Maricela Hernandez

From:	Andy Shrader <andshr@gmail.com>
Sent:	Wednesday, March 10, 2021 10:49 AM
To:	James Bozajian - External; Mary Sue Maurer - External; David Shapiro; Alicia Weintraub; Peter Kraut; Maricela Hernandez
Subject:	Comment on Item #2 for tonight's agenda
Attachments:	EV-Ownership-Cost-Final-Report-1 (1).pdf; Says 7 billion people.JPG

Dear Honorable Mayor Bozajian and Councilmembers,

In looking at this week's agenda, item #2, particularly considering this LA Times Op Ed, I have concerns about the necessity of the new SUV purchases.

While promoted in the staff report as relatively environmentally-friendly, according to the Dodge website these Dodge SUVs *only* get 19 mpg city/26 highway, and they will likely last -- even if the city eventually resells them -- for 15 years, which means 2035, five years beyond the 2030 date that the United Nations IPCC climate scientists believe we need to be as close to zero emissions as possible to keep the planet below the vital 1.5 degrees Celsius of heating. Every decision the city makes can either make things better or make things worse. I am constantly thinking of my children's futures in each of these decisions.

The new Chevy Bolt EUVs are coming later this year, for the very same price ($33K) and get 250 miles per charge. If you add in state of California EV purchasing incentives, they are likely cheaper. Is there a long distance component to these SUV purchases? I'm thinking it would be difficult to drive more than 250 miles in one day around Calabasas, and that's without stopping for lunch and a fast charge-up.

Additionally, an important consideration in this time of budget uncertainty where every bit of savings helps, the attached Consumer Reports study shows that owning electric vehicles will actually save the city money in energy cost and maintenance over the long haul.

Perhaps waiting a few extra months on these purchases might be both fiduciarily and environmentally helpful?

Mayor Garcetti's EV policy expert, Michael Samulon (michael.samulon@lacity.org), has generously offered to assist Calabasas staff on these issues if desired and I have listed some State of California and Climate Mayors resources he provided below:

Here are the State of California resources:
https://www.green.ca.gov/fleet/Documents/147013-DGS-DriveGreen-2019-ADA.pdf

https://www.dgs.ca.gov/OFAM/Resources/Page-Content/Office-of-Fleet-and-Asset-Management-Resources-List-Folder/State-Electric-Vehicle-Charging-Guide

State now has a Tesla contract also:
https://caleprocure.ca.gov/pages/LPASearch/lpa-details.aspx?Page=ZZ_CTR_SUP_PG&Action=U&ForceSearch=Y&CNTRCT_ID=1-20-23-10I&SETID=STATE&VERSION_NBR=1

Climate Mayor's electric vehicle purchasing cooperative:
https://driveevfleets.org/#

Two SUVs may not seem like much, but an old meme (which I've found and attached) comes to mind: "What difference is one bottle going to make, says 7 billion people."

I encourage you to table this item, have the city staff look into the electric vehicle alternatives and perhaps save the city some money while saving the atmosphere some emissions. And maybe this could be a first step towards a "no more fossil fuel powered vehicles purchasing policy" for the city, towards that "climate action plan" I see under future agenda items.

Thank you for your consideration.

All the best,

Andy Shrader

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

CHRIS HARTO

OCTOBER 2020

CR Consumer Reports

Table of Contents

Executive Summary

Up-front purchase price is only part of the cost consumers pay to own their vehicle. Over the lifetime of a conventional gas-powered vehicle, fuel and maintenance costs can add up to even more than the original purchase price. While electric vehicles (EVs) typically have higher up-front purchase prices, they can save consumers a lot on operating expenses. This study relies on new data on electric vehicle depreciation rates and maintenance and repair costs, along with real world average vehicle prices, to estimate how much today's most popular EVs can save consumers when compared with similar ICE vehicles.

New data obtained by CR from ALG, a data and analytics subsidiary of automotive pricing and information website TrueCar, shows that when adjusted for federal purchase incentives, both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) are expected to depreciate at the same rate as ICE vehicles in the same class over the first five years of ownership. In addition, new data extracted from recent Consumer Reports reliability surveys shows that both BEV and PHEV drivers are saving 50 percent on their repair and maintenance costs, when averaged over a typical vehicle lifetime.

Based on average driving habits, fuel costs for BEVs were estimated assuming mostly home charging and an estimated six fast-charging sessions required per year for BEVs with a range of 250 miles. Overall, BEVs were estimated to save consumers about 60 percent on fuel costs compared with the average vehicle in their class. Fuel costs were also analyzed by state, with the majority of states falling within 10 percent of the national average.

The nine most popular EVs on the market under $50,000 were compared to (1) the best-selling, (2) the top-rated, and (3) the most efficient vehicles in their class. For six of the nine EVs analyzed, the first-owner ownership costs are estimated to be lower than those of all three comparable ICE vehicles in their class. For all nine EVs analyzed, the first-owner ownership costs are estimated to be lower for at least one of the three comparable ICE vehicles. In many cases, the EVs matched or exceeded the performance of some of the top-performing ICE vehicles in their class. For all EVs analyzed, the lifetime ownership costs were many thousands of dollars lower than all comparable ICE vehicles' costs, with most EVs offering savings of between $6,000 and $10,000. While new EVs were found to offer significant cost savings over comparable ICE vehicles, the cost savings of 5- to 7-year-old used EVs was found to be two or three times larger on a percentage savings basis.

Overall, these results show that the latest generation of mainstream EVs typically cost less to own than similar gas-powered vehicles, a new development in the automotive marketplace with serious potential consumer benefits.

Key Terms

Battery electric vehicle (BEV): A vehicle that operates only on electric power.
Depreciation: The portion of the initial value of an asset (such as a vehicle) that has been lost after a given amount of time. Depreciation is the inverse of the *residual value*.
Discount rate: An interest rate used for discounting future income and expenditures relative to the present value.
Electric vehicle (EV): A vehicle capable of operating on electricity only for an extended period of time. Includes battery electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles[1].
Internal combustion engine vehicle (ICE): A conventional vehicle fueled only by gasoline.
Plug-in hybrid electric vehicle (PHEV): A vehicle that can operate on either electricity or gasoline.
Present value (PV): A sum of future income and expenditures discounted to current year using a discount rate to take into account the fact that costs and expenditures further into the future have a lower value in the present.
Residual value: The portion of the original purchase price of a vehicle remaining after a certain number of years. Residual value is the inverse of *depreciation*.

[1] There are currently no high-volume mainstream fuel cell electric vehicles.

Chapter 1—Resale Value: Long-Range Electric Vehicles Expected to Hold Value As Well As Internal Combustion Engine Vehicles

Introduction

The electric vehicle market is rapidly changing, largely because the cost of batteries has decreased dramatically over the past decade.[2] One of the most significant changes is extended driving range. The 2011 Nissan Leaf, for example, had a single-charge range of only 73 miles, whereas the 2019 version had three times that range, at 226 miles. As of model year 2020, at least 11 electric vehicles on the market have a range of 200 miles or more. This sharp improvement in range delivers far more utility for many consumers.

This increased utility is likely to be reflected in higher resale values for the current model year of the Leaf and other higher-range EV models. The purposes of this chapter are to test this hypothesis and estimate how the values of these electric vehicles will hold up over time. The analysis relies on data from proprietary algorithms developed by ALG based on real-world vehicle transaction prices adjusted by CR to account for government purchase incentives.

Key Findings

- Current longer-range battery electric vehicles (BEVs) are expected to maintain their value about as well as comparable internal combustion engine (ICE) vehicles, on average, over the next five years.
- Plug-in hybrid electric vehicles (PHEVs) are expected to hold their value about as well as conventional hybrids of the same vehicle class, on average, over the same period.

Approach

ALG, a data and analytics subsidiary of automotive pricing and information website TrueCar provided CR with projected residual values of all model year 2019 vehicles after five years of ownership as a percentage of the average original price for each model. These projections were made using proprietary algorithms and data from millions of real-world new and used vehicle transactions.

These residual value estimates were then adjusted to take into account the effect of purchase incentives available at the state and federal level on the original price of battery electric and plug-in electric vehicles. This was necessary because the net price after incentives represents

[2] https://www.bloomberg.com/news/articles/2020-03-17/an-economic-crash-will-slow-down-the-electric-vehicle-revolution-but-not-for-long

the true price paid by consumers for these vehicles, and it is expected that both the new- and used-car markets will reflect the availability of these incentives.

ALG provided estimates of residual values based on the month of purchase, and the data were updated every two months throughout the year, resulting in six data points per year. Because incentives were phased out for some automakers—General Motors and Tesla, for example—at different points throughout the year, the incentives were applied only for the months in which they were offered, and the resulting residual values were averaged across the six data points for each vehicle for the year.

The value of the federal tax credit for each vehicle model was taken from fueleconomy.gov.[3] For state incentives, a weighted average incentive for all BEVs was derived by multiplying the percentage of EV sales in 2019 in a given state[4] by the value of the state purchase incentive for BEVs.[5] Ten states provided purchase incentives for BEVs in 2019, and those states accounted for 65 percent of national EV sales. From this, it was calculated that, on average, BEV vehicles sold in 2019 each received $1,400 in state purchase incentives. Because vehicles are often sold across state lines, we used this weighted average to approximate the effect of state incentives on the overall market. State tax credits were not calculated for PHEVs because of the complexity of how different state incentives apply to different specific PHEV models based on battery size.

Detailed Results

Electric vehicles were grouped into different segments, based on range and price, for analysis. Vehicles were segmented by whether they were classified as luxury or mainstream by TrueCar, and the mainstream EVs were divided by range: greater than 200 miles, between 100 and 200 miles, and under 100 miles. All luxury BEVs had a range of over 200 miles.

Table 1.1 shows a summary of the predicted five-year residual values for each category, with different levels of adjustment (adjusted for federal tax credit, and adjusted for both federal and state tax credits). These values are then compared with the predicted average residual values for comparable conventional internal combustion engine (ICE) vehicle segments. The residual values in the table represent the portion of the effective initial purchase price that is retained after five years of ownership, which is the inverse of depreciation. For example, a residual value of 0.45 indicates that the vehicle has depreciated by 55 percent.

[3] https://www.fueleconomy.gov/feg/taxevb.shtml.
[4] https://www.atlasevhub.com/materials/state-ev-sales-and-model-availability.
[5] https://afdc.energy.gov/laws/state.

The data show that with the exception of mainstream BEVs with less than 100 miles of range, all EV categories are expected to hold their value approximately as well as comparable internal combustion engine vehicles.

It should be noted that every vehicle in the under-100-mile category is a low-volume car with sales of less than 1,000 units in 2019[6] and available only in states with zero-emissions vehicle mandates. This indicates that these vehicles were likely sold largely for compliance reasons, not as mass-market vehicles that were compelling to a broad cross-section of consumers.

