# Clean Vehicle Purchase Executive Order – Rationale and Implementation Strategy

## Overview:

In 2018, the City's municipal fleet represented approximately 9% of local government greenhouse gas emissions.[1] Prioritizing the use and purchase of low and no emission vehicles, such as electric vehicles, demonstrates the City's leadership in transitioning to a cleaner fleet and reducing municipal vehicle emissions. Declining purchase costs for electric vehicles, combined with lower fuel and maintenance costs, offer potential for cost savings in some applications. This Appendix provides a Clean Vehicle Purchase Rationale in Part 1, and an Implementation Strategy in Park 2.

In all likelihood, the Clean Vehicle Policy will first only apply to light-duty vehicles. The terms will expand to cover medium and heavy-duty fleet vehicles as electric models become commercially available and cost-competitive. The policy changes include provisions about utilizing special decals/wraps to promote electric vehicle use, application of the policy update to vehicle donations and leasing, updated reporting requirements, and guidance on fleet EV charging infrastructure.

## Part 1: Clean Vehicle Purchase Rationale

### Rationale for Municipal Fleet Electrification Policy Recommendations:

There are numerous potential benefits that support development of a City Fleet & Vehicle Electrification policy, in conjunction with the existing City Vehicle Policy. Some of the primary reasons include:

- **Greenhouse gas emission reduction:** The 2017 Climate Action & Adaptation Plan (CAAP) for the City of St. Louis Sustainability Plan includes a target for the City to reduce total greenhouse gas emissions 80% by 2050, and in 2019 Mayor Krewson set a target of achieving carbon neutrality by 2050. The CAAP outlines a number of municipal and community-wide strategies to achieve the City's Climate Protection goals, such as recommending the adoption of electric vehicles.
- **Air quality, health & equity:** Mobile sources contribute a substantial percentage of criteria pollutant emissions in St. Louis, up to 91% for carbon monoxide emissions, and 76% of NOx emissions.[2] These criteria pollutants contribute to respiratory, cardiovascular, and other health issues. Minority and underserved communities are frequently disproportionately impacted by air pollution, and in St. Louis suffer from related health impacts - such as asthma - in greater numbers.[3]
- **Strategic electrification:** As more solar and wind power is used as a source for regional energy, the electricity used to power EVs will become cleaner. In its 2017 Integrated Resource

[1] City of St. Louis 2018 Greenhouse Gas Emissions Inventory Report.
[2] EPA National Emissions Inventory, 2014.
[3] City of St. Louis Climate Vulnerability Assessment 2018.

Plan, Ameren Missouri pledged to reduce its electricity greenhouse gas emissions 80% by 2050. Updated goals are expected in the 2020 Integrated Resource Plan.

- **Cost-effective:** Declining upfront costs for EVs means that transitioning to electric fleets is becoming affordable, particularly for light-duty vehicles. Additionally, incentives, such as offered by dealers and Ameren Missouri, plus awards from the Missouri Department of Natural Resources Volkswagen Trust program, are increasingly available to help offset the upfront costs of fleet electrification.
- **Total cost of ownership savings:** Due to lower fuel costs and fewer maintenance needs, electric vehicles are estimated to provide savings on a total cost of ownership basis, particularly when replacing high mileage, low fuel efficiency vehicles. Fleets across the country have documented maintenance costs for EVs that are less than half that for conventional vehicles.[4]
- **Leading by example:** Incorporating EVs into the City fleet helps raise awareness among employees, auto dealerships and local auto industry stakeholders, and the general public, in turn enabling greater adoption of EVs.
- **Best in class**: St. Louis joins other peer cities that have set goals or created purchasing policies designed to accelerate vehicle electrification.[5]

## Clean Vehicle Policy Terms:

The changes to the existing City Vehicle Policy require departments to prioritize electric vehicles when procuring new vehicles for the City fleet, except when there is no electric model to suit the operating needs for the vehicle being replaced, or there is no cost-effective electric alternative. In those cases, departments are be required to prioritize purchase of a clean vehicle pursuant to the following structure:

(1) plug-in hybrid vehicle, (2) hybrid-electric vehicle, (3) alternative fuel or other vehicle with demonstrated lowered emissions than the vehicle eligible for replacement.

