to low speed patrolling. Given the performance characteristics and potential for cost savings endemic of EVs, they are well-suited for campus patrol and pursuit use in the Georgia Tech Police Department fleet.

II. Electric Pursuit Vehicles

In recent years, police departments across the country have begun experimenting with adding electric patrol vehicles to their fleets. In our research, we were able to find six departments that have run pilot electric vehicle programs. Of these, we have raw performance data from the Michigan State Police, and cost benefit analyses from Fremont Police Department (CA) and Brookhaven Police Department (GA). Across all six departments, five different models of EV were explored, and a summary of these can be found in Table 1.

Table 1. Summary of Police Department EV Pilot Programs

Department	EV Model	Condition	Number
Brookhaven, GA PD	2015 Tesla Model S	Used	1
Michigan State Police	2021 Ford Pro Mustang Mach-E	New	1
NYPD	Tesla Model 3[1]	New	1
Bargersville, IN PD	Tesla Model 3[1]	New	5
Fremont, CA PD	2014 Tesla Model S 85kWh 2020 Tesla Model Y	Used New	1 1
Westport, CT PD	Tesla Model 3[1]	New	1

Electric Pursuit/Patrol Vehicle Frontrunners

Tesla Model 3 Standard Range Plus

The Model 3 is Tesla's cost competitive performance sedan. It boasts front and rear cargo space, a high top speed, quick acceleration, premium safety features, and high maneuverability all for the price of a Ford Utility Interceptor. Due to its range and price,

[1] Model year unavailable

many of the departments transitioning to electric vehicles have used the Model 3 as a pilot car. We believe it can replace the current sedans such as Dodge Chargers, Ford Crown Victorias, and Ford Tauruses while providing a high return on investment.

Tesla Model Y Long Range

While not fully analyzed in this report, Tesla's more affordable SUV, the Model Y, has many of the same characteristics that make the Model 3 an appealing option while offering more space. In the reports from Fremont and Brookhaven, the lack of sufficient cargo space and the smaller stature required for comfortable operation hindered the Model S's effectiveness as a patrol vehicle. The Model Y is larger than both the Model Y and Model S, but it also costs $56,990, over $10,000 more than the Model 3.

Ford Mustang Mach-E AWD

Ford's new electric SUV debuted in 2020 as Ford's first premium electric SUV. In September 2021, Ford built an all-wheel-drive police pursuit version of the 2021 model year Mach-E for testing by the Michigan State Police (MSP). This testing was meant to serve as a pilot program for the eventual launch of a Ford Pro Mustang Mach-E for police use. Preliminary data from MSP demonstrate the Mach-E pilot build as a strong competitor to existing police SUVs.

Fremont Police Department Findings

The report obtained from the Fremont Police Department Electric Patrol Vehicle Pilot Program found significant evidence that expansion of the department's electric patrol vehicle program was a feasible option from both a performance and cost standpoint. Fremont PD purchased a used 2015 Tesla Model S for its testing, and detailed findings can be found in the Electric Patrol Vehicle Pilot Program Outcome Report. The key findings of this report were as follows:

1. The Tesla Model S exceeded performance and operational objectives.
2. The Tesla model S withstood the rigors of police use requiring minimal maintenance.
3. Although build cost for the Tesla Model S was slightly higher than conventional police vehicles, maintenance/repair and fuel savings appears to balance or slightly reduce the overall operating cost as projected and compared to the lifespan of a police vehicle.

The report found that the Model S averaged 50% power usage during a typical 11 hour patrol shift, and the vehicle easily accommodated the 40-70 mile average daily range driven by typical patrol vehicles in Fremont. Additionally, the Model S was reported to incur a significant reduction in maintenance downtime compared to current police vehicles (the report found a 7.26% reduction in downtime). The report also estimates a roughly 50% reduction in annual maintenance and repair costs, although the raw data to support this claim are not apparent in the report. Fuel savings were reported to be $4,097 for the one year pilot program. With respect to resale value and lifespan, the Tesla was expected to hold its value twice as well as the average internal combustion

vehicle and the reduced maintenance needs are expected to lead to >5 year lifespan. It's also worth mentioning that officers reported improvements to radio communication due to the lack of background engine noise.

The Fremont report did cite several drawbacks discovered by officers during the pilot program. The Model S has reduced ground clearance which limited its ability to travel over certain types of terrain. Taller drivers reported difficulty entering and exiting the vehicle. The department also found that the Model S, while possessing enough storage space for their needs, lacked the truck space for "trunk organizers" and equipment had to be distributed between the front and rear trunks. The rear seat also posed a challenge to larger prisoners due to its limited space. Finally, the on-campus charging stations took two to four hours to fully charge the Model S from 50%, leading to difficulty redeploying between consecutive shifts.

After determining the program to be a success, the department purchased an additional EV, a 2020 Tesla Model Y, identifying it as an option that most closely satisfied their deployment needs. The report cites the following benefits of the Model Y:

- Lower starting price than the Model S
- Crossover SUV similar to current police SUV platforms
- More rear cargo and storage for police equipment
- Increased range of over 300 miles
- Overall performance similar to Model S
- Added front entry/exit space enhancing driver comfort
- Higher ground clearance allowing vehicle to traverse a greater variety of terrain

The department projects a need for 23 dual port level 2 chargers and 1 DC fast charger for long-term fleet electrification beyond 2023. The size of such charging capacity will be impacted by the size and composition of the EV fleet.

Brookhaven Police Department Findings

Overall, the Brookhaven Police Department had approximately the same findings as Fremont PD with respect to their 2015 Tesla Model S. Detailed findings can be found in their report.

Cost Analysis

Electric vehicles are often associated with higher costs and luxury markets, however, given the falling price of batteries and low operational costs, even electric vehicle options available today offer short and long-term cost savings. The Bargersville, Indiana Police Department, which is currently replacing their gas vehicle fleet with Tesla Model 3s, reports expected fuel savings of $6000/year and a return on investment period of 19 months. Westport, Connecticut saw similar savings in their Tesla Model 3 pilot program.

The savings bear true in real world testing by police departments, confirming assumptions of operational savings.

EV Options vs Conventional Pursuit Vehicles

As seen in Table 2, the Ford Mustang Mach-E and the Tesla Model 3 cost more than standard SUV and sedan options yet see notable improvements in performance. It is also worth noting that the Mach-E MSRP was estimated based on specifications reported by the Michigan State Police in their pilot program testing. The consumer model most closely resembling the performance characteristics reported was the Mach-E GT, a luxury trim package with more power than the standard package. The actual cost of the anticipated Ford Pro Mustang Police Interceptor is likely to be significantly lower given that it will be optimized to the needs of police use, not consumer driving. Additionally Ford's experience in designing purpose-built vehicles for police use may contribute to lower conversion costs.

Table 2. EV Performance and Cost Comparison

Pursuit Vehicle Performance Comparison				
Technology	Battery Electric		Internal Combustion Engine	
Vehicle Options	Ford Mustang Mach-E eAWD	Tesla Model 3 Standard Range Plus	Ford Police Interceptor Utility AWD Hybrid	Dodge Charger Pursuit
Price	$59,995 (estimate)	$41,990	$41,000	$35,555
Range	270 mi (estimate)	262 mi	437/456 mi	333/500 mi
Mileage/Equivalent	93 mpge	142 mpge	23/24 mpg	18/27 mpg
Top Speed	124 mph	140 mph	136 mph	139 mph
0-60 mph	4.03 sec	5.3 sec	7.25 sec	7.17 sec

In Figure 1, we compare the per mile cost of operating four potential police pursuit vehicles during the first five years of ownership. We assumed the vehicles would be driven 13,000 miles annually for our calculations and used cost of ownership data from Edmunds, Kelley Blue Book, and auto repair shop websites to estimate insurance and operational costs. In addition the current federal tax credits for EV purchases were applied, though they are likely to increase pending federal legislation. The capital costs of purchasing the electric vehicles clearly account for the largest share of their cost per mile driven while they cost comparatively little to refuel and maintain. Over time, the cost of maintaining a conventional internal combustion vehicle increases due to the complexity of the mechanical systems within the car. Depending on the manufacturer,

battery electric vehicles can be reliably operated as long as the battery capacity stays above a workable threshold, sometimes lasting as long as 500,000 miles. Therefore, GTPD would be able to keep an electric patrol car for longer without seeing fluctuations in reliability or operational cost.

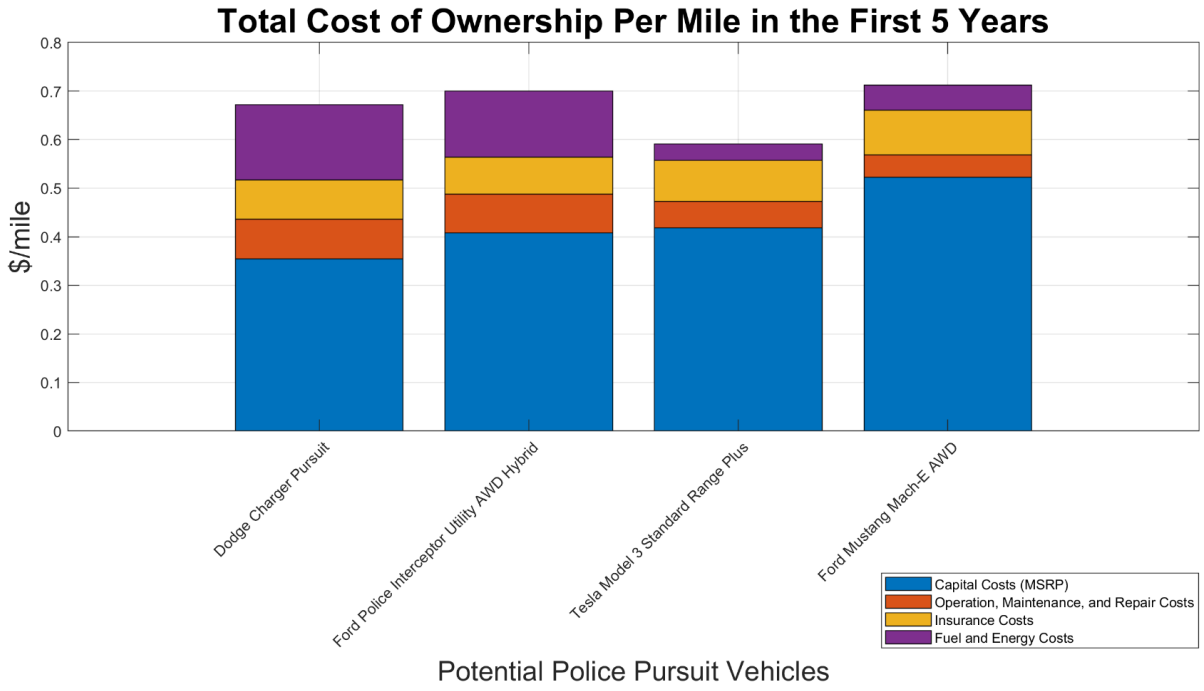

Figure 1. Total Cost of Ownership Per Mile for Four Pursuit Vehicle Options

Conclusion

Premise

Electric vehicle options can meet or exceed the performance requirements for GTPD's patrol and pursuit fleet while saving the Department money in fuel and maintenance costs and surpassing conventional expectations of vehicle longevity.