Table 1.1. Average Predicted 5-Year Residual Values for EVs Compared with ICE Vehicles

EV/PHEV Category	Adjusted for Federal Tax Credit	Adjusted for Federal and State Tax Credits	Comparable ICE	ICE Segment Comparison
Luxury EV (n=6)	0.47	0.48	0.46	Luxury car, luxury SUV, luxury performance
Mainstream 200-plus-mile range (n=4)	0.44	0.46	0.45	Compact car
Mainstream 100- to 200-mile range (n=4)	0.43	0.45	0.45	Compact car
Mainstream <100-mile range (n=3)	0.28	0.29	0.36	Subcompact car
PHEV (n=12)	0.47		0.48	Hybrid
Luxury PHEV (n=10)	0.43		0.45	Luxury hybrid

6 https://insideevs.com/news/343998/monthly-plug-in-ev-sales-scorecard.

The predicted residual data adjusted for federal tax credits are also shown as a scatter plot of all vehicles in each category in Figure 1.1. ICE values are shown for comparison as the average (represented by ◆), +/- one standard deviation (+ and - symbols), and +/- two standard deviations (*) by combining the compact car, midsized car, and compact-utility categories. This illustrates that, like ICE vehicles, not all EVs are expected to hold their value the same, and that other vehicle- and manufacturer-specific factors, such as style, features, reliability, and manufacturer reputation, still affect the relative depreciation of different vehicles.

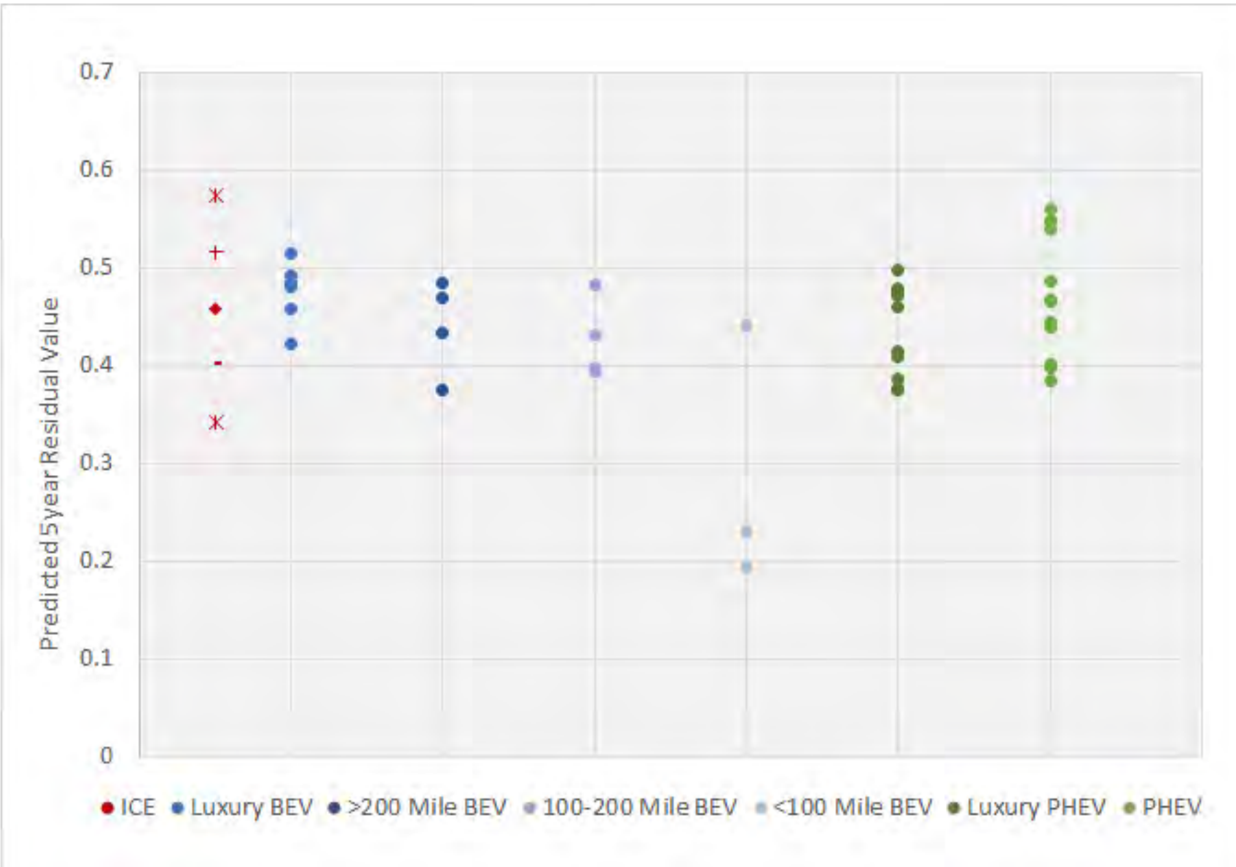

Figure 1.1. Scatter Plot of Predicted 5-Year Residual Values for EVs by Type and Range Adjusted for Federal Tax Credit

Chapter 2—Maintenance: EVs Cost Half as Much to Maintain

Introduction

Electric vehicles (EVs) are generally expected to cost less to maintain because their electric motors and other drivetrain components have fewer moving parts than internal combustion engines, and they don't require fluid changes.[7] However, because EVs are relatively new, little hard data are available to put numbers to these claims, and most estimates in the literature are based on predicted repair and maintenance costs.[8] However, each year CR surveys hundreds of thousands of our members about the reliability and maintenance costs of their vehicles. In recent years this survey sample has included more and more electric vehicles, including thousands of both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). This data was analyzed to estimate average real-world repair and maintenance costs for BEVs, PHEVs, and internal combustion engine (ICE) vehicles.

Key Findings

- Analysis of real-world maintenance and repair cost data from thousands of CR members shows that BEV and PHEV owners are paying half as much as ICE owners are paying to repair and maintain their vehicles.

Approach

Data for this analysis came from Consumer Reports' 2019 and 2020 spring reliability surveys.[9] This comprehensive survey is sent to hundreds of thousands of CR members and is used as the basis for CR's reliability ratings. Among many other questions, individual drivers are asked to estimate how much they spent on repairing and maintaining their vehicle over the past 12 months, as well as how many miles they drove in the past 12 months, and how many total miles their vehicle has on it.

The data were filtered to remove:

- Incomplete responses.
- Vehicles that reported traveling less than 2,000 miles in the past 12 months.
- Vehicles that reported traveling more than 60,000 miles in the past 12 months.
- Vehicles that reported maintenance costs of over $20,000 over the past 12 months.
- Vehicles with more than 200,000 total miles.

[7] https://www.consumerreports.org/hybrids-evs/your-ev-questions-answered-electric-vehicle-faq/#reliable
[8] https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf
[9] https://www.consumerreports.org/car-reliability-owner-satisfaction/consumer-reports-car-reliability-faq/

These filters on the data were used to eliminate outliers and keep the sample within the range of reasonably likely consumer experience while retaining as much of the original data set as possible. While 60,000 miles is a lot of driving for one year, it's within the range of possibilities for, for example, a salesman with a large territory, or someone who drives full-time for a ride-hailing company, such as Uber or Lyft. Similarly $20,000 is a lot to spend on vehicle repairs but may represent the cost of major repairs on a luxury vehicle.

The final data set was then sorted by total vehicle mileage. Average maintenance costs were estimated in three mileage bins: 0 to 50,000 miles, 50,000 to 100,000 miles, and 100,000 to 200,000 miles. For each bin, a vehicle-miles-traveled (VMT) weighted average repair and maintenance cost per mile was calculated. To account for any bias in the data based on the brands of vehicles purchased by CR members, for ICE vehicles the estimates were reweighted based on calculated average maintenance costs for each automaker and the average market share over the past five years for each brand, using data from auto industry analyst Wards Intelligence.[10] The sample size for PHEVs and BEVs was not large enough to do a similar automaker weighted average calculation, but for ICE vehicles the difference between the automaker weighting and the total average sample for each mileage bin was negligible.

Detailed Findings

The results of the analysis are shown in Table 2.1, binned by mileage range and averaged over a 200,000-mile vehicle lifetime. Notable results are that estimated lifetime average repair and maintenance costs for BEVs and PHEVs are approximately half the cost for ICE vehicles. This is generally consistent with other sources that have estimated the relative repair and maintenance costs of EVs at 40 percent[11] and 47 percent.[12]

The data show that repair and maintenance costs are slightly higher for PHEVs than for BEVs until the 100,000-mile mark, and slightly lower beyond 100,000 miles. It should be noted, however, that there is a higher degree of uncertainty in these numbers because of a lower sample size: A little over 200 PHEV vehicles with more than 100,000 miles, and only 55 BEVs. Furthermore, the 55 BEVs with more than 100,000 miles were predominantly early versions of the Nissan Leaf and Tesla Model S, suggesting that our projections may overestimate the long-term maintenance costs expected from current-generation BEVs as automakers learn from their early models. These estimates will continue to be refined over the next few years as more data

[10] Wards Intelligence, U.S. Vehicle Sales by Company, 2015-2019 data series. https://wardsintelligence.informa.com/WI060875/US-Vehicle-Sales-by-Company-20152019.
[11] https://neo.ubs.com/shared/d1ZTxnvF2k.
[12] https://www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf.

on more electric vehicles at higher mileages become available in Consumer Reports' survey sample.

Table 2.1. Estimated Per-Mile Repair and Maintenance Costs by Powertrain

Powertrain Type	0-50K Miles	50K-100K Miles	100K-200K Miles	Lifetime Average
BEV	$0.012	$0.028	$0.043[13]	$0.031
PHEV	$0.021	$0.031	$0.033[5]	$0.030
ICE	$0.028	$0.060	$0.079	$0.061

The results are put into the context of consumer budgets in Table 2.2, which shows the lifetime repair and maintenance costs for vehicles of the different powertrain types. They show that BEVs and PHEVs will both cost consumers about $4,600 less to repair and maintain over their lifetimes, compared with ICE models when discounted to the present value.

Table 2.2. Lifetime Maintenance Costs by Powertrain[14]

Powertrain Type	Lifetime Maintenance and Repair Cost	Lifetime Savings vs. ICE
ICE	$9,200	
BEV	$4,600	$4,600
PHEV	$4,600	$4,600

[13] Lower confidence in this value because of the small sample size.
[14] Present value at 3 percent discount rate in 2019 dollars over a 200,000-mile lifetime.

Chapter 3—Fuel Costs: No More Trips to the Gas Station

Introduction

Home charging has the potential to provide several benefits for consumers, one of which is simply the convenience of not needing to stop at a gas station multiple times per month. Further, charging a BEV at home is much less expensive than paying for gasoline. Longer trips will still require occasional stops at stations equipped with DC fast chargers—or Superchargers, as Tesla calls them[15]—which can recharge your battery in 30 to 45 minutes, or about the time it takes to eat a quick meal.[16] This chapter estimates how much of a consumer's typical charging can be done at home vs. on the road at a DC fast-charging station. Then it estimates the total fuel cost savings a consumer can expect for different classes of BEVs compared with internal combustion engine vehicles.

Key Findings

- EV owners will spend 60 percent less to fuel their vehicle.
- While there is variability among states because of differing gasoline and electricity prices, electric vehicle drivers will save on fuel in every state, with consumers in the majority of states saving within 10 percent of the national average savings.
- Owners of BEVs with a range of 250 miles or greater will be able to do 92 percent of their charging at home, requiring only six stops at a DC fast-charging station per year.