**Definitions:**

***Cost-effective****: An electric vehicle will be considered* ***cost-effective*** *if its estimated lifecycle cost is within 5% of a comparable conventional vehicle's cost.*

This threshold helps provide a buffer for small variances in the lifecycle cost analysis due to assumptions that are subject to fluctuation (*e.g.*, future fuel prices). It also accounts for additional indirect social and environmental benefits, such as air pollution reduction and local jobs benefits from EVSE installation, not captured explicitly in the lifecycle cost analysis.

***Lifecycle cost:*** *The* ***lifecycle cost*** *consists of (1) all capital acquisition costs - including vehicle purchase/lease and any associated charging infrastructure – (2) operating costs over the expected*

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[4] Reducing Maintenance Costs with Electric Vehicles, NYC. Municipal Fleet Electrification Case Study.

[5] Other cities with similar fleet electrification policies include Cincinnati, OH; Charlotte, NC; Albuquerque, NM; and Sacramento, CA, amongst others.

*life of the vehicle - including fuel/energy and maintenance costs- and (3) estimated environmental benefits of avoided greenhouse gas emissions.*

### Estimated Clean Vehicle Policy Impact:

Based on projected EV model availability and costs, the analysis projects a policy update as recommended is expected to result in 46% of total new light-duty purchases being electric vehicles by 2025, and 72% by 2030 (Table 1).

*Table 1: Percent Electric Vehicles of New Light-Duty Vehicle Purchases for the City Fleet by 2030*

| Vehicle Type | 2022 | 2025 | 2030 |
|---|---|---|---|
| **Cars and SUVs** | 15% | 50% | 100% |
| **Pick-ups and Vans** | 10% | 25% | 25% |
| **Percent of total** | **16%** | **46%** | **72%** |

By 2030, this policy is expected to result in an estimated 33% (438 vehicles) of the City's light-duty fleet being electric. The procurement trajectory above is estimated to result in the cost savings and emissions reductions by 2030 summarized in Table 2.

*Table 2: Projected Cost & Emissions Impact of Light-duty Electric Vehicle Purchases, 2021-2030*

| Description | Cost/Emissions Impact |
|---|---|
| **Vehicles Converted to Electric by 2030** | 438 (33% of light-duty fleet) |
| **Total Capital Cost Increase** | $2.0M |
| **Total Operational Cost Savings** | $2.8M |
| **Total Cost of Ownership Savings** | $836,000 |
| **Total Vehicle Lifetime GHG Emission Savings** | 4,940 metric tons |

# Part 2: Implementation Strategy

## Guidance to Departments: City Fleet & Vehicle Electrification Policy

While there are many cost-competitive electric light-duty sedan options in 2020, electric pickup, SUV, and van models are just becoming available. To respond to this evolving market, this Appendix offers guidance to support departments to make every effort to comply with the policy and support the City's climate goals, while the policy provisions also offer flexibility for compliance where needed. The Commissioner of Equipment Services may grant an exemption from a Battery-electric vehicle (BEV) or other clean vehicle, based on operational needs or cost-effectiveness.

***Definitions of Clean Vehicles***[6]

**Battery-electric vehicle (BEV)**

- BEVs run on electricity alone. They are powered by one or more electric motors that use the energy stored in a battery (larger than the batteries in an HEV or PHEV). EV batteries are charged by plugging the vehicle in to an electric power source and through regenerative braking.

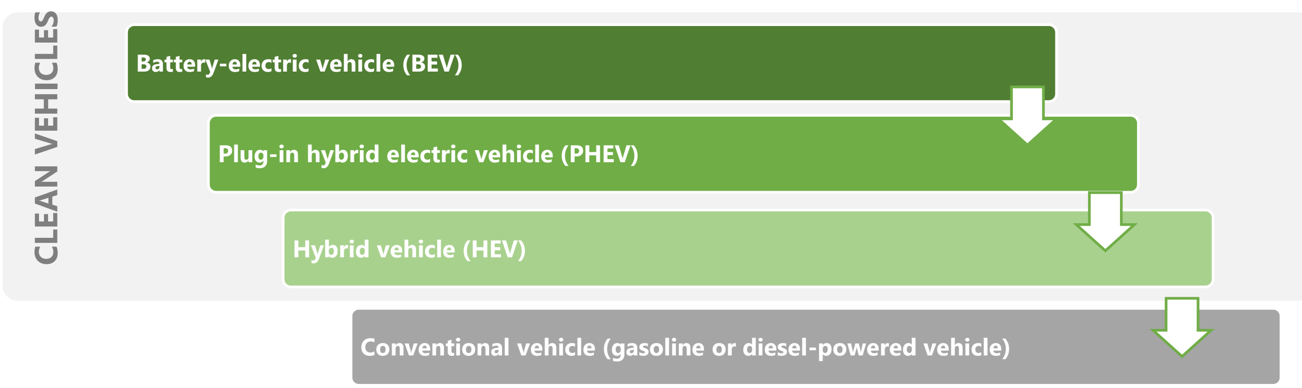
**Plugin hybrid electric vehicle (PHEV)**