Vehicle Selection

Given the experience of Ford Pro in customizing models for police work, the Mustang Mach-E shines through as the potential future of the pursuit force. Pricing and ultimate performance of the model chosen for the commercially available Mach-E police interceptor will, however, be a determining factor. The Tesla Model 3 and Model Y also offer solid versatility, speed, and handling. Tesla designs their vehicles with longevity in mind, which may provide the greatest cost savings as maintenance costs were lowest of

the vehicles and manufacturers analyzed. Overall, the Ford Mustang Mach-E and the Tesla Model 3 span the needs of GTPD' fleet.

Charging

The logistics of charging did not disrupt any of the departments analyzed, but installation of Level 2 AC charging stations in GTPD's parking lot is likely necessary. AC chargers cost between $500 and $5000 to install and tak 4-10 hours to fully charge an EV. In the event that a quick charge is ever needed, the installation of a single DC Fast Charger would allow officers to charge most of their battery during a lunch or bathroom break. ABB, Signet, and other manufacturers offer commercially available DC Fast Chargers chargers capable of transferring 50-350kW of power with charge times below half an hour. DC Fast Charging is not a necessity and may prove cost prohibitive.

Timeline

Largely, the timeline for execution is up to the Georgia Tech Police Department. The Tesla Model 3 is on the market and ready for purchase today. The Mustang Mach-E intended for police use has not yet been released, but is highly anticipated to arrive in late 2021 or 2022. GTPD may want to consider a pilot program beginning next year for self assessment of the vehicles before ultimately moving to replace the fleet with electric alternatives. To minimize the cost considerations, replacing each vehicle as it reaches the end of its service life may smooth the transition and still allow GTPD to meet a reasonable date of electrification by 2030.

III. Low-Performance Electric Patrol Vehicles

Low Performance Electric Patrol Vehicles

Low-performance patrol vehicles serve an important role in GTPDs daily operations around campus. They offer the flexibility for intra-campus travel while presenting a more approachable appearance to the campus community. Electrifying such vehicles would reduce the noise and emissions profile of these vehicles, reducing the impact that they have on the interior of campus. Table 3 summaries several low-power electric vehicle options currently on the market.

Table 3. Low Performance Electric Patrol Vehicles

Model	Hisun Sector E1	Massimo MGC2X Crew Golf Cart	Polaris Ranger EV	Polaris GEM e4
Motor	48V AC	36V AC		48V AC
Top Speed		16 Mph		25 mph
Range	42 Miles			10-25 Miles (base) 30-55 Miles ($1,458)
Charge Time	6-10 hours			6-8 hours
Seats	2	4 (2 front, 2 folding rear)	2	4
Roof	Included	Included	$300	Included
Windshield	Included	Included	$370-$470 (front), $260 (rear)	Rear + Front & Rear Defrost $777
Doors	Not Available	Not Available	$2,100	$3,705
Cargo Bed	Included	rear seats fold out, no gate	Included (32"x42"x11.5")	Locking Trunk Box Available $966
Warranty	2 year	1 year parts + labor	1 year	Inquire
Price	$12,499	$10,999	$12,499	$14,660

Among these vehicles, the Polaris GEM e4 stands out as a superior option. It is a four-seat, street-legal, low speed vehicle available through Polaris' commercial brand, GEM. This vehicle offers extensive customization options, beyond those of the three consumer UTVs. It can be customized to include an enclosed cabin, front and rear defrosters, heating and fan, extended battery range, trunk storage, and many other options. Customized with a mid-tier battery upgrade, an enclosed cabin, defrosters, heating, fan system, and locking rear trunk, the GEM e4 costs $22,173 and should be a comfortable and versatile vehicle for officers to patrol inner campus year-round. The vehicle also comes in two additional variants, the e2 and e6, which are two and six seat versions respectively.

Figure 2. GEM e4 with Trunk Box

In addition to its performance, comfort, and utility, we feel that the GEM e4 presents a more approachable design language compared to the aggressive off-road options. The e4 looks friendly and embodies a community-centric model of policing.

Electric Bicycles

Another valuable mode of intra-campus patrol is the bicycle. Bikes are used to quickly traverse campus by students, faculty, and staff alike. They have a smaller impact on pedestrian activity than larger motor vehicles, and they remove physical barriers between patrolling officers and the student population, improving the perceived approachability of officers. We think that electric bicycles are a great low-impact transportation option that reduce the physical burden of patrol on officers.

IV. Sources

Pursuit Vehicles

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Non-pursuit Vehicles

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City of Fremont Police Department

Electric Patrol Vehicle Pilot Program

Outcome Report

March 2019 – March 2020

By: Captain Sean Washington

November 19, 2020

Contents

PILOT PROGRAM TIMELINE

- 2015 – Developed pilot program idea in support of the City's policy to identify and implement clean energy technology
- 2016 – Detailed discussions with City Manager, City Attorney, and Chief of Police
- 2017 – City leadership approved the Pilot Program
    - Various City departments formed a planning committee, including: City Manager's Office, City Attorney's Office, Finance, Public Works (Fleet and Building Maintenance), Community Development (Sustainability), and IT Services
    - Extensive research on various vehicle options (Tesla Model S 85 selected)
        - Visit with Los Angeles Police Department / Los Angeles Sheriff's Department who were initiating a similar pilot program
- Late 2017/Early 2018 – Fremont Police Department (FPD) purchases and accepts delivery of a used Tesla Model S 85
    - 12-month customized build/equipment installation
- 2019 – Vehicle build completed
    - Vehicle tested at Alameda County Emergency Vehicle Operations (EVOC) track
        - Exceeded expectations and performance objectives
    - Deployment date set for March 25, 2019
        - Pilot Program initiated
    - Media and law enforcement interest nationally and internationally
        - Multiple media & community presentation requests

PILOT PROGRAM OVERVIEW

- Program assessed the following:
  - Does the technology meet police application?
  - Is the electric vehicle durable enough for police usage?
  - Is the electric vehicle cost effective?
- Modifications to the Tesla Model S 85 included:
  - Overhead light-bar
  - Rear flashers
  - Wheel well lights
  - Headlight flashers
  - WatchGuard vehicle camera
  - Trunk lighting
  - Panasonic Mobile Digital Computer
  - Push-bumper
  - Prisoner partition
  - Prisoner seat
  - Center equipment console
  - Armor door panels for the driver and front passenger door
- Estimated $30,000 in fuel consumed during the life span of conventional police vehicles. As a result, the project was projected to have cost savings or be cost neutral (based on purchase price of test vehicle and anticipated lifespan)
- On-campus Tesla charging station installed
  - Tesla charging station supplemented by existing on-campus electric vehicle charging stations
- Data gathered daily for six to 12 months, including:
  - Electric vehicle's average range during an 11-hour patrol shift
  - Vehicle's performance during emergency response, safety, and comfort
  - Police Officer comments and input from City's department stakeholders were also collected as an added layer of evaluation
- Ongoing media and community interest

- Government agencies throughout the nation contacted City officials for information regarding the Electric Patrol Vehicle Pilot Program
- Vehicle requested for numerous community events, parades, and presentations

OUTCOMES

Methodology

The Electric Patrol Vehicle Pilot Program ran from March 25, 2019 to March 25, 2020. To calculate the annual cost comparisons between the Tesla Model S 85 and the Ford Utility police pursuit vehicle (PPV), various reports were generated to collect data for each vehicle's actual or average annual cost of maintenance, repair, fuel, energy, and downtime for comparison purposes. What follows is a description of the reports and how the data was collected and presented.

The Tesla Model S 85 actual annual energy cost was derived from Geotab's "Advanced Fuel & EV Energy Report," spanning the pilot program period. To calculate energy consumption and miles driven for the Tesla, City of Fremont Fleet Services used Geotab's fleet management software and a GPS vehicle tracking device. The kilowatt-hour (kWh) energy used for miles driven was converted into kWh per mile. Then, that total was multiplied by the Pacific Gas and Electric (PGE) kWh rate of $0.15 to get the energy cost per mile.

The Tesla Model S 85 average annual maintenance and repair costs were derived from 16 months of data and then converted to an average annual cost from the Faster 4150 Report, "Equip History: Cost and Quantity Detail Report." The yearly average maintenance and repair costs for the Tesla were calculated using data from the 16 months the vehicle has been patrolling, including the pilot program period.

The Ford Utility PPV maintenance, repair, and fuel costs were derived from 58 months of data from 10 2015 Ford Utility PPV vehicles and then converted to an average annual cost for comparison purposes.[1] This data was sourced from the Faster 4150 Report, "Equip History: Cost and Quantity Detail Report." The average annual fuel costs for the conventional Ford Utility PPV was determined from the

[1] The 10 2015 Ford Utility PPV vehicles were selected because they were in service the longest, came very close to the five-year life cycle of the Ford Patrols, and would give a closer true cost of maintenance/repair and fuel.

total gallons consumed and multiplied by a three-year average fuel cost of $3.00/gallon.

The Tesla Model S 85 actual downtime, presented in both annual percentage and days, was derived from one year of data spanning March 2019 to March 2020 from the Faster 4309 report, “Downtime-Detail Report.”

The Ford Utility PPV average downtime was derived from the same downtime report spanning three years of data from July 2017 to July 2020. This data was then converted to average annual downtime percentage and days. The downtime data was collected from all PPVs existing at this time, with vehicle models including Chevrolet Tahoe, Chevrolet Caprice, and Ford F150.

The actual and average annual maintenance, repair, energy, fuel, and downtime data for the Tesla Model S 85 and Ford Utility PPV are shown side-by-side for comparison purposes in the chart on page 8.