Approach

The first step in this analysis was determining what fraction of a consumer's charging could typically be done at home. One commonly used approach is to calculate what's called a utility factor, which is an estimate of the fraction of total miles driven by a typical driver that could be completed by an EV that charges only at home once a day. Using data from over 100,000 consumer trips, researchers at the Argonne National Laboratory developed an equation for a BEV utility factor as a function of that EV's range.[17] The utility factors calculated by ANL are shown in Table 3.1.

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[15] https://www.tesla.com/supercharger.
[16] https://www.consumerreports.org/hybrids-evs/electric-car-charging-network-is-expanding.
[17] Duoba, M., "Developing a Utility Factor for Battery Electric Vehicles," SAE Int. J. Alt. Power. 2(2):362-368, 2013 (https://doi.org/10.4271/2013-01-1474).

These numbers were then adjusted to account for the fact that consumers are unlikely to drive their BEV until its charge is fully depleted. Using a safety factor of 20 percent, we determined the number of trips to a public charging station required for every 15,000 miles of driving.[18]

Table 3.1 BEV Utility Factor as a Function of BEV Range

BEV Range	Utility Factor	Percentage of Charging at Home[19]	Estimated DC Fast-Charging Sessions for 15K Miles[20]
100	78%	70%	56
150	88%	84%	20
200	92%	89%	11
250	95%	92%	6
300	96%	94%	4

To estimate charging expenses, costs were split between home charging and public DC fast charging (DCFC) based on the figures in Table 3.1.[21] Home charging costs were taken from the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2020 baseline scenario.[22] State-by-state charging costs were also estimated, but the AEO does not project state-level costs, so average residential electric costs were drawn from the EIA State Energy Data System over the past five years (2014 to 2018) of data that were available.[23] For the cost of DC fast chargers, a value of 40 cents per kilowatt-hour was used, based on data from multiple sources.[24] The same methodology and EIA sources were used for both national and state gasoline prices for comparison with ICE fueling costs.

[18] Approximately the average annual distance driven over the first seven years of a vehicle lifetime for an SUV or crossover. Cars tend to be driven slightly fewer miles and pickup trucks slightly more. National Highway Traffic Safety Administration Final Regulatory Impact Analysis, Table VI-212 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).
[19] Assumes a 20 percent safety factor. For example, a 100-mile range is treated as effectively an 80-mile range for the purposes of this calculation.
[20] Number of sessions is calculated by dividing the number of miles needing public charging by 80 percent of the range of the vehicle, assuming consumers charge up 80 percent of their total range at each charging stop.
[21] This analysis assumes that consumers do not opportunistically take advantage of the over 15,000 free Level 2 chargers that are available around the country (https://www.ucsusa.org/sites/default/files/attach/2017/11/cv-report-ev-savings.pdf).
[22] https://www.eia.gov/outlooks/aeo.
[23] https://www.eia.gov/state/seds/seds-data-complete.php?sid=US#PricesExpenditures.
[24] Union of Concerned Scientists found the majority of DCFCs cost between 36 cents and 48 cents per kilowatt-hour (https://www.ucsusa.org/sites/default/files/attach/2017/11/cv-report-ev-savings.pdf).
NREL found an average cost of 35 cents/kWh (https://www.nrel.gov/docs/fy19osti/72326.pdf).
Tesla DCFC costs 28 cents/kWh (https://www.tesla.com/support/supercharging).
Elektrek estimate of 41 cents/kWh (https://electrek.co/2019/08/12/kwh-pricing-ev-drivers-miss-benefits).

For comparison, average vehicle efficiency levels were assumed for each of three vehicle classes (car, crossover/SUV,[25] and pickup). Efficiency levels for ICE vehicles were taken from the 2020 Environmental Protection Agency trends report for model year 2019 vehicles.[26] These efficiencies were then adjusted to increase them to account for the increase in fuel-economy standards between 2019 and 2020.[27] For BEVs an average efficiency level was calculated for cars based on the average efficiency of the seven BEV cars available on the market with at least 150 miles of range and costing less than $100,000.[28] Efficiency levels for BEVs in other classes were estimated by assuming the same relative efficiency for BEVs as ICE vehicles between classes.[29] The efficiencies used in the analysis are shown in Table 3.2.

Table 3.2. Average Vehicle Efficiencies by Vehicle Class

Class	Electric Efficiency (MPGe[30])	Gasoline Efficiency (mpg)
Car	120	32
Crossover/SUV	97	24
Pickup	76	20

Detailed Findings

For analysis in this chapter, a single standard-range EV was selected for estimation of charging costs. Based on the best-selling EVs on the market, a value of 250 miles was selected for the range. The numbers in Table 3.1 may help explain why many automakers are targeting EVs with a range of around 250 miles per charge. At that range, even with a 20 percent safety factor, a typical consumer could do 92 percent of their driving with home charging and would require an average of only six stops at a fast charger per year. This compares with around 40 stops at gas

[25] Utility includes both crossovers and SUVs, given the difficulty in clearly differentiating these two vehicle classes.
[26] The utility class is based on a sales weighted average of the "car SUV" and "truck SUV" classes defined by EPA (https://www.epa.gov/automotive-trends/explore-automotive-trends-data#DetailedData).
[27] Based on the current Corporate Average Fuel Economy (CAFE) and greenhouse gas standards, an estimated improvement of 4 percent improvement in car fuel economy and 1.7 percent improvement in light truck fuel economy was required for model year 2020 as compared with model year 2019. Based on analysis from: https://advocacy.consumerreports.org/wp-content/uploads/2019/08/The-Un-SAFE-Rule-How-a-Fuel-Economy-Rollback-Costs-Americans-Billions-in-Fuel-Savings-and-Does-Not-Improve-Safety-2.pdf.
[28] Tesla Model 3, Tesla Model S, Nissan Leaf, Chevrolet Bolt, Hyundai Ioniq, Hyundai Kona, and Kia Nero.
[29] This assumption was tested by calculating the ratio of the efficiency of Tesla Model 3 and Model S (car) to the Model Y and Model X (utility), and the results were found to be within a few percentage points of each other for both vehicle classes.
[30] Miles-per-gallon equivalent.

stations every year for the same driving distance in an ICE vehicle. Moving from 250 to 300 miles of range per charge adds 20 percent to the cost, weight, and volume of batteries but reduces the percentage of total annual miles that require public charging by only 2 percent. At ranges below 200 miles per charge, the number of annual charging trips for the typical driver increases much more quickly, potentially indicating why earlier, lower-range EVs were less popular.

The estimated fuel savings a consumer will experience from buying an EV is illustrated in Figures 3.1 to 3.3. Figure 3.1 shows the fuel cost for ICE vehicles compared with BEV vehicles over 15,000 miles, the approximate average annual mileage for owners of new vehicles.[31] This shows that even factoring in some charging at relatively expensive DC fast chargers, BEVs are expected to cost about 60 percent less to fuel than comparable ICE vehicles, resulting in $800 to $1,300 in annual savings, depending on vehicle class.

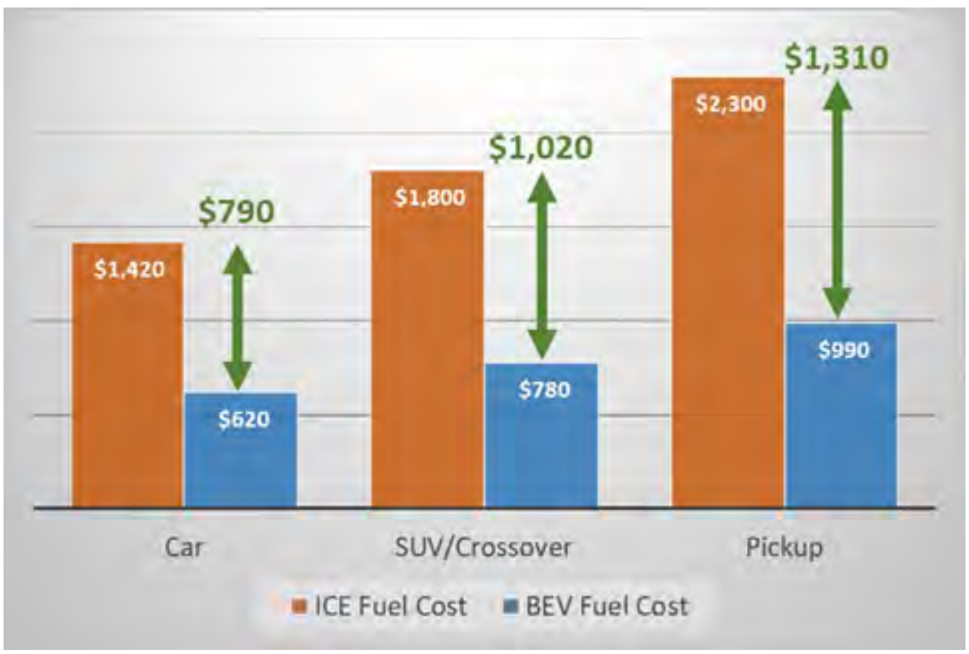

Figure 3.1. Estimated Fuel Cost for 15,000 Miles by Vehicle Class

[31] Based on recent NHTSA VMT schedules. See Tables VI-212-214 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

Figures 3.2 and 3.3 are based on a discounted cash-flow analysis[32] of typical vehicles over the first ownership period[33] and vehicle lifetime.[34] These values represent the present value (at the time of purchase) of future fuel savings from the vehicle.

A number of sensitivities were run with different gas-price assumptions, which are detailed in Appendix A. Even at fairly low gas prices, BEVs offer very large savings over comparable ICE vehicles in all classes. Using the EIA's low-gas-price scenario, which projects an average gas price of $2.33 per gallon over the next 10 years, consumers can still expect to save around one-third of their fuel costs. However, the recent history of gas prices and economic activity indicates that dramatic gas-price declines during challenging economic times tend to be relatively short-lived, while most new vehicles last 15 to 20 years.[35] Because a return to gas prices closer to what we have experienced over the past decade is likely over the next year or two, as the economy recovers from its current downturn, consumers are likely to save a lot more over the first seven years and lifetime of the vehicle than estimated assuming using today's fuel prices.

Another thing to note is that gasoline and electricity prices can vary significantly from state to state. We analyzed costs by state; the results are summarized in Appendix B. This analysis showed that the fuel savings for EVs for 48 of the 50 states were within 30 percent of the average, with the majority of states falling within 10 percent of the average. The only two states outside of the 30 percent range were Oregon and Washington, where consumers who switch to a BEV can expect to see increased savings of 32 percent and 38 percent, respectively, compared with the national average. The high savings in these states result from a combination of higher-than-average gas prices and lower-than-average electricity prices because of the abundance of cheap hydropower in the Pacific Northwest.

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[32] Present value at a 3 percent discount rate in 2019 dollars.

[33] Assumed to be seven years, based on data from IHS Markit (https://news.ihsmarkit.com/prviewer/release_only/slug/automotive-vehicles-getting-older-average-age-light-cars-and-trucks-us-rises-again-201).

[34] VMT schedules in Tables VI-212-214. Survival weighted average lifetime mileage in Table VI-219. Lifetime miles rounded down to 200,000 for all vehicle classes from 210,000 for cars and 230,000 for light trucks
(https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

[35] Antonio Bento, Kevin Roth, Yiou Zuo, "Vehicle Lifetime Trends and Scrappage Behavior in the U.S. Used Car Market" (Jan. 18, 2016). Available at http://faculty.sites.uci.edu/kevinroth/files/2011/03/Scrappage_18Jan2016.pdf.