- PHEVs are similar to HEVs but have a larger battery that allows them to travel on electricity alone. The battery can be charged by plugging in to an electric power source, through regenerative braking, and by the ICE. Unlike EVs, PHEVs don't have to be plugged in before driving. They can be fueled solely with gasoline, like an HEV. However, they will not achieve maximum fuel economy or take full advantage of their all-electric capabilities without plugging in.

**Hybrid electric vehicle (HEV)**

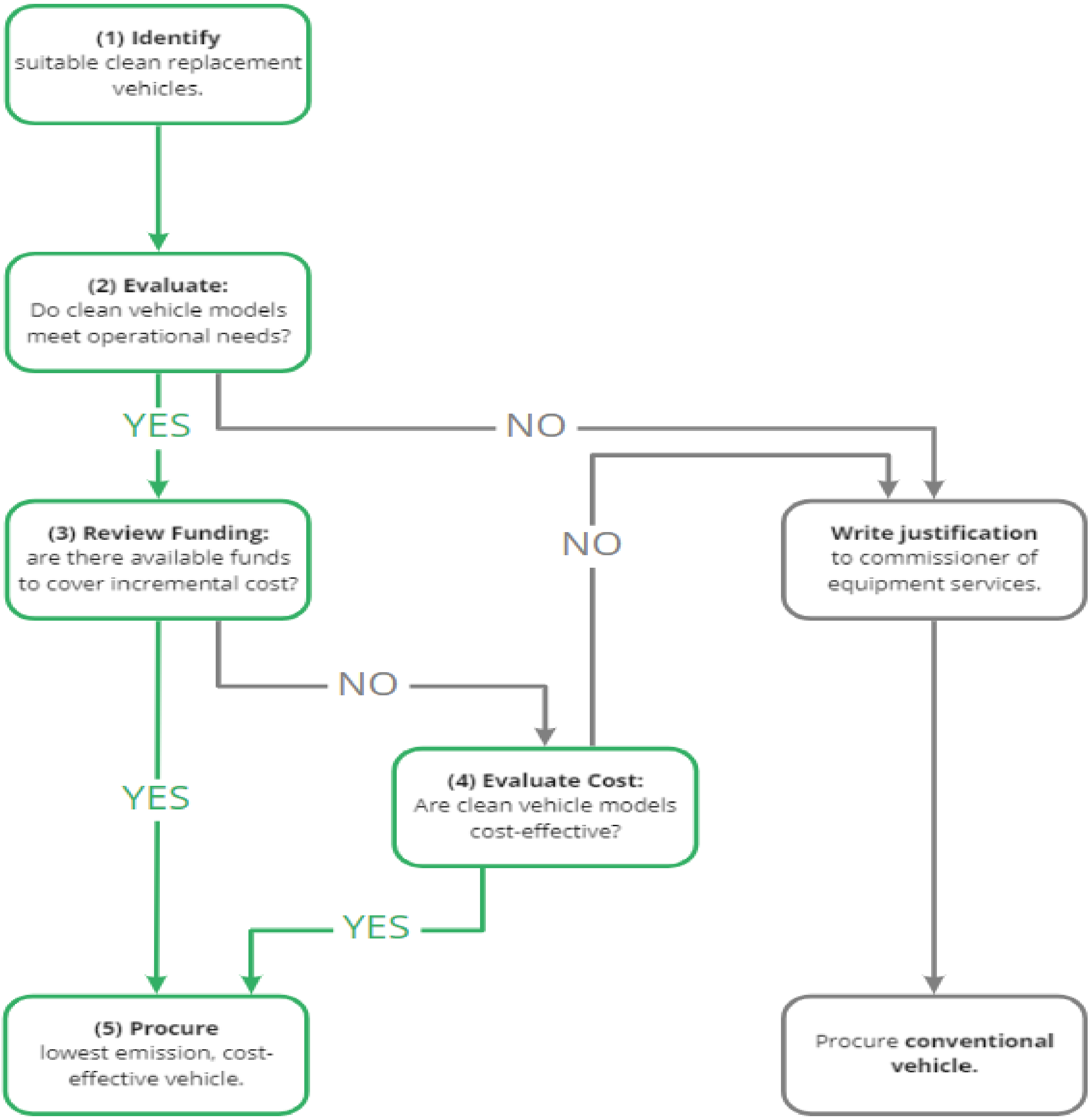
- HEVs are powered by a traditional gasoline or diesel ICE and by one or more electric motors that use energy stored in a battery. The battery is charged by the ICE and through regenerative braking. The vehicle cannot be plugged in to charge.