Outcome Summary

The Pilot Program clearly established that an electric patrol vehicle is a feasible option for our City's police department. The Pilot Program affirmed the following information:

1. Does the technology meet police application?
    - Results: The Tesla Model S 85 exceeded performance and operational objectives.
2. Is the electric vehicle durable enough for police usage?
    - Results: The Tesla Model S 85 withstood the rigors of police use requiring minimal maintenance.
3. Is the electric vehicle cost effective?
    - Results: Although build cost for the Tesla Model S 85 was slightly higher than conventional police vehicles, maintenance/repair and fuel savings appears to balance or slightly reduce the overall operating cost as projected and compared to the lifespan of a police vehicle.

The chart below lists data derived from the pilot program and beyond as compared to calculated annual averages for a standard gas Ford police pursuit vehicle (PPV):

Factors	2014 Tesla Model S 85	Gas Ford PPV
Vehicle Cost	$61,478.50[2]	$40,500
Standard Equipment Build Cost	$35,000*	$35,000
Modifications Above/Beyond Standard Equipment Build Cost	$6,774.48*	$0

[2] Tesla and City of Fremont Motor Vehicle Purchase Agreement on December 13, 2017

OEM Range	265 miles (85kWh battery)	344 miles (18.6 tank cap)
Actual Annual Energy/Avg. Annual Fuel Cost	$1,036 *Cost of energy consumed while charging*	$5,133 *Calculated assuming $3.00 per gallon*
Avg. Annual Repair/Maintenance Cost	$4,865	$2,915
Actual Annual Costs of Energy/ Avg. Fuel and Maintenance/Repair Costs	**$5,901**	**$8,048**
Avg. Annual Maintenance Downtime	39.125 Days (10.72%)	66 days (17.98%)
Avg. Annual Operational CO2 Emissions	0 lbs.	42,198 lbs.

**Some costs were donated as part of the Pilot Program.*

After careful review, the Pilot Program was determined to be a success. The police patrol electric vehicle met the needs of police services.

Deployment Benefits

- Performance
    - The Tesla Model S 85 met or exceeded expectations often demonstrating superior performance when compared to gas-powered police vehicles.
    - Due to the vehicle's performance, Police Officers reported an enhanced feeling of safety and control when responding to emergency calls for service.
    - Police Officers reported a reduction in anxiety and stress when responding to emergency calls for service due to fewer engine noises.
    - Police Officers reported improved radio communication due to the lack of background engine noise.
- Range and Charging
    - The Tesla Model S 85 averaged **50% power usage** during a typical patrol shift (11 hours).
    - The 265-mile range of the Tesla Model S 85 easily accommodated the 40-70-mile range that patrol vehicles drove on average per day.
    - These results provided confidence in the ability to deploy an electric vehicle (with similar range) for a standard 11-hour patrol shift.
    - Electric vehicle technology was reasonably managed utilizing available on-campus charging stations.
    - FPD currently has charging infrastructure in place to support additional electric police vehicles. Capacity, however, will be limited until expansion of charging stations is achieved.
- Durability
    - The vehicle withstood the rigorous operational demands associated with policing a mid-sized municipality.
    - City's Fleet Maintenance staff reported significant reduction in repairs, maintenance, and downtime over the course of one year when compared to current police vehicles. Due to this reduction, the Tesla Model S 85 was able to remain in service more consistently (**27 more days** than a conventional PPV).

- It is expected that the Tesla's average annual maintenance and repair costs will decrease over time as more data is available and the sample period is extended, with a roughly 50% reduction (approximately $2,910).

- Fuel Costs and Sustainability
    - Over the course of the one-year Pilot Program, the Tesla Model S 85 reduced the cost of fuel that would have been required for a traditional gas-powered police vehicle by **$4,097**.
    - Although only one vehicle out of a fleet of over 60 vehicles, the Tesla Model S 85 reduced greenhouse emissions produced annually by FPD.
    - The program demonstrated the effectiveness of electric vehicles in helping the City of Fremont meet its goals to reduce 2005 levels of GHG emissions by 55% by 2030 and achieve long-term carbon neutrality by 2045.
- Re-sale Value of the Model S
    - The total cost of ownership (TCO) over a five-year period was calculated for the Tesla Model S 85 at $132,758 and the Ford Utility Interceptor at $115,740 factoring in upfront costs such as purchase price and modification, miles driven, fuel/energy costs, and maintenance costs. However, the TCO for the Tesla Model S 85 will likely decrease over time as more data is collected and the sample period is extended. Additionally, the TCO will decrease if the vehicle exceeds 5 years of service as is projected.
    - The Tesla Model S 85 appears to **hold its value twice as well** as the average internal combustion engine (ICE) vehicle[3].
    - One study calculated the average five-year depreciation of Tesla Model S 85 to be 61.7%.[4] Taking the depreciation to be 80% after seven years, to account for the additional age and hard driving in a police application, would decrease the TCO by about $12,000-$13,000.

[3] City of Fremont Municipal Fleet Electrification Study May 2020
[4] https://www.iseecars.com/cars-for-sale#section=studies&study=cars-that-hold-their-value&v=2019

    - As the City continues to electrify its fleet, particularly if purchasing Tesla models or other long-range EVs for the Police Department, the potential higher resale value may reduce the TCO compared to ICE vehicles.

- Expected Lifespan
    - Initial data has indicated that the reduced maintenance needs of the Tesla Model S 85 will likely result in an expected lifespan of longer than five years. However, this assumption is still being proven through real-world application.

Deployment Challenges

- The Tesla Model S 85 has low ground clearance which reduces its ability to traverse certain types of terrain.
- Taller drivers of 6' or above reported the position of the Tesla Model S 85's "B pillar" made it more difficult to enter/exit the vehicle when compared to traditional Ford SUV police vehicles.
- The on-campus charging stations required two to four hours of charging to reach a full charge when battery power was at 50% or less. This created a challenge to redeploy the vehicle rapidly between consecutive patrol shifts.
    - While the on-campus Tesla charging stations were adequate for the Pilot Program, a Supercharger would be preferable to reduce the amount of time needed to redeploy the vehicle after the conclusion of a patrol shift.
- Police equipment storage was adequate in the Tesla Model S 85; however, a larger rear space would be preferred to allow for "trunk organizers" to be placed in a single location. The Tesla Model S 85 utilized the front and rear areas to accomplish storage needs which was not an ideal configuration.
- The rear seat (prisoner barrier) in the Tesla Model S 85 posed a challenge for larger prisoners due to the limited space.

RECOMMENDATIONS AND FUTURE PLANS

Though data garnered from the Electric Patrol Vehicle Pilot Program, the Fremont Police Department has concluded that it was a success and provided significant evidence that expansion of electric patrol vehicles is a feasible option.

Further, TCO calculations that were derived from the 388 City vehicles studied[5] indicated that EV replacement results in $3,156,000 of savings to the City over the next 20 years, with $2,457,000 of these savings directly related to Police vehicle replacement. Additionally, data from the City's current inventory of non-electric vehicles' greenhouse gas (GHG) emissions demonstrated that electrifying the fleet could reduce its GHG impact by 53% by 2030.

In determining the next EV to purchase, the FPD analyzed both the benefits and challenges that have been experienced with the Tesla Model S 85. Though the Tesla Model S 85 is cost-effective, energy-efficient, and a superior patrol vehicle when compared to gas vehicles, it lacks space for larger drivers and passengers, as well as sufficient rear storage for police gear.

Recently, various other car manufacturers have made significant progress in EV technology. For example, in 2021, Ford will be producing a vehicle with similar performance and specifications as the Tesla Model S 85. However, as it stands, Tesla currently remains the leading manufacturer that meets the needs of Fremont's policing environment.

To date, the FPD has already acquired two out of the three additional electric/hybrid patrol vehicles it has budgeted for the last two fiscal years: the 2020 Tesla Model Y (purchased for $57,126.83[6]) and the 2021 Ford Utility Hybrid PPV (purchased for $48,223). The third vehicle has not been purchased yet, as the City is considering a variety of car manufacturers and vehicle options prior to moving forward with this investment.

[5] City of Fremont Municipal Fleet Electrification Study May 2020
[6] Tesla and City of Fremont Motor Vehicle Purchase Agreement on July 20, 2020

The Tesla Model Y was identified as a vehicle that most closely satisfied its deployment needs and addressed many of the challenges noted in the assessment of the Tesla Model S 85 vehicle tested in the Pilot Program.

Benefits of the Tesla Model Y include:

- Lower starting price
- Crossover SUV similar to current police vehicle SUV platforms
- More rear cargo and storage for police equipment
- Increased range of over 300 miles
- Overall performance similar to Tesla Model S 85
- Added front entry/exit space enhancing driver comfort
- Higher ground clearance allowing vehicle to traverse a wide variety to terrain

Additionally, seven 2020 Ford Utility Hybrid PPVs and seven more 2021 Ford Utility Hybrid PPVs are being added to the FPD fleet to replace existing patrol vehicles that are at the end of their lifespan, funded by the City's overall vehicle replacement budget.

The City is evaluating the feasibility of a larger scale replacement of fleet vehicles with EVs over the coming years via the Municipal Fleet Electrification study cited earlier this report[7]. This study, funded through a Bay Area Air Quality Management District Climate Protection grant, identifies upfront costs, long terms savings, GHG emissions reductions calculations, and EV charging infrastructure needs associated with an EV fleet and provides recommendations to the City on possible next steps. The project team has developed a website, https://evfleet.tools/, to share resources for other public agencies wishing to conduct a similar analysis.

Looking to the future, 23 dual port level 2 chargers and 1 direct current (DC) fast charger are projected to be needed at the Fremont Police Department complex to accommodate long-term fleet vehicle electrification into 2023 and beyond.

While the added cost of EV charging infrastructure was not included in the vehicle TCO, it will be considered as a separate infrastructure upgrade cost.

[7] City of Fremont Municipal Fleet Electrification Study May 2020

The study is now further evaluating options for EV charging infrastructure, including what costs would be for transitioning EV charging infrastructure to existing or new onsite solar photovoltaic systems and adding battery energy storage options. Funding for charging infrastructure is being evaluated as well, such as grants that would support its expansion within the FPD campus.

APPENDIX

The History of the Fremont Automobile Industry and the Fremont Police Department's Green Energy Initiative Timeline

- 1962 – The General Motors Fremont Assembly line is built.
- 1997 – The Fremont Police Department (FPD) begins to patrol using the Crown Victoria.
- 2009 – The FPD purchases two Ford Escape Hybrid vehicles and five 2009 Toyota Prius vehicles.
- 2010 –The GM Fremont Assembly line closes; Tesla Motors announces they had purchased part of the GM plant.
- 2011 – The FPD deploys nine Ford Escape Hybrids for CSO fleet; FPD discontinues use of the Crown Victoria.
- 2012 – The City of Fremont begins to implement the Climate Action Plan with the goal of reaching 25% greenhouse gas emission reductions from a 2005 baseline by the year 2020.
- 2016 –The FPD deploys five Ford Fusion Hybrids for command staff and admin Lieutenants.
- 2017 – The FPD purchases and deploys two additional Ford Fusion Hybrid Plug-Ins.
- 2018 – The FPD purchases and deploys one additional Ford Fusion Hybrid Plug-Ins for command staff; All Chief, Captains, and Administrative Lieutenants are driving hybrid vehicles; Tesla vehicle purchased.
- 2019 – The 2014 Tesla Model S 85 begins to patrol along with the 2019 Ford Fusion Police Responder PPV.
- 2020 – The Fremont Police Department shares findings from the nation's first Electric Patrol Vehicle Pilot Program.