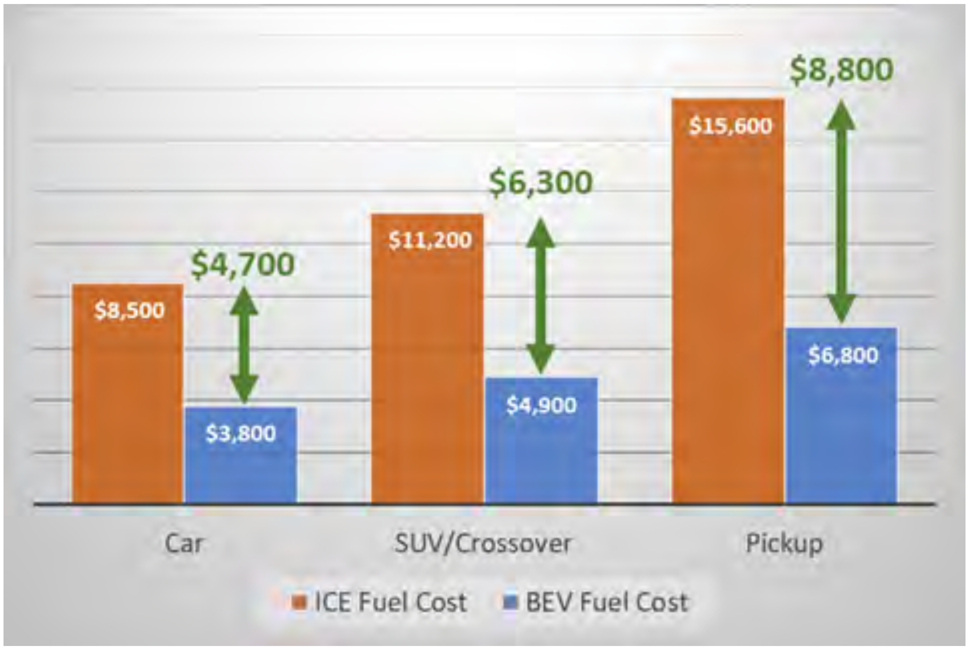

Figure 3.2. Discounted First Owner Fuel Costs for Average BEV and ICE by Vehicle Class[36]

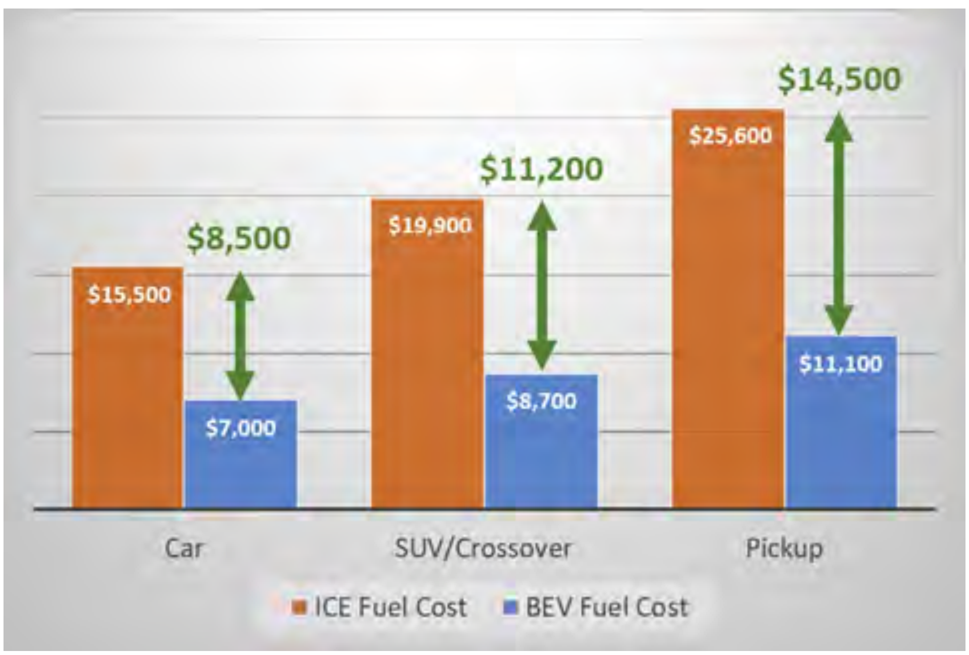

Figure 3.3. Discounted Lifetime Fuel Costs for Average BEV and ICE by Vehicle Class[37]

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[36] Present value at 3 percent discount rate 2019 dollars for the first seven years and 200,000-mile, 15-year lifetime.
[37] Present value at 3 percent discount rate 2019 dollars for the first seven years and 200,000-mile, 15-year lifetime.

Chapter 4—Current EV Ownership Costs: Adding Up the Savings

Introduction

This section applies the findings of the previous three chapters to estimate the relative ownership costs of currently available battery electric vehicles, plug-in hybrid electric vehicles, and comparable internal combustion engine vehicles.

While EVs save consumers money through lower fuel and maintenance costs, most EVs on the market today are priced higher than most comparable ICE models in their class, even after accounting for federal purchase incentives. So this chapter compares the most popular EVs (both BEVs and PHEVs) that consumers can buy today with the best-selling, top-rated, and most efficient non-EVs in their class to determine whether, on net, EVs will save consumers money. It also compares high-performing EVs with the least expensive ICE vehicle in their class that achieves the same 0-to-60-mph acceleration performance to understand the value that certain EVs may provide to the subset of consumers who place value on performance.[38]

Key Findings

- Seven of the nine most popular EVs on the market cost first-time owners less than the best-selling, and top-rated ICE vehicles in their class, in many cases matching or exceeding the performance of some of the top-performing ICE vehicles in their class.
- Lifetime ownership costs for all nine of the most popular EVs on the market under $50,000 are many thousands of dollars cheaper than the best-selling and top-rated ICE vehicles in their class, with typical savings ranging between $6,000 and $10,000.

Approach

This analysis focuses on model year 2020 and 2021 BEVs and PHEVs. It brings together depreciation, financing, fuel, and repair and maintenance costs, and compares them with similar ICE vehicles. It does not include other vehicle ownership costs, such as sales or property taxes, registration fees, and insurance. These costs are also important, but they vary much more by location and driver demographics and history, and are more challenging to generalize. Furthermore, the cost of installing a home Level 2 charger is also not included. Common chargers cost between $300 and $700, with an additional $750 for installation if a 240v outlet is

[38] In our 2019 fuel economy survey, only 12 percent of consumers said that performance was one of the top three attributes they wanted to see improved in their current vehicle as compared to 37 percent who wanted better fuel economy and 26 percent who wanted lower maintenance costs. https://advocacy.consumerreports.org/wp-content/uploads/2019/08/Consumer-Reports-Fuel-Economy-Survey-Report-2019-1.pdf.

not available.[39] This is not an insignificant cost, and it will have to be factored into a purchasing decision, but it is a one-time cost that will not have to be repeated for future BEV purchases. Furthermore, many utilities offer rebates to help reduce the cost of installing an EV charger, and there is a 30 percent federal tax credit on the purchase and installation of home EV chargers.[40] Also, most PHEVs have small enough batteries that they can often be charged directly from a standard wall outlet and don't require a special charger.[41]

The EVs included in this analysis were selected based on popularity and price. They fall into a few categories: BEVs and PHEVs that sold at least 10,000 units in 2019,[42]recently released EV models (Tesla Model Y and Ford Escape PHEV), and models that are expected to arrive in dealerships within two months and can currently be ordered (Ford Mach E and Toyota RAV4 Prime). A price cap of $50,000 was also applied, which eliminated Tesla's Model X and Model S. This left five BEVs and four PHEVs. These vehicles were then sorted into five vehicle classes: hatchbacks, sedans, crossovers, luxury sedans, and luxury crossovers.

For each category, four comparable ICE vehicles were selected. For each vehicle class, three vehicles were selected: the most efficient ICE vehicle, the best-selling ICE vehicle, and the top-rated by Consumer Reports. Furthermore, all five BEVs and one PHEV had near-class-leading acceleration performance. To account for this, these vehicles were also matched against a fourth vehicle, an ICE vehicle selected as having similar 0-to-60-mph acceleration performance. For all vehicles the lowest trim was selected for comparison, except for the performance category, where specific trims were selected to find the lowest-cost vehicle in the class that matched the EV performance level. A summary of the vehicles selected for analysis is shown in Table 4.1. Detailed characteristics of the individual vehicles can be found in Appendix C.

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39 https://www.consumerreports.org/hybrids-evs/how-to-choose-the-best-home-wall-charger-for-your-electric-vehicle/
40 https://www.chargepoint.com/incentives/home.
41 https://www.energy.gov/eere/electricvehicles/charging-home#:~:text=Level%201%20adds%20about%202,even%20some%20all%2Delectric%20vehicles.
42 https://insideevs.com/news/343998/monthly-plug-in-ev-sales-scorecard.

Table 4.1. Summary of Vehicles Selected for Analysis and Comparison

Vehicle Category	Hatchback	Sedan	Crossover	Luxury Sedan	Luxury Crossover
BEV	Chevy Bolt Nissan Leaf		Ford Mach E	Tesla Model 3	Tesla Model Y
PHEV	Toyota Prius Prime	Honda Clarity	Ford Escape PHEV Toyota RAV4 Prime		
Most Efficient	Toyota Prius	Toyota Camry Hybrid	Toyota RAV4 Hybrid	Lexus LS 300h	Lexus NX300h
Best-Selling	Honda Civic Hatchback	Toyota Camry	Toyota RAV4	N/A[43]	Lexus RX350
Top-Rated	Hyundai Elantra GT	Subaru Legacy	Mazda CX5	Audi A4	Infinity QX50
Performance	VW Golf GTI		Mazda CX5 GTR Turbo	BMW 330i	BMW x3 m40i

All ownership costs were calculated as a present value at a discount rate of 3 percent. Costs were calculated separately as capital costs (depreciation and financing) and operating and maintenance (O&M) costs (fuel and repair and maintenance). Ownership costs were calculated for two time periods: the first ownership period and vehicle lifetime. For the first owner an ownership period of seven years was used.[44] For lifetime costs a total lifetime mileage of 200,000 miles was used.[45] For all ownership periods the VMT-per-year figure was determined using the National Highway Traffic Safety Administration's recently updated VMT schedules for cars, SUVs, and pickup trucks.[46]

[43] The Tesla Model 3 is the best-selling luxury sedan. The BMW 3-series is the best selling ICE vehicle in the class so the 330i is used as both the best-selling and performance comparison for the Model 3.
[44] https://news.ihsmarkit.com/prviewer/release_only/slug/automotive-vehicles-getting-older-average-age-light-cars-and-trucks-us-rises-again-201.
[45] NHTSA projects survival weighted average lifetime mileage of 210,000 miles for cars and 230,000 miles for light trucks. See Table VI-219 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).
[46] See Tables VI-212-214 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

For estimating capital costs the vehicle was assumed to be purchased with a six-year loan.[47] The interest rate on the loan was 4.7 percent.[48] The initial purchase price for each vehicle was obtained from CR partner TrueCar. TrueCar provides an estimated market average price, based on recent real-world transaction prices, for any vehicle you select. This accounts for the fact that vehicles rarely sell for their manufacturer's suggested retail price (MSRP). For EVs for which federal tax credits were available, the value of the federal tax credit was subtracted from the vehicle purchase price. Any state tax incentives were not factored into the analysis. For the first owner, the owner was then assumed to recover the residual value of the vehicle at the time of sale. A single depreciation curve was applied uniformly to all vehicles based on the analysis in Chapter 1. The specifics of the depreciation curve are described in Appendix D.