## Hierarchy of Replacement Vehicles




[6] Definitions adapted from U.S. DOE.

*Decision tree for complying with City Fleet & Vehicle Electrification Provisions:*




## Steps for Implementation

1. **Identify potential clean vehicle replacement options:** Available BEV, PHEV, HEV, and conventional vehicles can be researched and compared using the following sites (including light-duty, as well as medium- and heavy-duty vehicles):
    - https://afdc.energy.gov/vehicles/search/
    - www.fueleconomy.gov

2. **Evaluate: Do clean vehicle models meet operational needs?** As battery technology improves and costs decline, electric vehicle ranges have been increasing, and are now frequently more than 200 miles on a single charge. This is

likely sufficient for many City vehicles' needs, but should be considered if the vehicle in question is regularly driven longer distances than available vehicles' ranges. Vehicle ranges can be researched on www.fueleconomy.gov. Other operational needs to consider may include public safety vehicle capabilities, emergency response functions, and other operating requirements for specialized vehicles.

3. **Review funding: Are there available incentives or other funds to cover incremental cost?** Departments are encouraged to work with the Sustainability Director and Commissioner of Equipment Services to pursue available incentives or to cover the incremental cost of a clean vehicle. Incentives may be available from dealers, Ameren Missouri, the Missouri Department of Natural Resources Volkswagen Mitigation Settlement Trust program, and other sources to help offset the upfront costs of fleet electrification

4. **Evaluate cost: Are clean vehicle models cost-effective?** The remainder of this document offers guidance for conducting a lifecycle cost analysis as defined by the City Vehicle Policy to determine whether a suitable BEV, PHEV, or HEV replacement vehicle is cost-effective relative to the baseline conventional model. Departments should procure the lowest-emission cost-effective clean vehicle, according to the hierarchy of replacement vehicles above. As a general rule of thumb, vehicles most likely to see cost savings from switching to electric are likely to be driven at least 10,000 miles per year, though this will change as electric vehicle prices continue to decline.

## Lifecycle Cost Evaluation Guidance

Departments seeking an exemption on a lifecycle cost basis are encouraged to develop an analysis utilizing the following equation. The following sources and inputs can be utilized to analyze the lifecycle cost of an electric vehicle compared with other vehicle types. Lifecycle cost is calculated as follows:

Capital Costs (acquisition and infrastructure, less incentives received)
+ Lifetime Operating Costs (maintenance costs, fuel and/or energy costs, and other annual costs)
+ Lifetime Environmental Costs (cost of carbon associated with vehicle emissions)

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Total Lifecycle Cost of the vehicle

Individual components under lifetime operating costs and lifetime estimated environmental benefits of avoided GHG emissions can be calculated using the following equations. Recommended sources and inputs for these equations are explained further below. A spreadsheet template is available for departments to utilize using the following inputs and equations.

| Component | Equation to calculate |
|---|---|
| ***Lifetime Maintenance Costs*** | *= maintenance cost per mile * miles driven per year * vehicle lifetime* |

| | |
|---|---|
| ***Lifetime Fuel/Energy Costs*** | *= miles driven per year * vehicle lifetime ÷ fuel economy * fuel price* |
| ***Other Annual Costs*** | *= (annual insurance + annual registration) * vehicle lifetime* |
| ***Lifetime Cost of Carbon*** | *= miles driven per year * vehicle lifetime ÷ fuel economy * emissions factor * scaling factor * social cost of carbon* |

## Recommended Sources, Inputs, and Assumptions

The remaining elements of this guidance cover recommended sources, assumptions, and inputs for use in conducting a lifecycle cost evaluation, as well as example calculations. Step 1: calculate Vehicle Capital Costs. Step 2: calculate Vehicle Operating Costs. Step 3: calculate Environmental Impact.