The Fremont Police Department's Current Hybrid Fleet

- 9 Ford Escape Hybrids for Community Service Officers
- 9 Ford Fusion Hybrids for Admin Lieutenants
- 3 Ford Fusion Hybrid Plug-Ins for Chief and Captains
- 5 Toyota Prius Vehicles for Admin assignments
- 1 2019 Fusion Hybrid Responder PPV
- 1 Tesla Model S 85
- 1 Tesla Model Y

- 7 2020 Ford Utility Hybrid PPVs
- 8 2021 Ford Utility Hybrid PPVs

Additional Sustainability Facts from the Fremont Police Department

- The City's General Plan vision is for Fremont to serve as a national model of how an auto-oriented suburb can evolve into a sustainable, strategically urban, modern city.
- The City's Robert Wasserman Police Complex has 872 kW of solar carport structures installed onsite, providing clean and renewable electricity to the facility and to the electric vehicle as well as saving the City money on its electricity and vehicle operation bills.
- With all of Fremont's electricity supply coming from either onsite renewable solar power or 100% carbon-free, grid-based electricity through East Bay Community Energy (EBCE), each police vehicle that is replaced with an EV will completely zero out the greenhouse gas emissions associated with that vehicle's operation.

The Fremont Police Department Police Patrol Vehicle Image Gallery

A fleet of vintage Fremont police patrol vehicles sit outside the Fremont Police Station.

A Police Officer poses with a pedestrian while out on patrol.

A Police Officer smiles next to his police patrol vehicle.

The FPD's 1958 Chevy

The FPD's Tesla Model S 85, complete with modifications

The Tesla Model S 85 is tested ahead of its deployment in 2019.

Electric Vehicle for Police Operations Proof of Concept
(Tesla 2015 Model S Pilot Project)

The purpose of this report is to assess the performance of the City of Brookhaven's fleet in the context of transitioning to a 100% electric / hybrid fleet as part of the Sustainable Brookhaven policy. Specifically, this assessment compared traditional gasoline-powered vehicles to an electric vehicle for strategic fleet investment recommendations. Areas of focus include performance, operating and maintenance costs, and environmental impact.

EXECUTIVE SUMMARY

The City currently expends approximately $228,000 per year on fuel (gasoline), and approximately $50,000 in oil changes and minor maintenance for vehicles across all departments. Approximately 98% of fuel is purchased by the Police Department. Using conservative estimation, the fuel and maintenance costs could be reduced by roughly $200,000 annually if the entire fleet transitioned to electric vehicles. Over the course of a six-year lifespan of an all-electric vehicle fleet, cost savings would be approximately $1.2 million. If the City were to transition all 112 vehicles to all-electric models, the reduction of carbon emissions would be between five million and seventeen million pounds over six years. This equates to planting between 40,000 and 123,000 trees in an urban environment and letting them grow for ten years.[1]

In 2019, the City of Brookhaven developed a strategic framework for sustainability known as Sustainable Brookhaven. It is a way of governing and managing that seeks to avoid and prevent the depletion or permanent damage of Brookhaven's resources. The framework consists of five elements that provide guidance so that the City may act consistently and assist with resource allocation decisions. The five sustainability elements include natural environment, built environment, financial, organizational, and civic governance.

Given the increasing viability of electric vehicles as a fleet platform, Brookhaven is considering options to move toward a more efficient fleet by adoption of electric vehicles (EV) and / or hybrid vehicles. In the interest of reducing expenditures on vehicle fleet fuel and maintenance, and in alignment with the Sustainable Brookhaven framework, the City of Brookhaven purchased a 2015 Tesla Model S to test the suitability of an electric vehicle for police operations. Note: The selection of the pre-owned Tesla Model S was not from a perspective that the City is seeking to transition

[1] Carbon emissions are based on estimations for two sample vehicles measured by Georgia Power. Number of trees is calculated based on EPA metrics, assuming one tree can offset ~0.06 metric tons of carbon. See **Appendix Exhibit H** for breakdown.

to Tesla specifically, but the pre-owned Telsa Model S was the most operationally-compatible model for police patrol operations at the time of this pilot study.

The City of Brookhaven has 112 fleet vehicles, the vast majority of which (roughly two-thirds) are utilized for police patrol purposes. Police officers have individually assigned vehicles and are allowed to take their vehicles home. Patrol officers spend a large portion of their shifts working in their vehicles. As Brookhaven looks to future fleet investments, it has measured data on gasoline-powered sedans and SUVs to compare with the all-electric Tesla Model S.

The City has a relationship with Georgia Power based on the mutual interest of optimizing natural resources. When Brookhaven began considering EV options, Georgia Power assisted in data collection and analysis by providing three telemetry devices to collect detailed usage data. Beginning in March 2019, the City began a detailed review of fleet usage and comparison of different vehicle types.

After monitoring and analyzing the usage and performance of various vehicle types, it is apparent that an operational cost savings of 70% or more could be achieved through the usage of electric vehicles rather than traditional gasoline-powered vehicles.

While the operating savings are significant, the EV market does not have an all-electric platform presently suitable for police patrol operations. A Tesla Model S is not designed to be a fleet vehicle or utility vehicle, and presents some difficulties as such. Its unique aerodynamic design made mounting lights and other police auxiliary equipment a challenge, and the low seat and roof line would make it impractical for a driver of large stature. Though the car is spacious enough for equipment, having a front and back trunk, the backseat is not suitable for transporting prisoners. Due to proprietary issues and the newness of this vehicle as a fleet option, outfitting the car took longer than expected. The delay between delivery to readiness for service was approximately five months. Despite these issues, the Tesla performs as a superior vehicle in speed and maneuvering, and has not demonstrated a lack of battery life for a full 12-hour patrol shift.

The Tesla Model S is a good option for some police purposes, though not an ideal choice for patrol operations, which is a bulk of the City fleet. Given the current market options available, all-electric vehicles should be considered for administrative purposes in the near term to achieve fuel savings and a reduction of the City's carbon footprint. Considerations for all-electric or hybrid patrol vehicles should be revisited regularly as the EV market evolves to offer mission-specific models.

INTRODUCTION: BROOKHAVEN'S VEHICLE FLEET

Currently, the Brookhaven fleet consists of 112 vehicles, with 101 in the Police Department. About 80% of the Police Department vehicles are Ford Taurus or Ford Explorer models **(Exhibit A)**.

The City uses Fleetio and Networkfleet fleet management software. Within these systems, vehicles are categorized as listed below. Some vehicles are unassigned and used as spares when other fleet vehicles require repairs or maintenance, or as shared pool vehicles, as in the case at City Hall.

Group	Number of Vehicles
Patrol	63
Investigations	14
Police (Administrative)	14
Support Services	7
K-9 Patrol	2
Citizen Patrol	1
Parks & Recreation	3
City Hall (Community Development)	5
City Hall (Administrative)	3
TOTAL	**112**

City vehicle replacement policy recommends police patrol vehicles are replaced after 100,000 miles or five years in service. When these vehicles are removed from patrol service, they can be repurposed and utilized by other City departments. Brookhaven has used Ford vehicles out of convenience, affordability, and suitability.[2] Additionally, the City purchases all its vehicles via a competitively bid state contract. Outfitting a police patrol vehicle costs approximately $12,000 including installation of decals, window tint, lights, sirens, radios, computer, prisoner transport screens, etc.

Fuel Costs and Vehicle Usage

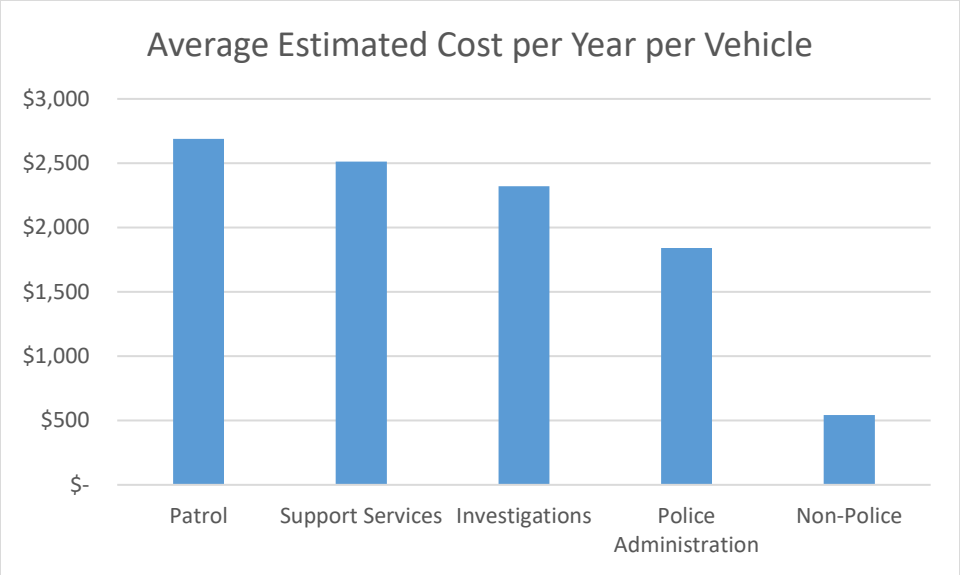
Brookhaven police officers in the Patrol Division drive between 35 and 100 miles each 12-hour shift (includes commuting mileage). On average, the gasoline-powered police vehicles get 15 miles per gallon (mpg) and SUVs get 12 MPG.[3] In 2018 and 2019, the annual fuel cost across all departments was approximately $228,000.[4]

Based on 2019 gasoline expenditures of $227,787, the average per vehicle gasoline cost was $2,034. This number encompasses spare vehicles as well as pool administrative vehicles, which are used infrequently or for very short trips, and does not accurately reflect average fuel cost per vehicle group; therefore, it is important to recognize that police patrol vehicles are responsible for the higher fuel costs to the City.