Operating and maintenance costs were calculated based on the approaches laid out in Chapters 2 and 3. Maintenance costs were calculated each year based on the per-mile numbers in Table 2.1. Fuel costs were calculated as described in Chapter 3 for BEVs and ICE vehicles using the EIA's AEO 2020 baseline scenario gasoline and electricity cost projections into the future. Vehicle efficiencies were taken from CR's real-world fuel-economy tests, where available; EPA ratings were used for vehicles not yet tested by CR.[49]

For BEVs the fraction of miles charged at home vs. public fast charging was adjusted for their actual EPA-rated range, and the range was reduced by 10 percent after five years and 20 percent after 10 years to account for battery degradation.[50] This results in some small increases in average per-mile charging costs for BEVs over time. For PHEVs the average miles driven on electricity vs. gasoline was estimated using the Society of Automotive Engineers' Standard J2841 Multi-Day Individual Utility Factor.[51] It was developed based on real-world driving data from individual consumers and estimates the percentage of miles that individuals are likely to drive on electric vs. gasoline, based on the electric range of their vehicle. All charging for PHEVs is assumed to be home charging because PHEVs can easily run on gasoline for longer trips.

Detailed Findings

Across all ownership periods almost all BEVs and PHEVs showed significant savings over all comparable vehicles. In general, savings were greater relative to the best-selling and Consumer

[47] The average new-car loan in June 2020 was 70 months (https://www.edmunds.com/industry/press/auto-loan-interest-rates-see-a-slight-lift-in-june-according-to-edmunds.html).
[48] Based on rates for consumers with a credit score between 660 and 720 (https://www.experian.com/blogs/ask-experian/auto-loan-rates-by-credit-score).
[49] Fueleconomy.gov.
[50] Based on data on battery degradation from real-world values averaging 2 percent per year (https://storage.googleapis.com/geotab-sandbox/ev-battery-degradation/index.html).
[51] https://www.sae.org/standards/content/j2841_200903.

Reports' top-rated vehicles than when compared with the most efficient vehicles. This is expected because most fuel-efficiency technologies for ICE vehicles are known to pay for themselves many times over in increased fuel savings, reducing the ownership costs of these vehicles.[52] Alternatively, savings really ramp up when buyers seek an ICE vehicle that achieves the same acceleration performance as an EV. This reflects the fact that achieving high performance in an ICE vehicle requires a larger, more expensive engine that is also much less efficient, increasing both the capital and operating costs of the vehicle compared with a more typical vehicle in the class. While most PHEVs are not tuned to perform better than most ICE vehicles in their class, all BEVs had near-class-leading acceleration performance.

A summary of the present-value lifetime savings for all nine EVs compared with the best-selling vehicle in their class is presented in Figure 4.1. It shows that in all cases the EV provides lifetime savings worth thousands of dollars at the time of purchase. This general conclusion also holds for comparisons with the top-rated and most efficient ICE vehicle[53] in their class. Detailed cost breakdowns, as well as sensitivity cases, are available for all vehicles in Appendix E.

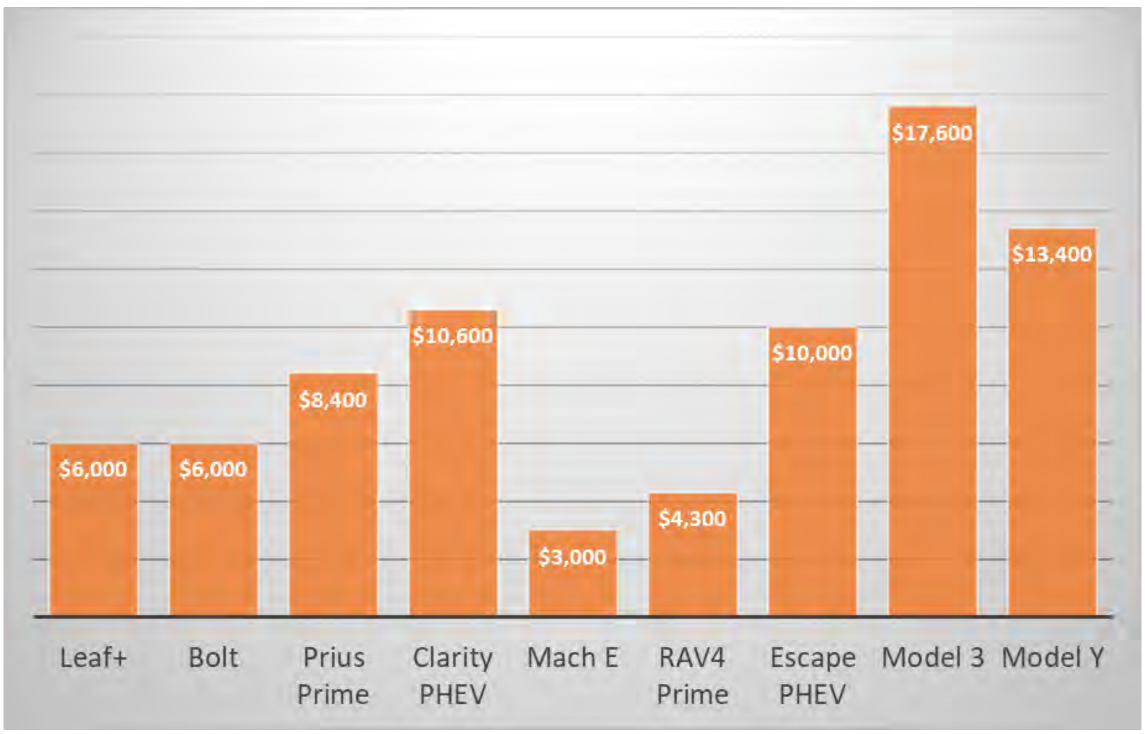

Figure 4.1. Lifetime Savings From EVs vs. Best-Selling ICE Vehicles in Class[54]

[52] On average, fuel-efficiency technology was found to provide a 3-to-1 return on investment (https://advocacy.consumerreports.org/wp-content/uploads/2019/08/The-Un-SAFE-Rule-How-a-Fuel-Economy-Rollback-Costs-Americans-Billions-in-Fuel-Savings-and-Does-Not-Improve-Safety-2.pdf).
[53] For the Ford Mach E, it only breaks even with Toyota RAV4 Hybrid, which costs over $10,000 less and is highly efficient.
[54] Costs as present value at a 3 percent discount rate in 2019 dollars.

Detailed results for the first owner in the hatchback and crossover class are shown in Figures 4.2 and 4.3. These figures break out the capital and O&M costs in addition to the totals. They illustrate that while in all these cases the EVs had higher capital costs, the cumulative fuel, repair, and maintenance savings close the ownership cost gap, resulting in overall savings in most comparisons. The two exceptions are the Toyota RAV4 Prime, which only roughly breaks even with the base RAV4 LE and the efficient RAV4 hybrid. However the RAV4 prime is currently selling for an average of more than $1,300 over MSRP,[55] likely indicating that demand is outpacing supply, which makes sense because it offers a higher trim level and higher performance at roughly the same net price as the base model. The other vehicle with lower savings is the Ford Mach E, which is available for preorder at around MSRP and expected to hit dealer lots in the coming months.[56] This vehicle is designed and marketed to be more of a performance/semi-luxury vehicle, and its buyers are more likely to be cross shopping for other higher performance or luxury vehicles than for the base model crossovers it is compared with here.

Figure 4.2. First Owner Capital, O&M, and Total Costs for Hatchbacks[57]

[55] This higher purchase price is included in the analysis, so consumers who can buy the vehicle at MSRP or less will see savings vs. other RAV4 trim levels.
[56] Rumored preorder numbers range from fewer than 10,000 to more than 40,000 of an estimated 20,000 model year 2021 vehicles expected to be available in the U.S. (https://electrek.co/2019/11/27/ford-mustang-mach-e-first-edition-sold-out-year-early/#:~:text=All%20we%20know%20is%20that,electric%20car%20revealed%20last%20week, https://www.torquenews.com/9539/2021-ford-mustang-mach-e-order-bank-opens-may-11).
[57] Costs as present value at a 3 percent discount rate in 2019 dollars.

Figure 4.3. First Owner Capital, O&M, and Total Costs for Crossovers[58]

CR surveys have consistently shown that most consumers are satisfied with average performance and that more consumers would prefer increased fuel economy (37 percent of consumers) or lower maintenance costs (26 percent) than would prefer more horsepower (12 percent).[59]

Automakers, however, focus most of their marketing on performance, making it a key theme in almost half of their advertisements.[60] Given this heavy industry focus on performance, high-performing EVs were compared with ICE vehicles that achieve similar 0-to-60-mph acceleration performance. The results, shown in Figure 4.4, illustrate the first owner and lifetime savings of high-performing EVs relative to ICE vehicles that achieve similar acceleration levels. The results are stark: In most cases new-car buyers who care a lot about performance can get that performance for around $10,000 less by buying an EV.

[58] Costs as present value at a 3 percent discount rate in 2019 dollars.
[59] https://advocacy.consumerreports.org/wp-content/uploads/2019/08/Consumer-Reports-Fuel-Economy-Survey-Report-2019-1.pdf.
[60] https://advocacy.consumerreports.org/wp-content/uploads/2018/09/auto-ad-content-fact-sheet-9.19.18.pdf.

Figure 4.4. First Owner and Lifetime Savings From EVs vs. ICE That Matches Acceleration[61]

Overall, these results show that many EVs on the market today can provide consumers the two features they say they most want improved in their next vehicle—lower fuel and maintenance costs—in addition to the feature the auto industry advertises most often —performance—all at a lower overall cost.

[61] Costs as present value at a 3 percent discount rate in 2019 dollars.

Chapter 5—Used EVs: A Pathway Toward More Affordable Transportation

Introduction

While new cars get most of the attention in the automotive industry, used cars account for most car purchases—70 percent of them in 2019.[62] This is not surprising because used cars can offer consumers tremendous value: The first owner bears the brunt of the steepest period of depreciation, while new vehicles today are expected to run for an average of over 200,000 miles.[63] Hence, used-car buyers capture a large fraction of the lifetime utility of a vehicle while paying a relatively low percentage of the new-car price.

For ICE vehicles this used-car savings is partially offset by higher expected repair and maintenance costs for older vehicles, and the need to continue to pay for fuel, which makes up a large fraction of the total lifetime ownership costs for ICE vehicles. However, as shown in the previous chapters, EVs significantly reduce these costs, while their biggest drawback—higher purchase prices—is partially offset by depreciation. This chapter explores how the savings opportunities of EVs only increase for their subsequent owners, offering a potential pathway toward lowering the cost of transportation for lower-income drivers.