## 1. Vehicle Capital Costs (Acquisition Costs, Infrastructure Costs, and Incentives)

**To calculate Vehicle Acquisition Costs:** visit www.fueleconomy.gov

| Description | Vehicle type | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Vehicle Acquisition Cost | BEV | *(Look up for each vehicle type)* | $ | **Source:** Look up MSRP range at www.fueleconomy.gov and use lower end of range. Departments are also encouraged to review prices through the state contract. |
| | PHEV | | $ | |
| | HEV | | $ | |
| | Conventional | | $ | |

**To calculate Vehicle Infrastructure Costs:** utilize the following inputs:

| Description | Vehicle type | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Fueling Infrastructure | BEV | $2,678 | $ | **Source:** AFLEET, Argonne National Laboratory (Level 2 parking garage cost per charger). *Assumes $5,356 cost per Level 2 charging plug, assumes one charging plug can be shared between 2 fleet vehicles.* |
| | PHEV | $2,678 | | |
| | HEV | $0 | $ | |
| | Conventional | $0 | $ | |

**To calculate Vehicle Incentives:** Incentives vary over time. They may be available from utilities, agencies or other sources. Departments are encouraged to work with the Sustainability Director and Commissioner of Equipment Services to pursue available incentives and factor those into any lifecycle cost analysis.

## 2. Vehicle Operating Costs

(Maintenance Costs, Fuel/Energy Costs, Other Annual Costs)

To calculate Lifetime Maintenance Cost, use this equation:

*(maintenance cost per mile) * (miles driven per year) * (years of vehicle lifetime)*

| Description | Vehicle type | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Maintenance cost per mile | BEV | $0.05 | $/mile | **Source:** Alameda County, 2017 (Passenger Vehicle) via U.S. DOE-funded Atlas Public Policy Fleet Procurement Analysis Tool (https://atlaspolicy.com/rand/fleet-procurement-analysis-tool/) |
| | PHEV | $0.08 | $/mile | |
| | HEV | $0.09 | $/mile | |
| | Conventional | $0.09 | $/mile | |

**To calculate Lifetime Fuel Costs, use this equation:**

*(miles driven per year) x (years of vehicle lifetime) ÷ (fuel economy) x (fuel price)*[7]

| Description | Vehicle type | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Fuel economy | BEV | *(look up for vehicles under consideration)* | MPGe[8] | Look up at fueleconomy.gov |
| | PHEV | | MPG | |
| | PHEV | | MPGe[9] | |
| | HEV | | MPG | |
| | Conventional | | MPG | |

| Description | Fuel | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Fuel price | Electricity | *(Look up for relevant fuels)* | $/kWh | **Source:** Look up EIA average statewide retail electricity price for previous year for all sectors. |
| | Gasoline | | $/gallon | **Source:** Look up EIA regional retail gasoline prices for previous year (Midwest (PADD 2)) |

**To calculate Other Annual Costs, use this equation:**

*(annual insurance cost + annual registration cost) * (years of vehicle lifetime)*

| Description | Vehicle type | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Insurance | All | $993 | $/year | **Source:** Argonne Labs AFLEET tool (https://greet.es.anl.gov/afleet_tool) |
| Registration | All | $45 | $/year | **Source:** Estimated annual registration fee, Missouri Department of Revenue (https://dor.mo.gov/motorv/fees.php) |

[7] Equation varies slightly for BEVs and PHEVs, see accompanying spreadsheet for examples.

[8] MPGe refers to miles per gallon of gasoline equivalent, or a quantity of electricity with the same energy content as a gallon of gasoline.

[9] Because PHEVs runs on both gasoline and electricity, fuel economy estimates are provided for each mode.