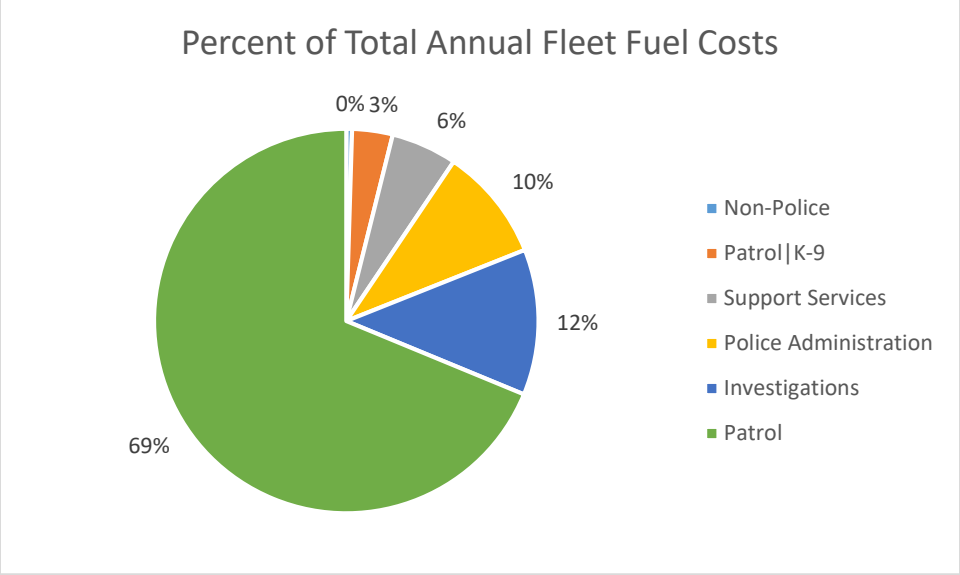
[2] There are a limited number of widely accepted police patrol vehicle platforms. Since the City's inception the Police Department has utilized the following models as the primary patrol operations vehicle: Chevrolet Impala, Ford Taurus; Ford Explorer.

[3] Networkfleet data over the past year

[4] Paid to WEX Bank for fuel card purchases per Tyler (financial management system): 2018: $227,739, 2019: $227,787 with non-Police Department gasoline fuel purchases representing about 2% of the total



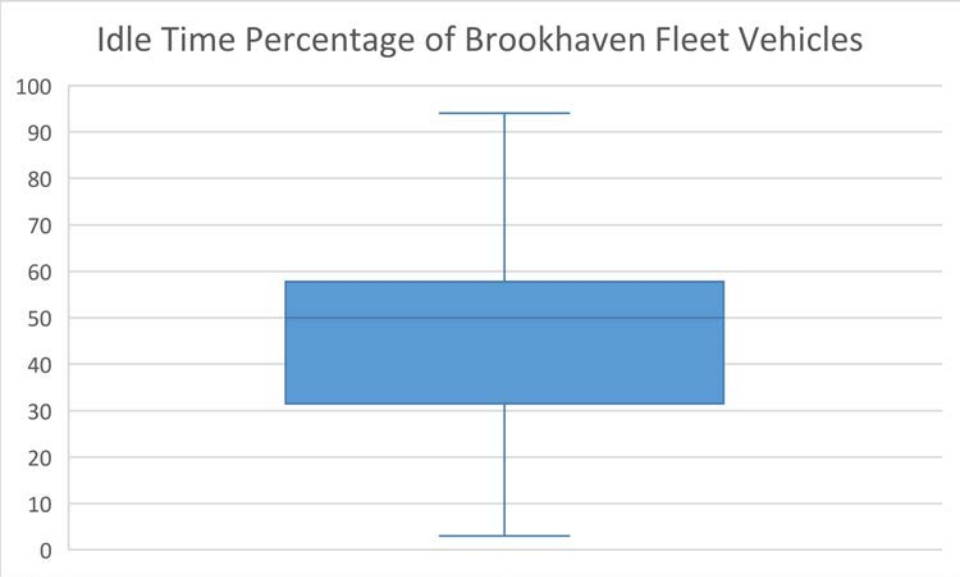
Data provided from vehicles tracked over a 12-month period indicates that Brookhaven police vehicles have an average fuel cost of $2,598 per year, and of the fifty-eight (58) patrol vehicles within that sample, the average is $2,688 per year. See **Appendix** for a note on fuel cost calculation methodology.



As depicted in the two preceding graphs, patrol vehicles have the highest annual fuel cost by usage and represent the largest portion of overall fuel expenditures.

It is important to note that employees using vehicles for specific job-related purposes often lead to idle times much higher than those of personal-use vehicles. This is because they may go from site to site and do paperwork and make calls before and after getting out of their vehicles. Police vehicles need to be pursuit-ready and therefore are not turned off every time an officer exits the

vehicle. Idling consumes approximately one-fifth a gallon of gasoline fuel per hour. Switching to hybrid or all-electric vehicles would reduce or eliminate emissions created when idling.



This box-and-whisker plot divides the numbers into quartiles: the top and bottom lines show the full range of the data points, including the maximum and minimum outliers. The blue box shows half of Brookhaven fleet vehicles are idle between 31% and 58% of the time, with one quarter of vehicles idling between 58% and 94% of the time.

Concerning vehicle maintenance costs, in 2018 and 2019 the City expended approximately $50,000 for oil changes and maintenance on brakes, tires, etc.[5] **(Exhibit B).** When vehicles are undergoing regular service and maintenance, officers must use spare vehicles. This can interrupt their normal operations and require transferring equipment. If the maintenance is quick (i.e., an oil change) there is still an estimated downtime that interrupts an officer's time on patrol duty.

[5] This number represents costs for maintenance only, not collision repair.

TEST PERIOD RESULTS: TESLA

The Tesla began patrol operational service in August of 2019. Note: The vehicle was assessed by the driving instructors at the Georgia Public Safety Training Center on a closed-course track prior to placing in patrol service to ensure the vehicle could be safely driven in emergency operations mode.

Patrol officers work a 12-hour shift, 15 days a month depending on the calendar month and in-service training and court time. The driver assigned the Tesla Model S for the EV pilot study, Officer John Clifford, has logged ninety-four (94) days of data as of March 10, 2020.

Given the starting mileage of 23,864 and the March 10, 2020 mileage of 33,399, and taking into consideration variation in monthly or weekly usage, it is estimated that the Tesla would be used roughly 16,000 to 17,500 miles per year **(Exhibit C).** It should be noted that due to the inability to install an after-market protection shield / cage in the Tesla, Officer Clifford does not do prisoner transports to the DeKalb County jail. With additional miles associated with prisoner transports, the Tesla would have comparable annual mileage to other Brookhaven patrol vehicles.

Using data from a telemetry device supplied by Georgia Power from August through the end of 2019, reports identified that the Tesla is idle 43% of the time.[6] The Networkfleet data Brookhaven uses to monitor vehicle usage indicates other police vehicles average an idle rate of fifty percent (50%) of the time **(Exhibit D)**. When in idle mode, the all-electric Tesla is not releasing carbon emissions like a gasoline-powered vehicle.

The speed and usage were also measured, revealing hard braking[7] and hard acceleration about 25% of the time. The Tesla, like other EVs, has a regenerative braking system which is an energy recovery mechanism that converts its kinetic energy into a form that can be stored. The vehicle tested well in terms of performance, and its low center of gravity allows for quick and safe movement. The increased maneuvering executed by a police officer compared to that of an average driver, and the additional weight of equipment and energy required to run lights and sirens and other police ancillary equipment take a higher toll on the battery, reducing the range from that advertised by Tesla (208-270 miles). A sample study run by Georgia Power in October

[6] The term "idle" for gasoline-powered cars indicates a vehicle is running but not being driven. Teslas, however, automatically stop using energy when they are not being driven and therefore the term "idle" is used here to measure comparable stop times.

[7] Tesla Model S brake pads are estimated to last 200,000 miles.

revealed that the Brookhaven Police Tesla realized 1.75 miles per kWh, much less than the industry standard of 3.48. Despite this, the battery range has not proven to be an issue during a 12-hour patrol shift.

Using the telemetry device, the City monitored energy consumption and concluded the Tesla uses an average of 413 Wh/mi. At a rate of $0.07 per kWh, given the number of annual miles assumed for the Tesla, the cost to provide electricity to the vehicle would be less than $700 annually **(Exhibit E)**, or about one-third the cost of fuel to power an average fleet vehicle.

With patrol vehicles using an average of $2,688 in fuel each year, EV fuel savings would approximate $2,000 annually per vehicle. Using electricity rather than gasoline to power its patrol fleet, City could reduce its fuel costs by 75%, more than $10,000 in the five-year life of a gas-powered fleet vehicle. Georgia Power data suggests fuel savings of 77-80% is achievable.

Although it takes longer to charge a vehicle's battery than it does to fill a gasoline tank, a driver is not required to be present while charging as one is to pump gas. An electric vehicle can be left overnight, and chargers can be shared to service multiple vehicles around the clock.

One concern that was considered when purchasing an EV was that of range anxiety, or fear of the battery running out. This has not proven to be a problem with the Brookhaven Tesla, which has been driven an average of 92 miles daily, with a highest daily total of 166 miles. During the test period, without any change in the daily patrol routine, the lowest remaining battery capacity experienced was 29%. Average starting battery life after charging was 85% and average ending (when the driver begins to charge) is 49%. Note: Charging to over 90% of capacity is not recommended to preserve battery life.

Officer Clifford typically charges overnight at home, and usually leaves for work with an 87-90% charge. By the time the officer arrives at the police station in Brookhaven, the battery life is typically 72-75%. Once at the station, Officer Clifford charges the battery during roll call and pre-shift activities. Additionally, during the shift, Officer Clifford has the opportunity to use one of the 13 charging ports that the City has installed for public use around Brookhaven. While boosting the battery, the officer can complete reports, make phone calls, and perform other administrative duties.[8] When using one of these charging stations, or those made by Tesla, the officer can simply plug in without additional equipment. When using a fast charger that is not made by Tesla, an adapter is needed. Officer Clifford stated that due to the availability of charging stations at his home and around the City, he rarely feels the need to use a fast charger.

[8] Charging literally tethers the officer to a particular location. Officers with gas-powered vehicles typically write reports, return calls, etc. in highly visible areas, increasing the sense of police presence.