Key Findings

- While new EVs offer significant cost savings over comparable ICE vehicles, the relative cost savings of an EV purchased when it is 5 to 7 years old can be two or three times as large.

Approach

The same ownership cost model described in Chapter 4 was used to estimate the potential savings for used-EV buyers—with a few modifications. Used vehicles were assumed to cost the residual value plus a dealer markup of 15 percent for 3-year-old vehicles and 20 percent for 5-year-old and older vehicles.[64] The loan and ownership period were also changed to five years

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[62] There were 41 million used-car purchases in 2019, according to Edmunds.com, compared with 17 million new-car sales (https://www.edmunds.com/industry/press/used-vehicle-market-poised-for-record-sales-in-2019-according-to-new-report-from-edmunds.html, https://www.caranddriver.com/news/a30416492/us-auto-sales-2019).

[63] NHTSA projects survival weighted average lifetime mileage of 210,000 miles for cars and 230,000 miles for light trucks, with the average vehicle surviving around 15 years. See Table VI-219 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

[64] Based on analysis of the difference between private party and dealer retail value estimates at Edmunds.com for the vehicles in the hatchback class included in table 4.1.

each to reflect the typically shorter ownership period of used cars.[65] And the interest rate was increased to 6 percent to reflect higher rates on used cars.[66] Used vehicles were then analyzed for vehicles that were purchased when they were 3, 5, and 7 years old.

Detailed Findings

Detailed cost breakdowns are shown in Figure 5.1 for the ownership cost of purchasing a 7-year-old hatchback. It shows that operation and maintenance costs make up a much larger percentage of the total ownership costs for used EVs when compared to the new cars analyzed in the previous chapter. This results in even greater total savings for used EVs vs. comparable ICE vehicles.

Figure 5.1. 7-Year-Old Used-Vehicle Capital, O&M, and Total Costs for Hatchbacks[67]

This increase in savings is better illustrated in Figure 5.2, which shows the percentage savings for EVs relative to the best-selling vehicle in the class at different purchase times, from new to 7 years old. It shows that while purchasing a new EV saves consumers money, the savings increase significantly as the vehicle's age when purchased increases. The reason is that depreciation reduces the capital cost, increasing the portion of the total cost of ownership from

[65] Average ownership period of used cars almost 66 months (https://news.ihsmarkit.com/prviewer/release_only/slug/automotive-vehicles-getting-older-average-age-light-cars-and-trucks-us-rises-again-201).
[66] Based on rates for consumers with a credit score between 660 and 720 (https://www.experian.com/blogs/ask-experian/auto-loan-rates-by-credit-score).
[67] Present value in the year of initial vehicle purchase at a 3 percent discount rate in 2019 dollars.

operation and maintenance, where EVs have a significant advantage. In fact, the relative savings from buying an EV are two to three times as high if the EV is a 5- to 7-year-old used model, compared with purchasing a new EV.

Overall, these results show that used EVs are likely to be a major boon for used-car buyers, especially lower-income buyers. It will take time until these savings are available to a large number of consumers, both for the volume of EV sales in the new-car market to increase and for new EVs to be transferred from their first owners to the secondary market. Unfortunately, both of these factors will delay the realization of these savings to large numbers of potential used-car buyers for a number of years.

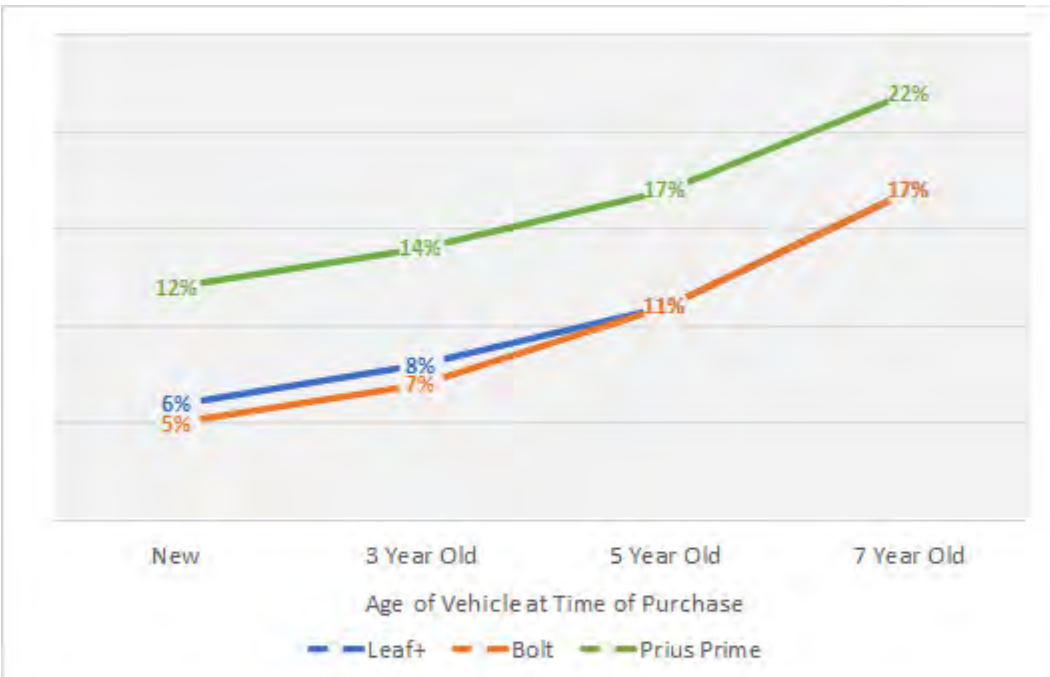

Figure 5.2. EV Percent Savings Compared With Best-Selling ICE by Vehicle Age at Purchase

Appendix A—Fuel-Cost Sensitivities

Table A.1. Discounted Fuel Savings for an Average BEV Compared With Average ICE, by Class, Assuming National Average Gasoline and Electricity Prices From AEO 2020 Low-Gas-Price Scenario

Class	15,000 miles	First Owner Savings	Lifetime Savings
Car	$470	$3,100	$5,200
Utility	$610	$4,200	$6,900
Pickup	$790	$5,900	$9,100

Table A.2. Discounted Fuel Savings for an Average BEV Compared With Average ICE, by Class, Assuming National Average Electricity Prices From AEO 2020 Baseline and Gas Price From AAA on Aug. 18, 2020[68]

Class	15,000 miles	First Owner Savings	Lifetime Savings
Car	$400	$2,600	$4,300
Utility	$520	$3,600	$5,800
Pickup	$670	$5,100	$7,700

[68] National average gas price on Aug. 18, 2020, was $2.18 per gallon (https://gasprices.aaa.com).

Appendix B—Fuel Costs by State

Table B.1. Savings from an Average BEV vs. an Average ICE per 15,000 Miles of Driving, by State

	Car			Crossover/SUV			Pickup			
State	**Gasoline**	**Electric**	**Savings**	**Gasoline**	**Electric**	**Savings**	**Gasoline**	**Electric**	**Savings**	**Relative Savings vs. National Average**
Alabama	$1,294	$591	$703	$1,648	$742	$906	$2,101	$940	$1,161	-12%
Alaska	$1,863	$917	$946	$2,373	$1,150	$1,223	$3,026	$1,458	$1,568	19%
Arizona	$1,499	$602	$896	$1,909	$756	$1,153	$2,434	$958	$1,476	12%
Arkansas	$1,309	$510	$799	$1,667	$640	$1,027	$2,126	$811	$1,315	0%
California	$1,693	$804	$889	$2,157	$1,009	$1,148	$2,750	$1,279	$1,471	12%
Colorado	$1,388	$597	$791	$1,769	$749	$1,020	$2,255	$950	$1,306	-1%
Connecticut	$1,475	$914	$561	$1,880	$1,148	$732	$2,397	$1,454	$942	-28%
Delaware	$1,439	$638	$801	$1,833	$800	$1,032	$2,337	$1,014	$1,323	1%
Dist. of Columbia	$1,513	$621	$892	$1,927	$779	$1,148	$2,458	$987	$1,470	12%
Florida	$1,337	$573	$763	$1,703	$720	$983	$2,171	$912	$1,259	-4%
Georgia	$1,296	$577	$719	$1,651	$724	$927	$2,105	$918	$1,187	-10%
Hawaii	$1,863	$1,327	$537	$2,374	$1,665	$709	$3,027	$2,110	$917	-30%
Idaho	$1,479	$514	$965	$1,884	$645	$1,240	$2,403	$817	$1,586	21%
Illinois	$1,378	$612	$765	$1,755	$768	$987	$2,238	$974	$1,264	-4%
Indiana	$1,331	$587	$744	$1,696	$737	$959	$2,162	$933	$1,229	-6%

	Car			Crossover/SUV			Pickup			
State	**Gasoline**	**Electric**	**Savings**	**Gasoline**	**Electric**	**Savings**	**Gasoline**	**Electric**	**Savings**	**Relative Savings**
Iowa	$1,354	$587	$767	$1,725	$736	$988	$2,199	$933	$1,266	-4%
Kansas	$1,345	$624	$720	$1,713	$783	$930	$2,184	$993	$1,191	-9%
Kentucky	$1,376	$533	$843	$1,753	$669	$1,084	$2,236	$848	$1,388	6%
Louisiana	$1,301	$497	$804	$1,657	$623	$1,034	$2,113	$790	$1,323	1%
Maine	$1,467	$741	$725	$1,868	$930	$938	$2,382	$1,179	$1,204	-8%
Maryland	$1,446	$660	$785	$1,842	$828	$1,013	$2,348	$1,050	$1,298	-1%
Massachusetts	$1,436	$882	$555	$1,830	$1,106	$723	$2,333	$1,402	$931	-29%
Michigan	$1,345	$706	$639	$1,714	$886	$828	$2,185	$1,123	$1,062	-19%
Minnesota	$1,382	$615	$767	$1,761	$771	$989	$2,245	$978	$1,267	-3%
Mississippi	$1,298	$555	$742	$1,654	$697	$956	$2,108	$883	$1,225	-7%
Missouri	$1,314	$561	$752	$1,674	$705	$969	$2,134	$893	$1,241	-5%
Montana	$1,473	$545	$927	$1,876	$684	$1,192	$2,392	$867	$1,525	16%
Nebraska	$1,391	$542	$849	$1,772	$680	$1,092	$2,259	$862	$1,397	6%
Nevada	$1,560	$599	$961	$1,988	$752	$1,236	$2,534	$952	$1,582	20%
New Hampshire	$1,424	$847	$577	$1,814	$1,062	$752	$2,313	$1,346	$967	-26%
New Jersey	$1,393	$732	$661	$1,775	$919	$856	$2,263	$1,165	$1,098	-16%
New Mexico	$1,350	$610	$741	$1,720	$765	$955	$2,194	$970	$1,224	-7%
New York	$1,425	$842	$582	$1,815	$1,057	$758	$2,314	$1,339	$975	-26%