## 3. Lifetime Cost of Carbon

Emissions factors and approaches are informed by the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions utilized by the City of St. Louis in their 2018 Greenhouse Gas Inventory Report.[10] To calculate the Lifetime Cost of Carbon, use this equation:

*(miles driven per year) * (years of vehicle lifetime) ÷ (fuel economy) * (emissions factor) * (scaling factor) * (social cost of carbon)*

To calculate social cost of carbon: utilize the following recommended inputs and sources:

| Description | Input | Year | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Social Cost of Carbon | $58 | 2020 | $ per metric ton of CO2 equivalent emitted | **Source:** U.S. EPA. Uses 3% average discount rate values in 2007 dollars, adjusted to 2019 dollars using BLS CPI Inflation Calculator. |
| | $58 | 2021 | | |
| | $60 | 2022 | | |
| | $61 | 2023 | | |
| | $62 | 2024 | | |
| | $63 | 2025 | | |
| | $65 | 2026 | | |
| | $67 | 2027 | | |
| | $68 | 2028 | | |
| | $69 | 2029 | | |
| | $70 | 2030 | | |
| | $70 | 2031 | | |
| | $72 | 2032 | | |
| | $73 | 2033 | | |
| | $75 | 2034 | | |
| | $76 | 2035 | | |
| | $77 | 2036 | | |
| | $79 | 2037 | | |
| | $80 | 2038 | | |
| | $81 | 2039 | | |
| | $82 | 2040 | | |

| Description | Fuel | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Scaling factors for full fuel-cycle emissions (converting direct GHG emissions to | Gasoline | 1.26 | N/A | **Source:** U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Appendix D: Transportation and Other Mobile Emission Activities and Sources (https://icleiusa.org/publications/us-community-protocol/) |
| | Electricity | 1.10 | N/A | |

[10] City of St. Louis 2018 Greenhouse Gas Emissions Inventory Report.

| | | | | |
|---|---|---|---|---|
| full fuel cycle) | | | | |

| Description | Fuel | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Emissions factors (full fuel cycle CO2e) | Gasoline | 0.011063 | Metric tons CO2e per gallon | **Source:** U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (https://icleiusa.org/publications/us-community-protocol/) |
| | Electricity | 0.000837 | Metric tons CO2e per kWh | **Source:** U.S. EPA eGRID 2018 (https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid). *Utilize most recently available eGRID figure for SRMW region.* |

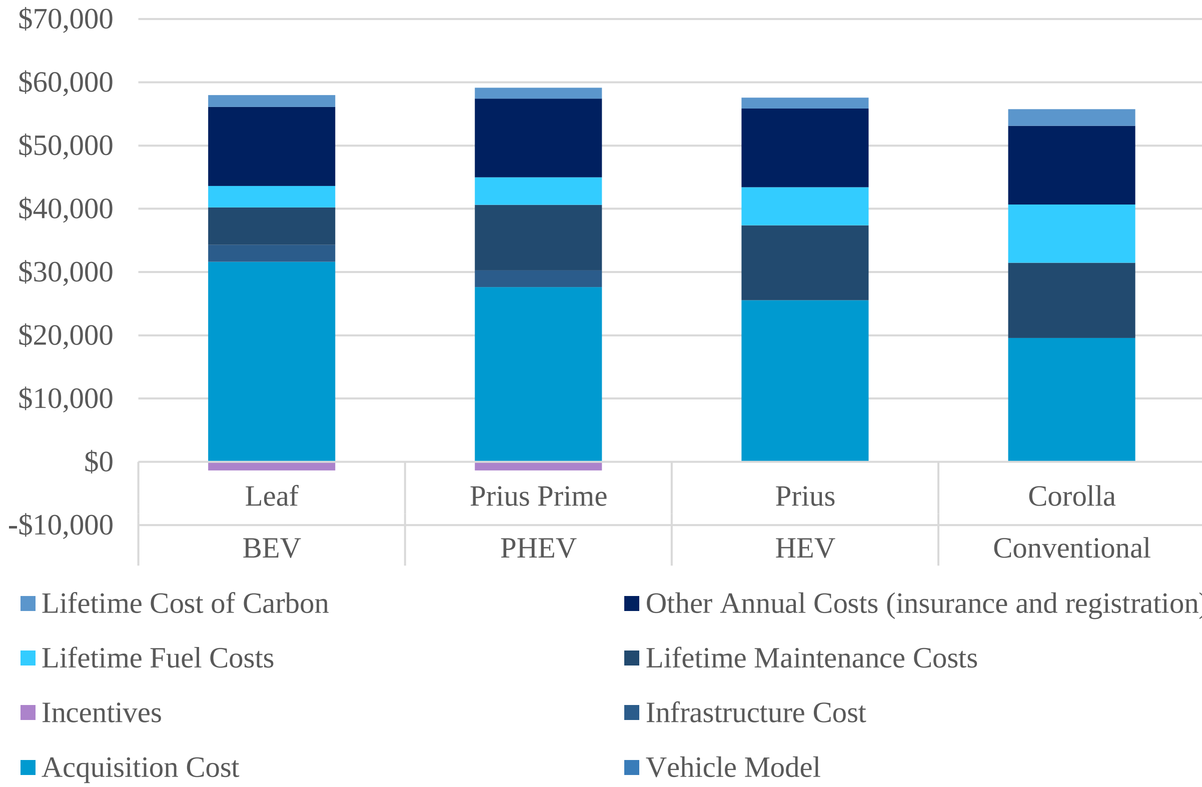
**General Inputs and Assumptions for Use in Equations**