TEST PERIOD RESULTS: OTHER VEHICLE MODELS

To compare the all-electric Tesla to current fleet vehicles, the City monitored three other vehicle models throughout 2019. Within the sample were a sedan used for police patrol, a sedan used by an inspector in the Community Development Department, and a police SUV. A summary comparison follows.[9]

Patrol Vehicle #108, 2014 Ford Taurus (March 19, 2019 – July 31, 2019)

Miles logged: 6,528
Days in service: 134
Total fuel consumption: 536 gallons
Idle time percentage: 66%
Idle fuel consumption: 159 gallons
Average MPG: 12
Estimated annual fuel cost to the City: $3,256

Community Development Administrative Vehicle, 2013 Chevrolet Impala (March 15, 2019 – July 31, 2019)

Miles logged: 2,123
Days in service: 138
Total fuel consumption: 176 gallons
Idle time percentage: 60%
Idle fuel consumption: 64 gallons
Average MPG: 12
Estimated annual fuel cost to the City: $1,038

Police SUV, 2019 Ford Explorer (September 1, 2019 – December 22, 2019)

Miles logged: 4,246
Days in service: 112
Total fuel consumption: 385 gallons
Idle time percentage: 79%
Idle fuel consumption: 142 gallons
Average MPG: 11
Estimated annual fuel cost to the City: $2,798

[9] Estimated annual fuel costs are calculated with an assumed cost of $2.23 per gallon, which was the average price of gasoline fuel in Georgia over the past year.

2015 TESLA MODEL S IMPACT AND SUITABILITY

The Tesla is superb in speed and handling, is one of the quietest vehicles on the market, is a zero-emission producing vehicle, and due to its design can have maintenance issues resolved quickly through software adjustments. A regenerative braking system allows for less wear on the brakes and therefore less need for replacements. It has a fraction of the internal parts compared to a conventional combustion engine, resulting in less need for repair and therefore lower expected maintenance costs. The elimination of required oil changes, brake checks, etc. also results in less vehicle downtime and increased officer productivity.

The cost of the pre-owned Tesla was $45,000, purchased with confiscated asset funds (i.e., not local tax revenues). Other EVs have similar benefits and are available at a lower cost. Several police officers and City Hall inspectors have expressed a preference for sports utility vehicles to meet the needs of their jobs in terms of size, power, and space. Currently, all-electric SUV options that would meet the needs of Brookhaven employees are not available at a price point that is practical for purchasing at scale. Hybrids are an option, and new electric and hybrid models are being developed at an increasing rate. The 2020 Police Department budget for vehicle replacements calls for 15 Ford Explorer hybrids. Ford is expected to have an all-electric SUV out by the end of 2020, and the anticipated price point may be within financial consideration.

The upfront acquisition cost of a new vehicle should not be the determining factor when deciding on fleet vehicles. Durability, suitability, reliability, and operating / maintenance costs should be factored into the financial sustainability of the investment. For example, a vehicle purchased at $40,000 would be worth $8,000 at the end of Year 4[10], which may be less than or close to the cost of required maintenance and / or repairs. Prior to 2019, the City had not tracked data on maintenance and repair costs of various vehicles by make, use, and number of years in service. Anecdotal evidence confirms that it would be cost effective to replace some vehicles rather than invest in repairs.

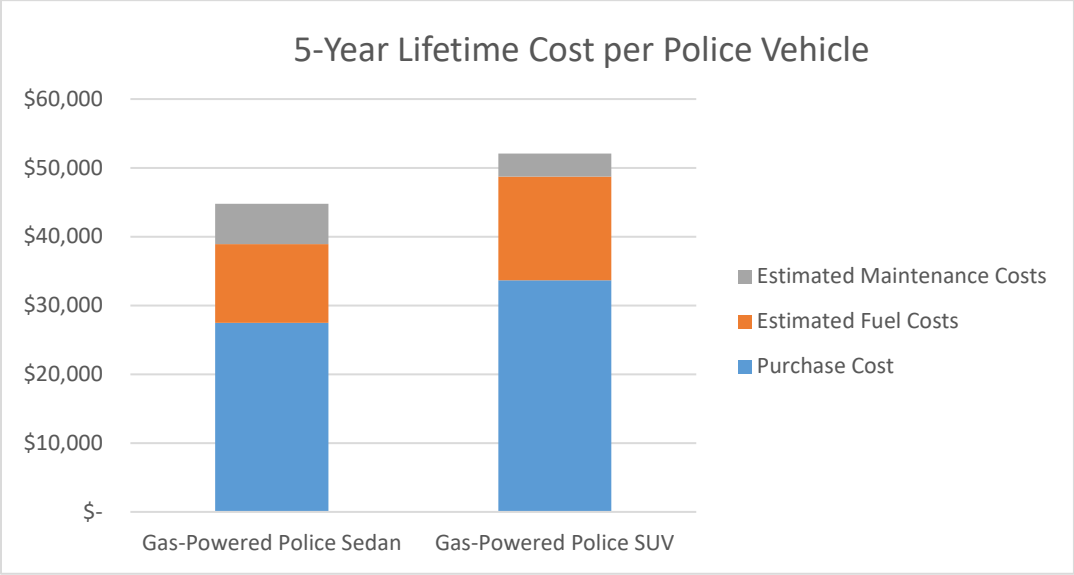
Given that the two police vehicles in the control test surpassed the fleet average in annual fuel expense, the cost savings estimated are conservative figures. Using the conservative maintenance cost estimate referenced in **Exhibit B**, fuel and maintenance can cost more than $13,000 per vehicle over the span of five years. The City has already installed 13 EV charging ports across the City for community use, thus there is no upfront charger infrastructure cost for City fleet conversion to EVs.

In addition to significant fuel and maintenance expenditure savings, there is a significant reduction in the City's carbon footprint associated with fleet operations. Georgia Power estimated the CO2 emissions over five years of the Brookhaven Impala and Taurus models would be 42,908 pounds and 131,963 pounds, respectively. Using these estimates, were Brookhaven to transition to an entirely all-electric fleet, a reduction of between five million and seventeen million pounds of carbon from the atmosphere over a six-year period could be achieved.

[10] The City of Brookhaven accounts for straight-line depreciation over five years.

LIFETIME COSTS

Considering purchase price, and estimated fuel and maintenance costs, the estimated five-year lifetime cost of a typical patrol vehicle is depicted in the following chart. (Costs for vehicle outfitting are not included in the comparison as the amount is the same for each model.)



This chart uses averages for the twenty-six (26) Ford Taurus and Chevy Impala patrol vehicles listed in Fleetio for "Gas-Powered Police Sedan" calculations. All models were 2014 or 2015, and the average manufacturer's suggested retail price (MSRP) is $27,472. Data for "Gas-Powered Police SUV" uses the thirty-two (32) Ford Explorers in Fleetio. All models were 2019 or 2020, and the average MSRP was $33,655. Maintenance costs for the gasoline-powered vehicles are strictly estimates based on historical data reported by drivers and manually uploaded over the past twelve months and likely are an under-representation of actual maintenance costs.[11]

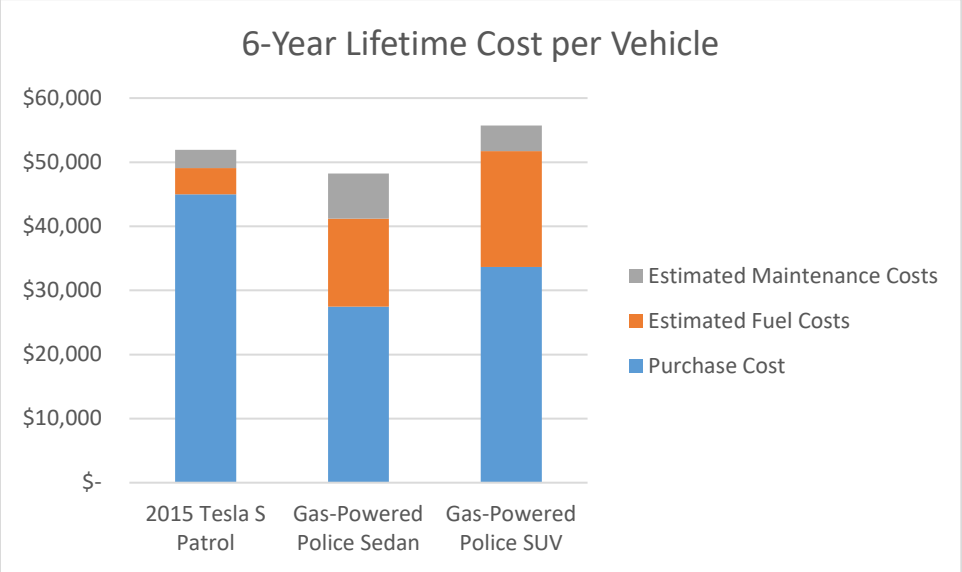
Based on reliability and reduced maintenance of an electric vehicle, serious consideration should be given to extend the anticipated service life of a fleet vehicle to six years and 120,000 miles.

A key reason EVs can be seen as a less popular investment is the cost of replacing the battery; however, battery replacement during the fleet vehicle lifespan should not be necessary. The Tesla Model S battery has an expected longevity of 300,000-500,000 miles, with 90% battery energy capacity after 160,000 miles. This exceeds the 100,000-mile lifespan Brookhaven has for its fleet vehicles, so not only should battery replacement not be necessary, but the capacity of the Tesla to perform could extend its lifespan in the fleet.

Given that a Tesla Model S has a guaranteed battery life of eight (8) years or 125,000 miles, and the expected annual mileage on the Brookhaven Tesla is roughly 17,000 miles, it can be argued

[11] Data provided by Georgia Power comparing maintenance costs of a standard gas-powered vehicle and a 2018 Nissan Leaf over a seven year lifecycle show a total maintenance cost savings of 84%, with only $500 in expected maintenance for the Leaf. See **Exhibit J** for detail.

that the Tesla could remain in the fleet longer than the stated five years. Total lifetime costs for a Tesla to remain in the fleet for six years are less than total lifetime costs for a gas-powered SUV that remains in the fleet for only five years, at $51,928 and $52,064 respectively.



Data used for calculating Tesla costs include: purchase cost of $45,000, electricity fuel costs (calculated in **Exhibit E**), and estimated maintenance costs that were averaged using a variety of sources. See **Appendix** and **Exhibit G** for cost calculation and source information.

EXAMPLES ELSEWHERE

Other cities around the country have started experimenting with EVs, though prior to Brookhaven's Tesla purchase, many jurisdictions were purchasing Nissan Leafs and Chevy Bolts for administrative purposes. The City of Fremont, California began patrol service with a 2014 Tesla Model S in March 2019. Despite having a Tesla manufacturing plant within the city, the delay between the date of purchase to full operation was significant (more than one year). This indicates that modifying a Tesla for police use presents challenges that can be experienced.