	Car			Crossover/SUV			Pickup			
State	**Gasoline**	**Electric**	**Savings**	**Gasoline**	**Electric**	**Savings**	**Gasoline**	**Electric**	**Savings**	**Relative Savings**
North Carolina	$1,396	$557	$839	$1,778	$699	$1,079	$2,267	$886	$1,382	5%
North Dakota	$1,437	$511	$926	$1,831	$642	$1,189	$2,335	$813	$1,521	16%
Ohio	$1,389	$614	$775	$1,770	$771	$999	$2,256	$977	$1,279	-3%
Oklahoma	$1,317	$525	$792	$1,678	$659	$1,019	$2,139	$835	$1,304	-1%
Oregon	$1,600	$542	$1,059	$2,039	$680	$1,359	$2,599	$861	$1,738	32%
Pennsylvania	$1,477	$660	$817	$1,882	$829	$1,053	$2,399	$1,050	$1,349	3%
Rhode Island	$1,463	$851	$612	$1,864	$1,068	$795	$2,376	$1,354	$1,022	-22%
South Carolina	$1,314	$616	$698	$1,673	$773	$901	$2,134	$979	$1,154	-12%
South Dakota	$1,401	$564	$837	$1,784	$708	$1,076	$2,275	$897	$1,378	5%
Tennessee	$1,336	$534	$802	$1,702	$670	$1,032	$2,170	$850	$1,321	1%
Texas	$1,298	$566	$732	$1,654	$710	$944	$2,109	$900	$1,209	-8%
Utah	$1,472	$545	$927	$1,875	$684	$1,191	$2,391	$867	$1,524	16%
Vermont	$1,474	$803	$670	$1,877	$1,008	$870	$2,394	$1,277	$1,116	-15%
Virginia	$1,355	$570	$786	$1,727	$715	$1,012	$2,202	$906	$1,296	-1%
Washington	$1,594	$490	$1,104	$2,031	$615	$1,416	$2,589	$779	$1,810	38%
West Virginia	$1,463	$543	$920	$1,864	$682	$1,182	$2,377	$864	$1,513	15%
Wisconsin	$1,422	$670	$752	$1,812	$841	$971	$2,310	$1,065	$1,244	-5%
Wyoming	$1,379	$556	$823	$1,757	$697	$1,059	$2,240	$883	$1,356	3%

Appendix C—Vehicle Characteristics

Table C.1. Selected Vehicle Characteristics

	Trim	Purchase Price[69]	Fuel Efficiency (mpg)[70]	Electric Efficiency (miles/kWh)[71]	Electric Range (miles)	0-60 Acceleration (s)[72]
Hatchbacks						
Nissan Leaf E+	S Plus	$25,398		3.2	226	7.0
Chevy Bolt	LT	$26,304		3.5	259	6.8
Toyota Prius Prime	LE	$23,885	54	4	25	10.8
Toyota Prius	LE	$23,443	52			10.3
Honda Civic Hatchback	LX	$20,363	34			7.1
Hyundai Elantra GT	GT Automatic	$18,555	28			8.7
VW Golf GTI	2.0T S DSG	$27,879	27			6.6
Sedans						
Honda Clarity PHEV	Base	$23,345	42	3.3	48	8.3
Toyota Camry Hybrid	LE	$24,846	47			7.8
Toyota Camry	LE	$21,690	32			8.0
Subaru Legacy	2.5i	$21,168	28			8.9

[69] Based on TrueCar.com market average price for Arlington, VA in August 2020 for specified trim with no options.
[70] Based on CR test results when available or EPA when not.
[71] Based upon EPA MPGe rating.
[72] Numbers from CR tests when available, but based on manufacturer spec or other automotive testing and rating websites. In general 0-60 times are imprecise measures, with CR numbers often a little higher than manufacturer spec when available.

	Trim	Purchase Price	Fuel Efficiency (mpg)	Electric Efficiency (miles/kWh)	Electric Range (miles)	0-60 Acceleration (s)
Crossovers						
Ford Mach E	Select	$36,495		3.4	230	<6
Toyota RAV4 Prime	SE	$33,105	38	2.8	42	5.7
Ford Escape PHEV	SE	$28,087	41	3	38	8.7
Toyota RAV4 Hybrid	LE	$27,301	37			7.8
Toyota RAV4	LE	$24,369	27			8.3
Mazda CX5	Sport	$25,021	24			8.6
Mazda CX5 GTR turbo	GTR Turbo	$34,670	24			6.2
Luxury Sedan						
Tesla Model 3	SR Plus	$37,990		4.2	250	5.3
Lexus ES 300h	300h	$41,159	44			8.3
Audi A4	Premium 40 TFSI	$35,953	27			6.3
BMW 330i[73]	330i RWD	$39,003	28			6.4[74]
Luxury Crossovers						
Tesla Model Y	Long Range	$49,990		3.6	316	4.8
Lexus NX hybrid	300h AWD	$38,493	29			8.9
Lexus RX	350 FWD	$42,885	22			7.5
Infinity QX50	Pure	$33,918	22			7.2
BMW X3 m40i	xDrive M40i	$53,105	23			4.8

[73] The model 3 is the best selling vehicle in this class, but the BMW 3 series is the best selling ICE vehicle in the class, so it is used for both the performance and best selling category.
[74] CR test result, although rated at around 5.3 seconds elsewhere.

Appendix D—Depreciation Curve

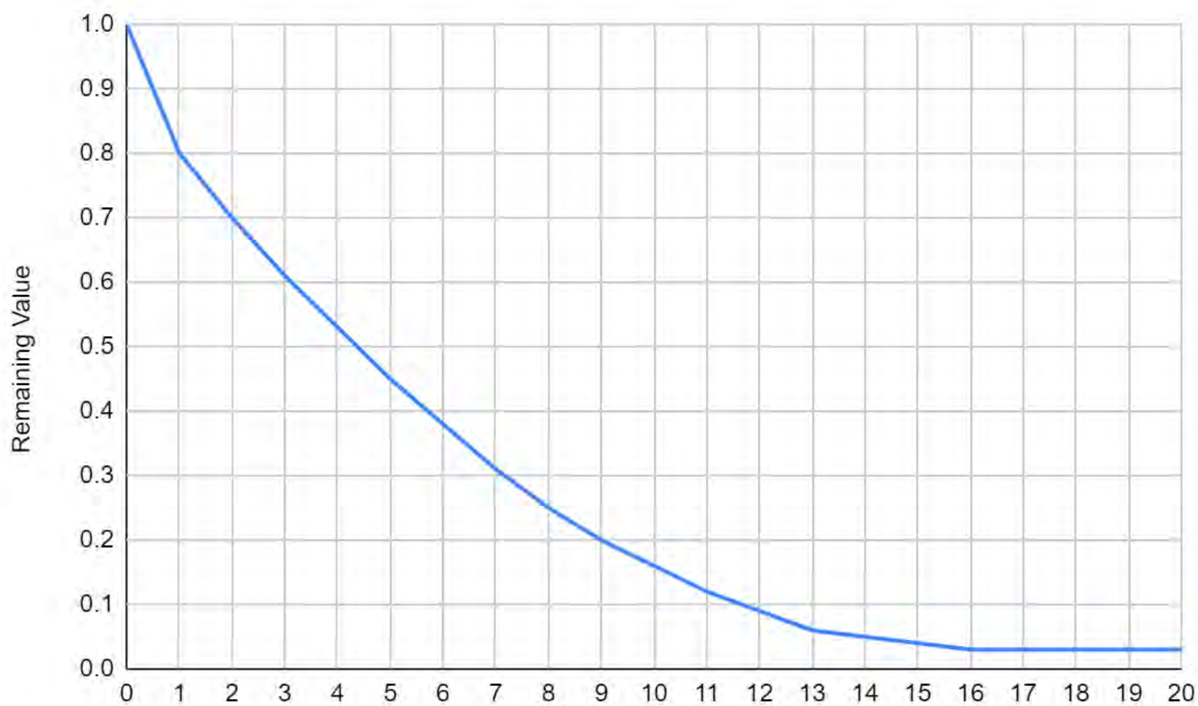

Figure D.1. Depreciation Curve

Appendix E—Detailed Results of New-Car Ownership Cost Analysis

Table E.1. Detailed Results of New-Car Ownership Cost Analysis for All Vehicles

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks						
Leaf E+	$20,100	$5,900	$26,100	$26,400	$12,500	$38,900
Bolt	$20,900	$5,400	$26,300	$27,300	$11,600	$38,900
Prius Prime	$18,900	$5,500	$24,400	$24,800	$11,700	$36,500
Prius	$18,600	$8,800	$27,400	$24,300	$18,700	$43,000
Civic Hatchback	$16,200	$11,600	$27,700	$21,100	$23,700	$44,900
Elantra GT	$14,700	$13,300	$28,000	$19,300	$26,900	$46,100
Golf GTI	$22,100	$13,600	$35,800	$28,900	$27,500	$56,500
Sedans						
Clarity PHEV	$18,500	$6,500	$25,000	$24,200	$12,300	$36,500
Camry Hybrid	$19,700	$9,400	$29,100	$25,800	$19,700	$45,500
Camry	$17,200	$12,100	$29,300	$22,500	$24,700	$47,200
Legacy	$16,800	$13,300	$30,100	$22,000	$26,900	$48,800
Crossovers						
Mach E	$28,900	$5,900	$34,800	$37,900	$12,100	$50,000
RAV4 Prime	$26,300	$6,900	$33,100	$34,400	$14,300	$48,600
Escape PHEV	$22,300	$6,600	$28,900	$29,200	$13,800	$42,900
RAV4 Hybrid	$21,700	$11,300	$33,000	$28,300	$22,600	$51,000
RAV4	$19,300	$14,100	$33,500	$25,300	$27,600	$52,900
CX5	$19,800	$15,400	$35,300	$26,000	$29,900	$55,900
CX5 GTR turbo	$27,500	$15,400	$42,900	$36,000	$29,900	$65,900

	Initial Ownership Period			Lifetime		
	Capital	**O&M**	**Total**	**Capital**	**O&M**	**Total**
Luxury Sedan						
Model 3	$30,100	$4,700	$34,800	$39,400	$10,300	$49,800
ES 300h	$32,600	$9,800	$42,400	$42,700	$20,400	$63,200
A4	$28,500	$13,600	$42,200	$37,300	$27,500	$64,800
330i	$30,900	$13,300	$44,200	$40,500	$26,900	$67,400
Luxury Crossovers						
Model Y	$39,700	$5,200	$44,900	$51,900	$11,000	$62,900
NX hybrid	$30,500	$13,400	$44,000	$40,000	$26,400	$66,300
RX	$34,000	$16,500	$50,500	$44,500	$31,800	$76,300
QX50	$26,900	$16,500	$43,400	$35,200	$31,800	$67,000
X3 m40i	$42,100	$16,000	$58,100	$55,100	$30,800	$86,000

Appendix F—Sensitivity Cases for New-Car Ownership Cost Analysis

This section includes three primary sensitivity cases:

- **Gas Prices-**This sensitivity case relates to the gas price assumptions. Instead of the AEO 2020 baseline, the gas prices are changed to match the AEO 2020 low gas price scenario.
- **Vehicle Ownership Period-**This sensitivity case changes the initial ownership period from 7 years to 5 years. In addition, the loan length is changed from 6 years to 5 years.
- **Discount Rate-**This sensitivity case changes the discount rate from 3% to 7%.