| Description | Vehicle type | Input | Unit | Source(s) and Notes |
|---|---|---|---|---|
| Vehicle lifetime | All | 12 | Years | **Source:** St. Louis Equipment Services Division – typical useful life. Some St. Louis fleet vehicles have a ~6-year primary life in one use, and then are transferred to another use for another ~6-year secondary life. |
| Miles driven per year | All | 10,500 | Miles | **Source:** St. Louis Equipment Services Division mileage data – average annual mileage for light duty vehicles**.** *Departments are also encouraged to utilize the average annual mileage for the specific vehicle use they are replacing.* |
| Gallon gasoline to kWh conversion factor | BEV, PHEV | 33.7 | kwh/mi in a gallon gas | **Source:** U.S. DOE AFDC (https://afdc.energy.gov/fuels/properties) |
| Pounds to metric tons conversion factor | All | 2,204.6 | Pounds per metric ton | **Source:** U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (https://icleiusa.org/publications/us-community-protocol/) |
| Electricity losses | BEV, PHEV | 2.8% | % | **Source:** EIA Form 861 - 2018 estimate for Ameren (https://www.eia.gov/electricity/data/eia861/) |

| | | | | |
|---|---|---|---|---|
| Portion driven on electricity for PHEV | PHEV | 55% | % | **Source:** U.S. DOE AFDC (https://afdc.energy.gov/vehicles/electric_emissions_sources.html) |

## Example Calculations

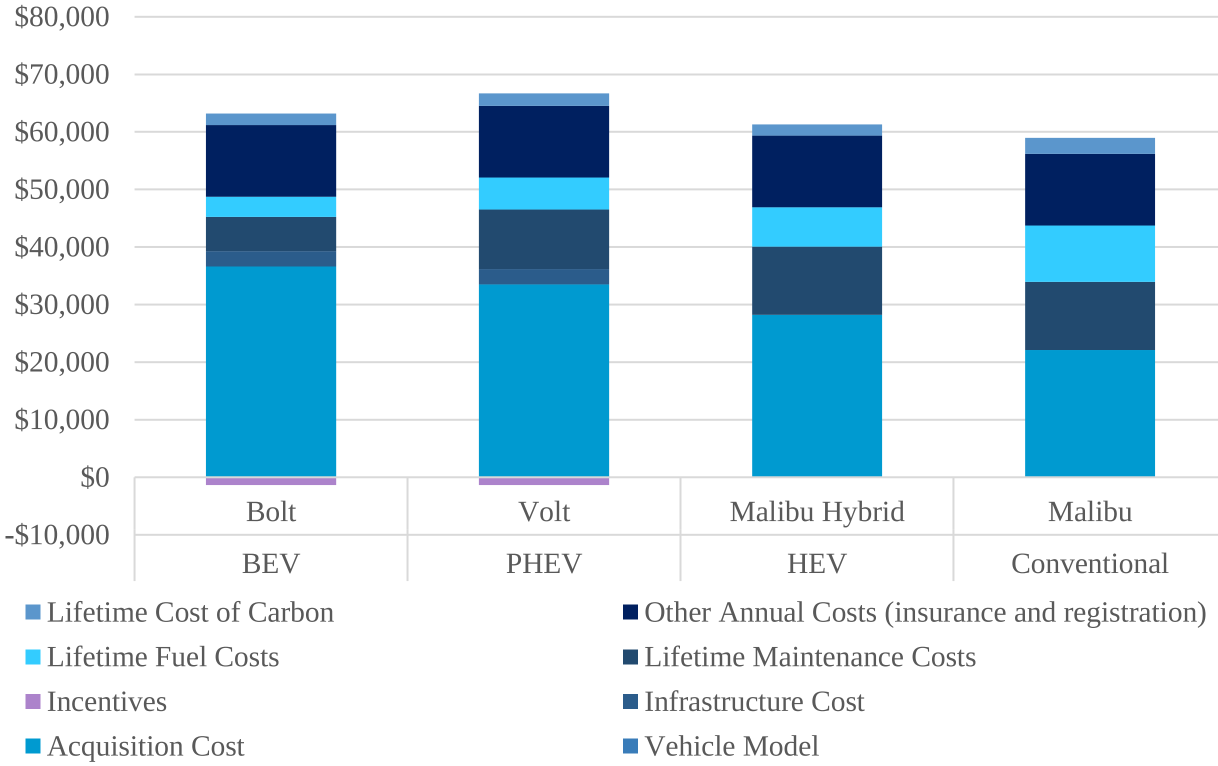
***Lifecycle Cost by Cost Category and Fuel Type – Example 1***