The City of Westport, Connecticut recently purchased a 2020 Tesla Model 3 for $52,590, primarily for performance, its five-star crash ratings, and collision avoidance technology.

Several other cities, including Atlanta, are committed to converting to lower or no emissions from their fleets to contribute to their goals of 100% clean energy for municipal operations, in alignment with the United Nations 17 Sustainable Development Goals.

CONCLUSIONS

EVs are cost effective and able to meet police applications, though other EV models that will emerge in the near future that would be more suitable for police patrol purposes than the Tesla Model S.

Officer Clifford finds the Tesla to be a superb police vehicle, and would prefer to continue using it to other vehicles. That being said, the Tesla does not meet some of the basic operational police needs. The biggest issues impeding the Tesla Model S from being a standard fleet police vehicle are the inability to transport passengers in the backseat, the discomfort of the driver's seat for a larger officer wearing full police gear, and the difficulty and time required to outfit or perform maintenance on the vehicle, compared to the ease of using the same vendors who are accustomed to quickly outfit and maintain or repair the models Brookhaven has predominantly used.

Some of the aforementioned deficiencies of the Tesla Model S were known going into the pilot study, but the study was mostly about fuel efficiency and performance. Using EVs can significantly reduce or eliminate carbon emissions, especially for police patrol vehicles with high idle times.

The transition to an all-electric fleet is certainly applicable to the natural environment and financial elements of the Sustainable Brookhaven strategy, but there needs to be careful attention given to the selection of the EV platform for police patrol vehicles from a perspective of operational need (i.e., transporting inmates and comfort) and true fleet availability at scale (i.e., prep time for service readiness and repair times).

APPENDIX

Exhibit A: Police Fleet Vehicles, March 2020

Model	Count
Explorer	43
Taurus	37
Impala Limited	5
Impala	4
F-150	3
Express Cargo	2
Fusion	2
Caprice	1
Escape	1
Model S	1
Transit Passenger	1
UD2000	1
TOTAL	**101**

Exhibit B: Vehicle Maintenance Costs

Vendor	2018	2019
Hi-Speed Car Wash*	$12,723	$3,408
Hi Speed Oil Change	$0	$6,922
Hennessy Ford	$38,030	$40,774
TOTAL MAINTENANCE	**$50,753**	**$51,104**

Maintenance costs do not factor in productivity losses due to vehicle downtime.

*The vendor Hi-Speed Car Wash was divided in the payment system as two separate business entities in 2019. Data here includes only two vendors as they are easily identified for maintenance costs; however, additional charges with any other vendors are unaccounted for in this report.

Exhibit C: Estimated Annual Mileage for Tesla, Calculated Two Ways

Starting mileage August 9, 2019:	23,864
Ending mileage March 10, 2020:	33,399
Estimated annual mileage	**16,263**

Or

Miles driven in 143-day period (August 1 – December 22, 2020):	6,873
Adjusted for 365-day period:	**17,543**

Exhibit D: Networkfleet Idle Time Analysis, March 2019 – March 2020

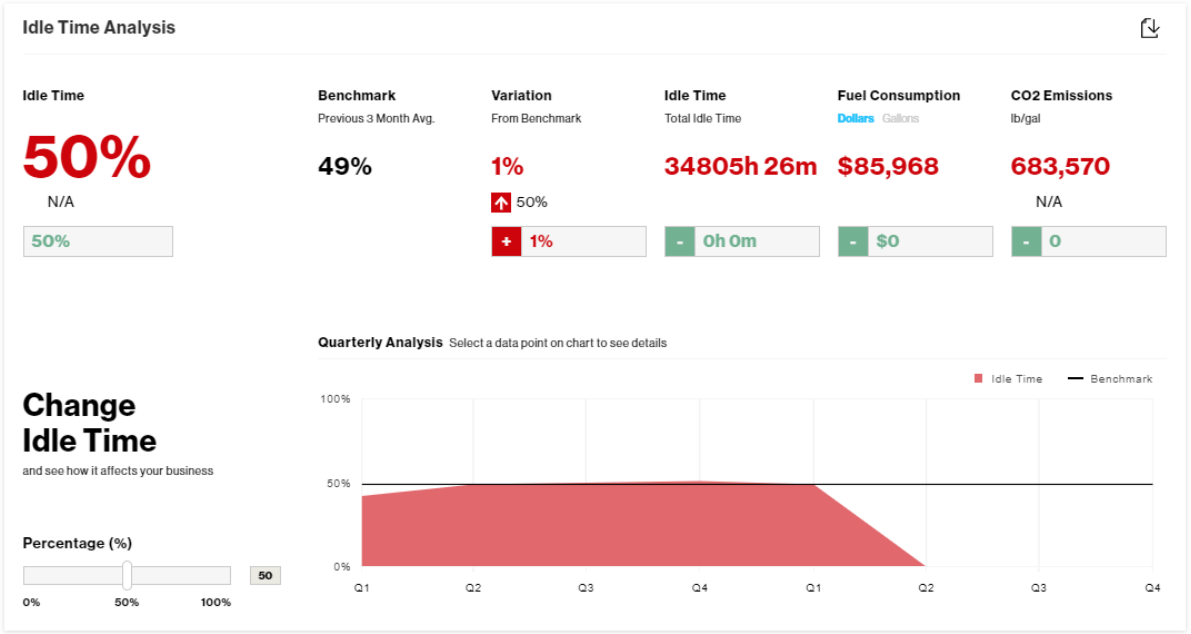


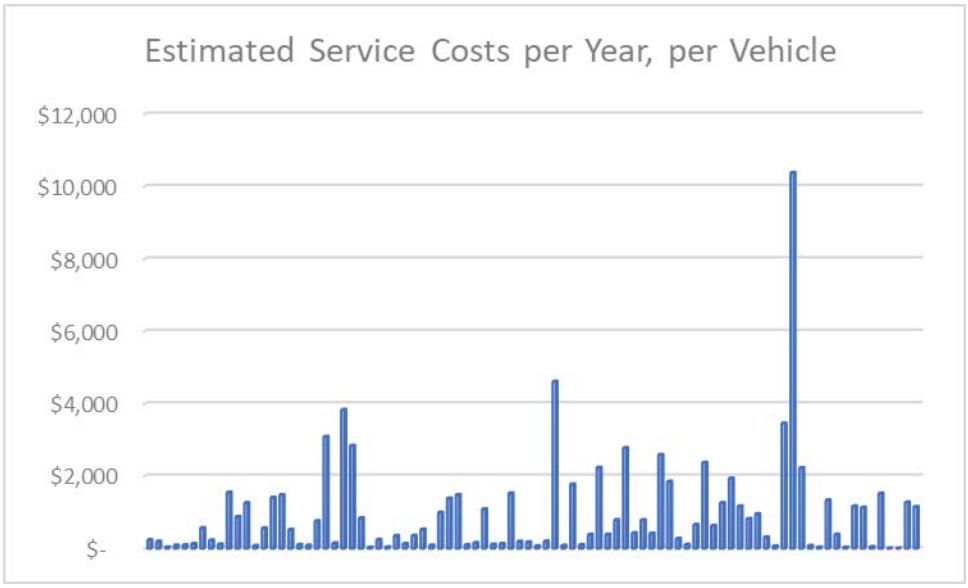
Exhibit E: Estimated Annual Electric Costs for Tesla

Data is extrapolated from a 143-day sample of Georgia Power telemetry report of the Brookhaven Tesla's electricity utilization.

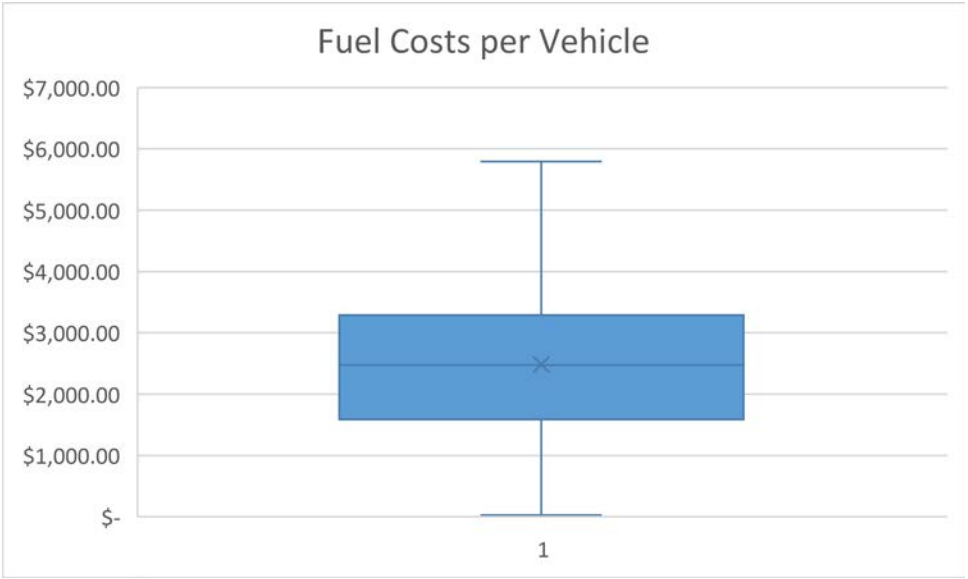
Total kWh used charging per Georgia Power		3,804
Average electricity used per day (kWh)		27
Average electricity used per year (kWh)		9,710
Average electricity cost per year at $0.07 per kWh	**$**	**679.67**

Exhibit F: Numbers Pulled from Fleetio

The following data was pulled from Fleetio. The City of Brookhaven began using this fleet management system in March of 2019 to track maintenance, fuel usage, costs, and other vehicle data points. Due to a lag in onboarding fleet vehicles into the system, and manual inputs of maintenance costs, this data does not fully reflect all vehicle costs the City has incurred over the last twelve months.



Average estimated service costs: $958, using data from 89 vehicles between March 2019 – March 2020. Data is self-reported by drivers and manually uploaded into Fleetio; therefore, this data is likely an underrepresentation of average maintenance costs.



This data reflects 87 vehicles and shows an average fuel cost of $2,481.09 per vehicle. Of the 41 vehicles that were in the top two quartiles, the average annual fuel cost was $3,476.95. For the purposes of this report, the average fuel cost of most relevance is that of the Patrol vehicle group, amounting to $2,688.