Table F.1. Results of Gas Price Sensitivity, AEO 2020 Low Gas Price

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks						
Leaf E+	$20,100	$5,900	$26,100	$26,400	$12,500	$38,900
Bolt	$20,900	$5,400	$26,300	$27,300	$11,600	$38,900
Prius Prime	$18,900	$5,600	$24,500	$24,800	$10,600	$35,400
Prius	$18,600	$7,700	$26,300	$24,300	$16,400	$40,800
Civic Hatchback	$16,200	$9,800	$26,000	$21,100	$20,300	$41,400
Elantra GT	$14,700	$11,200	$25,900	$19,300	$22,700	$41,900
Golf GTI	$22,100	$11,400	$33,600	$28,900	$23,200	$52,100
Sedans						
Clarity PHEV	$18,500	$6,100	$24,600	$24,200	$11,500	$35,800
Camry Hybrid	$19,700	$8,100	$27,800	$25,800	$17,200	$43,000
Camry	$17,200	$10,200	$27,400	$22,500	$21,000	$43,500
Legacy	$16,800	$11,200	$28,000	$22,000	$22,700	$44,600

	Initial Ownership Period			Lifetime		
	Capital	**O&M**	**Total**	**Capital**	**O&M**	**Total**
Crossovers						
Mach E	$28,900	$5,900	$34,800	$38,900	$12,100	$51,000
RAV4 Prime	$26,300	$7,500	$33,800	$34,400	$13,700	$48,100
Escape PHEV	$22,300	$7,200	$29,500	$29,200	$13,300	$42,400
RAV4 Hybrid	$21,700	$9,700	$31,300	$28,300	$19,500	$47,800
RAV4	$19,300	$11,900	$31,200	$25,300	$23,300	$48,600
CX5	$19,800	$12,900	$32,700	$26,000	$25,000	$51,000
CX5 GTR turbo	$27,500	$12,900	$40,400	$36,000	$25,000	$61,000
Luxury Sedan						
Model 3	$30,100	$4,700	$34,800	$39,400	$10,300	$49,800
ES 300h	$32,600	$8,400	$41,100	$42,700	$17,700	$60,500
A4	$28,500	$11,400	$40,000	$37,300	$23,200	$60,500
330i	$30,900	$11,200	$42,100	$40,500	$22,700	$63,100
Luxury Crossovers						
Model Y	$39,700	$5,200	$44,900	$51,900	$11,000	$62,900
NX hybrid	$30,500	$11,300	$41,800	$40,000	$22,300	$62,200
RX	$34,000	$13,700	$47,700	$44,500	$26,500	$71,000
QX50	$26,900	$13,700	$40,600	$35,200	$26,500	$61,700
X3 m40i	$42,100	$13,300	$55,400	$55,100	$25,700	$80,800

Table F.2. Results of Ownership Period Sensitivity, 5 year Initial Ownership Period

	Initial Ownership Period		
	Capital	**O&M**	**Total**
Hatchbacks			
Leaf E+	$16,600	$4,200	$20,800
Bolt	$17,200	$3,900	$21,000
Prius Prime	$15,600	$4,600	$20,200
Prius	$15,300	$6,200	$21,500
Civic Hatchback	$13,300	$8,300	$21,600
Elantra GT	$12,100	$9,600	$21,700
Golf GTI	$18,200	$9,900	$28,100
Sedans			
Clarity PHEV	$15,200	$4,800	$20,000
Camry Hybrid	$16,200	$6,700	$22,900
Camry	$14,200	$8,700	$22,900
Legacy	$13,800	$9,600	$23,400
Crossovers			
Mach E	$23,800	$4,100	$28,000
RAV4 Prime	$21,600	$5,500	$27,100
Escape PHEV	$18,300	$5,300	$23,600
RAV4 Hybrid	$17,800	$8,100	$25,900
RAV4	$15,900	$10,200	$26,100
CX5	$16,300	$11,200	$27,500
CX5 GTR turbo	$22,600	$11,200	$33,800

	Initial Ownership Period		
	Capital	**O&M**	**Total**
Luxury Sedan			
Model 3	$24,800	$3,200	$28,000
ES 300h	$26,900	$7,000	$33,800
A4	$23,500	$9,900	$33,400
330i	$25,500	$9,600	$35,100
Luxury Crossovers			
Model Y	$32,600	$3,700	$36,300
NX hybrid	$25,100	$9,600	$34,800
RX	$28,000	$12,000	$39,900
QX50	$22,100	$12,000	$34,100
X3 m40i	$34,700	$11,500	$46,200

Table F.3. Results of Discount Rate Sensitivity, 7% Discount Rate

	Initial Ownership Period			**Lifetime**		
	Capital	**O&M**	**Total**	**Capital**	**O&M**	**Total**
Hatchbacks						
Leaf E+	$18,600	$5,100	$23,700	$23,200	$9,400	$32,600
Bolt	$19,300	$4,700	$24,000	$24,000	$8,700	$32,700
Prius Prime	$17,500	$5,500	$23,000	$21,800	$9,000	$30,800
Prius	$17,200	$7,600	$24,800	$21,400	$14,000	$35,400
Civic Hatchback	$14,900	$10,000	$24,900	$18,600	$17,900	$36,500
Elantra GT	$13,600	$11,500	$25,100	$16,900	$20,300	$37,200
Golf GTI	$20,400	$11,800	$32,200	$25,500	$20,800	$46,200

	Initial Ownership Period			Lifetime		
	Capital	**O&M**	**Total**	**Capital**	**O&M**	**Total**
Sedans						
Clarity PHEV	$17,100	$5,600	$22,700	$21,300	$9,400	$30,700
Camry Hybrid	$18,200	$8,100	$26,300	$22,700	$14,800	$37,500
Camry	$15,900	$10,400	$26,300	$19,800	$18,600	$38,400
Legacy	$15,500	$11,500	$27,000	$19,300	$20,300	$39,600
Crossovers						
Mach E	$26,700	$5,100	$31,800	$33,300	$9,100	$42,500
RAV4 Prime	$24,300	$6,500	$30,800	$30,200	$10,600	$40,800
Escape PHEV	$20,600	$6,300	$26,800	$25,700	$10,200	$35,900
RAV4 Hybrid	$20,000	$9,800	$29,800	$24,900	$17,200	$42,100
RAV4	$17,900	$12,200	$30,100	$22,300	$21,000	$43,300
CX5	$18,300	$13,300	$31,700	$22,900	$22,800	$45,700
CX5 GTR turbo	$25,400	$13,300	$38,700	$31,700	$22,800	$54,500
Luxury Sedan						
Model 3	$27,800	$4,000	$31,900	$34,700	$7,700	$42,400
ES 300h	$30,200	$8,400	$38,600	$37,600	$15,300	$52,900
A4	$26,300	$11,800	$38,100	$32,800	$20,800	$53,600
330i	$28,600	$11,500	$40,100	$35,600	$20,300	$55,900
Luxury Crossovers						
Model Y	$36,600	$4,500	$41,100	$45,700	$8,300	$54,000
NX hybrid	$28,200	$11,600	$39,800	$35,200	$20,100	$55,200
RX	$31,400	$14,300	$45,700	$39,200	$24,300	$63,500
QX50	$24,900	$14,300	$39,100	$31,000	$24,300	$55,300
X3 m40i	$38,900	$13,800	$52,700	$48,500	$23,500	$72,000

Appendix G—Detailed Results of Used-Car Ownership Cost Analysis

Table G.1. Costs of Used Vehicles Over Five Year Ownership Period

	3-year-old used vehicle			5-year-old used vehicle			7-year-old used vehicle		
	Capital	O&M	Total	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks									
Leaf E+	$13,600	$4,700	$18,300	$11,200	$5,000	$16,200	$8,100	$5,100	$13,300
Bolt	$14,100	$4,300	$18,400	$11,600	$4,700	$16,300	$8,400	$4,800	$13,200
Prius Prime	$12,800	$4,400	$17,200	$10,500	$4,700	$15,200	$7,600	$4,800	$12,500
Prius	$12,600	$7,100	$19,600	$10,300	$7,500	$17,800	$7,500	$7,600	$15,100
Civic Hatchback	$10,900	$9,000	$19,900	$9,000	$9,300	$18,300	$6,500	$9,400	$15,900
Elantra GT	$9,900	$10,100	$20,100	$8,200	$10,500	$18,600	$5,900	$10,500	$16,400
Golf GTI	$14,900	$10,400	$25,300	$12,300	$10,700	$23,000	$8,900	$10,700	$19,600
Sedans									
Clarity PHEV	$12,500	$4,800	$17,300	$10,300	$4,700	$15,000	$7,500	$4,500	$12,000
Camry Hybrid	$13,300	$7,400	$20,800	$10,900	$7,900	$18,800	$7,900	$8,000	$15,900
Camry	$11,600	$9,300	$20,900	$9,500	$9,700	$19,200	$6,900	$9,700	$16,600
Legacy	$11,300	$10,100	$21,500	$9,300	$10,500	$19,800	$6,800	$10,500	$17,200

	3-year-old used vehicle			5-year-old used vehicle			7-year-old used vehicle		
	Capital	O&M	Total	Capital	O&M	Total	Capital	O&M	Total
Crossovers									
Mach E	$19,600	$4,800	$24,300	$16,000	$5,100	$21,200	$11,700	$5,300	$16,900
RAV4 Prime	$17,700	$5,600	$23,300	$14,600	$5,500	$20,100	$10,600	$5,300	$15,900
Escape PHEV	$15,100	$5,400	$20,400	$12,400	$5,300	$17,700	$9,000	$5,100	$14,100
RAV4 Hybrid	$14,600	$9,000	$23,600	$12,000	$9,500	$21,500	$8,700	$9,500	$18,300
RAV4	$13,100	$10,900	$24,000	$10,700	$11,300	$22,100	$7,800	$11,400	$19,200
CX5	$13,400	$11,800	$25,200	$11,000	$12,200	$23,200	$8,000	$12,200	$20,200
CX5 GTR turbo	$18,600	$11,800	$30,400	$15,200	$12,200	$27,500	$11,100	$12,200	$23,300
Luxury Sedan									
Model 3	$20,400	$3,900	$24,200	$16,700	$4,300	$21,000	$12,200	$4,400	$16,600
ES 300h	$22,100	$7,700	$29,800	$18,100	$8,200	$26,300	$13,200	$8,200	$21,400
A4	$19,300	$10,400	$29,600	$15,800	$10,700	$26,500	$11,500	$10,700	$22,200
330i	$20,900	$10,100	$31,000	$17,200	$10,500	$27,600	$12,500	$10,500	$22,900
Luxury Crossovers									
Model Y	$26,800	$4,300	$31,100	$22,000	$4,800	$26,800	$16,000	$4,900	$20,900
NX hybrid	$20,600	$10,400	$31,100	$16,900	$10,900	$27,800	$12,300	$10,900	$23,200
RX	$23,000	$12,600	$35,600	$18,900	$12,900	$31,800	$13,700	$12,900	$26,600
QX50	$18,200	$12,600	$30,800	$14,900	$12,900	$27,800	$10,800	$12,900	$23,700
X3 m40i	$28,500	$12,200	$40,700	$23,400	$12,600	$35,900	$17,000	$12,500	$29,500