| | **BEV** | **PHEV** | **HEV** | **Conventional** |
|---|---|---|---|---|
| Vehicle Model | Leaf | Prius Prime | Prius | Corolla |
| Acquisition Cost | $31,600 | $27,600 | $25,535 | $19,600 |
| Infrastructure Cost | $2,678 | $2,678 | $0 | $0 |
| Incentives | ($1,339) | ($1,339) | $0 | $0 |
| Lifetime Maintenance Costs | $5,922 | $10,332 | $11,844 | $11,844 |
| Lifetime Fuel/Energy Costs | $3,428 | $4,358 | $6,033 | $9,228 |
| Other Annual Costs | $12,456 | $12,456 | $12,456 | $12,456 |
| Lifetime Cost of Carbon | $1,907 | $1,716 | $1,722 | $2,634 |
| **Total** | **$56,652** | **$57,801** | **$57,590** | **$55,761** |
| *% Difference from conventional* | *1.6%* | *3.7%* | *3.3%* | |

In this sample calculation, the BEV is within 5% of total lifecycle cost as a conventional vehicle, so would be selected for procurement.

***Lifecycle Cost by Cost Category and Fuel Type – Example 2***




| | **BEV** | **PHEV** | **HEV** | **Conventional** |
|---|---|---|---|---|
| Vehicle Model | Bolt | Volt | Malibu Hybrid | Malibu |
| Acquisition Cost | $36,620 | $33,520 | $28,220 | $22,090 |
| Infrastructure Cost | $2,678 | $2,678 | $0 | $0 |
| Incentives | ($1,339) | ($1,339) | $0 | $0 |
| Lifetime Maintenance Costs | $5,922 | $10,332 | $11,844 | $11,844 |
| Lifetime Fuel/Energy Costs | $3,543 | $5,549 | $6,820 | $9,804 |
| Other Annual Costs | $12,456 | $12,456 | $12,456 | $12,456 |
| Lifetime Cost of Carbon | $1,971 | $2,177 | $1,947 | $2,798 |
| **Total** | **$61,852** | **$65,373** | **$61,287** | **$58,992** |
| *% Difference from conventional* | *4.8%* | *10.8%* | *3.9%* | |

In this sample calculation, the BEV is within 5% of total lifecycle cost as a conventional vehicle, so would be selected for procurement.

## Additional Tools

The American Cities Climate Challenge has provided a basic spreadsheet template for departments to utilize in conducting lifecycle cost analyses, or recommends utilizing readily available fleet electrification analysis tools, such as Argonne Labs' Alternative Fuel Life-Cycle Environmental and Economic Transportation tool (AFLEET), U.S. DOE Alternative Fuel Data Center's Vehicle Cost Calculator or Atlas Public Policy's Fleet Procurement Analysis Tool.