Exhibit G: A Note on Cost Calculation Methodology

Not all fleet vehicles use fuel equally. If average gasoline fuel costs per vehicle were calculated by taking the total spent by the City of Brookhaven and divided by the total number of vehicles, the average would be $2,034:

2019 total WEX fuel card purchases per Tyler: $227,787 / 112 vehicles = $2,034

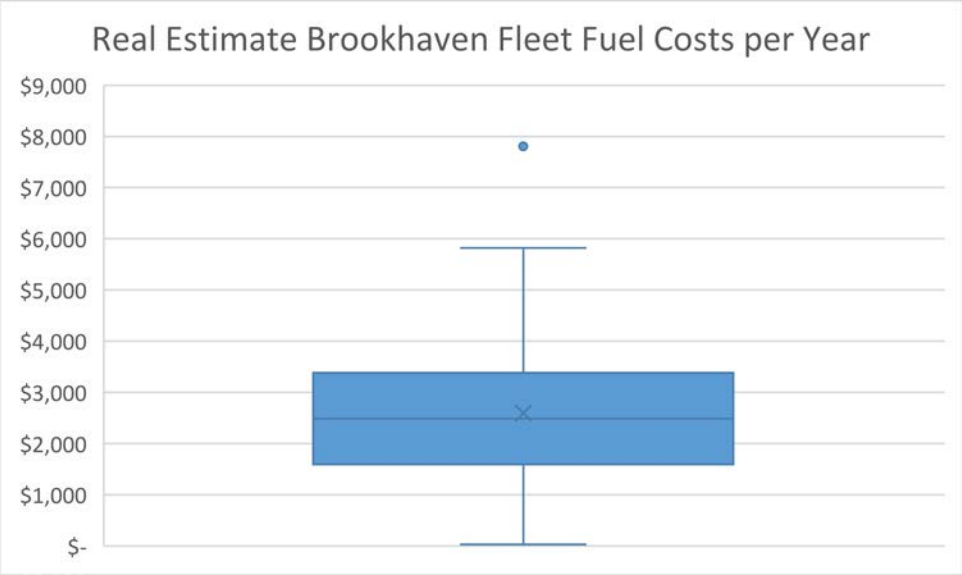
Consider that some vehicles are used for minimal administrative purposes, while others idle on work sites, and others engage in high-speed chases. It is necessary to look at average costs in different ways.

Fleetio fuel expense recorded for 87 vehicles from March 22, 2019 through March 27, 2020 for a total of 34,797 data point days. This data, while extremely helpful, does not create a complete representation of the entire fleet's usage over the course of a year. Estimations were extrapolated where possible, and other vehicles were removed from calculating estimations due to an insufficient number of data points.

Non-police vehicles, which tend to use less fuel, were among those not being logged throughout the year. Of the 112 vehicles registered in Fleetio, only 2 of the 87 which logged fuel costs were associated with City Hall. Those two, for the Fire Division, indicate an average of $548.06 per annum fuel cost per vehicle.

Fleetio shows $215,855 spent from March 2019-March 2020 for 87 vehicles. Not all vehicles were registered and updated for the full year, so a per diem average was calculated. (It indicated a total average expense of $7.12 on fuel per car per day.) Using average per diem calculations to estimate a full year of expense per vehicle, those same 87 vehicles would cost $226,015 per year (quite closely aligned with the actual expense of just over $227,000 in both 2018 and 2019 years).

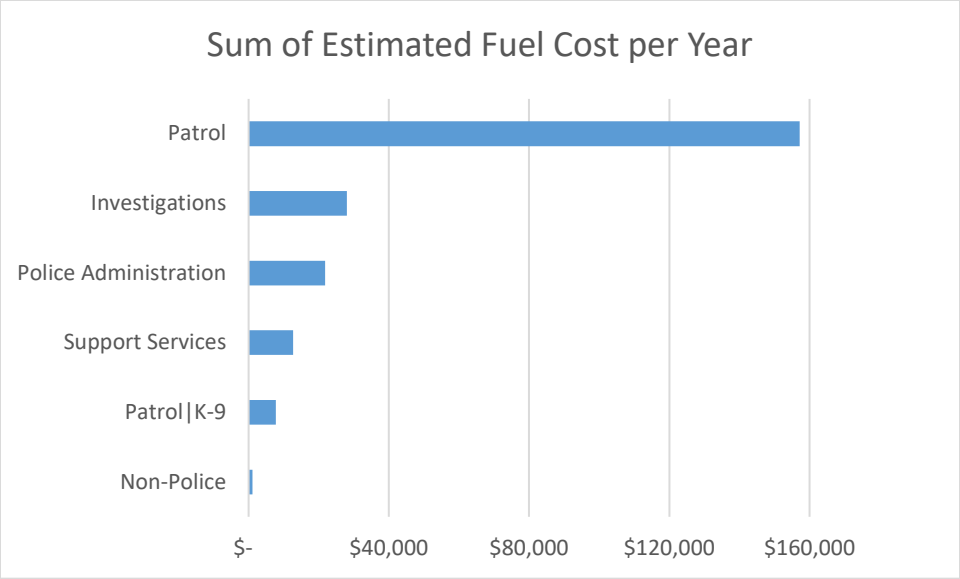
Using the recorded data from 87 vehicles and the per annum estimations, a more accurate representation of Brookhaven fleet fuel costs per year can be seen in the following chart:



The highest and lowest numbers are outliers and should be recognized as not accurate representations of Brookhaven fleet fuel usage.

Highest fuel spend	$	7,806.94
Second highest fuel spend	$	5,818.55
Average fuel spend	$	2,597.88
Median fuel spend	$	2,491.01
Second lowest fuel spend	$	170.36
Lowest fuel spend	$	31.20

Of the 87 vehicles with Fleetio fuel expense data, 58 were in the “Patrol” group. Of these, the average gasoline fuel use cost per day was $7.36, yielding an estimated average of $2,688.22 per year.



Since Teslas are newly designed vehicles, and the City of Brookhaven only has a few months of data-tracking for its proof of concept, maintenance costs are estimated based on analysis of outside information. The number used to determine maintenance costs per year is $475, a price recognized for a full-service Tesla inspection. Typical maintenance costs identified in the research ranged from $1,490 to $2,800 over a five-year period.

Exhibit H: CO2 Emissions and Offset Calculations

	CO2 Emissions over 5 Years, Reported by Georgia Power (lbs)	CO2 Emissions for 112 Vehicles over 6 Years (lbs)	Number of Trees to Offset Emissions over 6 Years, per EPA Calculations
Low Range Estimation, made for 2014 Impala (Administrative)	42,908	5,766,835.20	43,253
High Range Estimation, made for 2014 Taurus (Patrol)	131,963	17,735,827.20	133,023

Exhibit J: (Provided by Georgia Power) EVs Can Reduce Vehicle Operating Costs by 80%-90%

Compare Maintenance & Repair Costs

7 Year lifecycle, Projected Maintenance & Repair

Standard Gas Powered Car

Maintenance & Repair	Year 1 10k-15k	Year 2 20k-25k	Year 3 30k-35k	Year 4 40k-45k	Year 5 50k-55k	Year 6 60k-65k	Year 7 70k-75k	7 Year Lifecycle	Higher Mileage Additions
Oil Changes	$ 160	$ 160	$ 160	$ 160	$ 160	$ 160	$ 160	$ 1,200	$ 80
Air Filter, Engine			$ 35			$ 35		$ 70	$ 35
Air Filter, Cabin			$ 45			$ 45		$ 90	$ -
Fuel Filter			$ 40			$ 40		$ 80	$ 40
Coolant Flush			$ 79			$ 79		$ 158	$ -
Tire Rotation	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 140	$ 40
Brake Pads, Front			$ 150			$ 150		$ 300	$ 150
Brake Pads, Rear					$ 150			$ 150	
Serpintine Belt					$ 125			$ 125	
Thermostat					$ 160			$ 160	
Water Pump, Gasket							$ 225	$ 225	
Spark Plugs, Platinum							$ 145	$ 145	
Coil Pack						$ 325		$ 325	
Ignition Wires							$ 135	$ 135	
Starter, Engine								$ -	$ 365
Alternator, Engine								$ -	$ 485
12 Volt Battery					$ 125			$ 125	
Brake Fluid Flush			$ 90				$ 90	$ 180	
Transmission Fluid Flush	$ 129			$ 129			$ 129	$ 387	
Oil Pan Gasket, Plug								$ -	$ 235
Manifold Gaskets								$ -	$ 325
Timing Belt or Chain							$ 575	$ 575	
ICE Cost per Year	$ 309	$ 180	$ 619	$ 309	$ 740	$ 854	$ 1,479	$ 5,965	$ 1,755

2018 Nissan LEAF

Tire Rotation	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 140	$ 40
Annual Battery Check	Included	Included	$ 29	$ 29	$ 29	$ 29	$ 29	$ 145	$ 29
Brake Pads, Front								$ -	$ 150
Brake Pads, Rear								$ -	$ 150
Air Filter, Cabin			$ 45			$ 45		$ 90	$ -
12 Volt Battery					$ 125			$ 125	$ 40
EV Cost per Year	$ 20	$ 20	$ 94	$ 49	$ 174	$ 94	$ 49	$ 500	$ 150
Projected Savings	$289	$160	$525	$260	$566	$760	$ 1,430	$ 5,180	$ 1,605

Assumes maintenance and repair at intervals common within the automotive industry. Prices are averages, and may be higher or lower in certain regions. Skill and affiliation of the technician may also affect cost. Oil Changes calculated at 3 months or 5,000 miles, at $40 each. May be significantly more if synthetic oil or special filters are required. Repairs, such as gasket replacement, timing chain, sparkplugs or thermostat, consider average useful life. Some manufacturers may require added maintenance not specified. For simplicity, items common to both ICEs and EVs were omitted from this calculation, like Tires, Wiper Blades and Shocks. This comparison looks at like-sized vehicles comparable to a Nissan LEAF. Larger vehicles, or those used under stress, like police pursuit, may incur higher repair and maintenance costs, as will much older units. This comparison also doesn't consider modern safety features, like Automatic Emergency Braking, which is standard equipment on LEAF, and likely would reduce collision repair costs. It also doesn't consider a zero emissions vehicle like LEAF, will reduce CO^2 output, compared to a ICE vehicle by 6-9 Tons annually.

CVW

Apr-18

Other Sources Referenced:

- Analysis tracked and provided by Georgia Power
- Daily log created and provided by Officer John Clifford (driver assigned to Tesla)
- Networkfleet analytics
- ChargePoint analytics
- https://www.tesla.com/support/car-maintenance
- https://www.marketwatch.com/story/youll-save-money-on-gas-with-a-tesla-but-also-consider-these-unique-expenses-2017-07-06
- https://www.motor1.com/reviews/406938/tesla-maintenance-cost/
- https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
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- https://afdc.energy.gov/vehicles/electric_emissions.html