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It Ain't Easy Being Green

A Cost-Benefit Analysis of Electric Vehicles in Arizona

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Table of Contents

Executive Summary

The Arizona Corporation Commission (ACC) recently approved an electric vehicle (EV) policy framework to encourage more drivers to purchase EVs.[1] The proposed policy, yet to be implemented, will allow Arizona's public utilities to provide public charging stations for EVs, but pass along the construction costs for those stations to non-EV consumers. Unfortunately, the proposed ACC policy will act as another environmental subsidy that will benefit a few affluent car owners at the expense of every electricity user in the state.

The ACC's misguided policy is a bad solution in search of a problem. In Arizona, EV use has accelerated in recent years thanks to a broad network of publicly available charging stations. The private sector already meets the energy needs of EV users, and private firms have every incentive to continue improving efficiency, technology, and cost-effectiveness to attract new EV owners. Introducing unfair competition from public utilities that can pass their construction expenses on to every ratepayer in Arizona risks driving more efficient private sector providers from the market. Moreover, the proposed ACC policy overpays for the environmental benefits it seeks, and effectively functions like a regressive tax by raising electricity rates on the lower-income households—who spend proportionally more of their earnings on energy bills—without increasing the quality or quantity of the service provided.[2] There are better policies for Arizona to pursue.

Public utilities that build EV charging stations can and should do so without burdening non-EV owners. Other states currently require their public utilities to recoup construction costs by charging higher rates for electricity at the charging stations themselves. In the same way that EV owners do not pay gasoline taxes on fuel they do not consume, non-EV owners should not be forced to pay more for electricity to subsidize charging stations that they do not use.

After describing the Arizona EV market and policy landscape, this study examines the pros and cons of EV subsidies generally and the risks associated with the ACC's proposed policy specifically, and performs a cost-benefit analysis of the personal and social benefits accrued under EV policies by comparing the prices and subsidies associated with a broad range of vehicle makes, models, and engine types. The Economic Research Center at The Buckeye Institute worked closely with the Arizona Free Enterprise Club to conduct this study's careful cost-benefit analysis of the best-selling vehicles and comparable vehicle models across four vehicle types: internal combustion engine (ICV); a hybrid engine with battery and internal combustion, in which the battery is only charged when the vehicle is in operation (HEV); plug-in hybrid with battery and internal combustion, in which the vehicle can operate on battery for only a given range (PHEV); and battery electric, which is a vehicle that runs only on a battery that must be charged externally between trips (EV). That analysis reveals that governments are dramatically overpaying EV owners for the social benefits that the governments purport to seek:

- The average environmental benefits of an EV or PHEV are $346 relative to comparable traditional internal combustion vehicles (ICV) over five years;

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[1] Arizona Corporation Commission Staff Policy Statement for Electric Vehicles, **Electric Vehicle Infrastructure, and the Electrification of the Transportation Sector in Arizona**, December 12, 2018.

[2] **Consumer Expenditure Surveys**, BLS.gov (Last visited May 28, 2019).

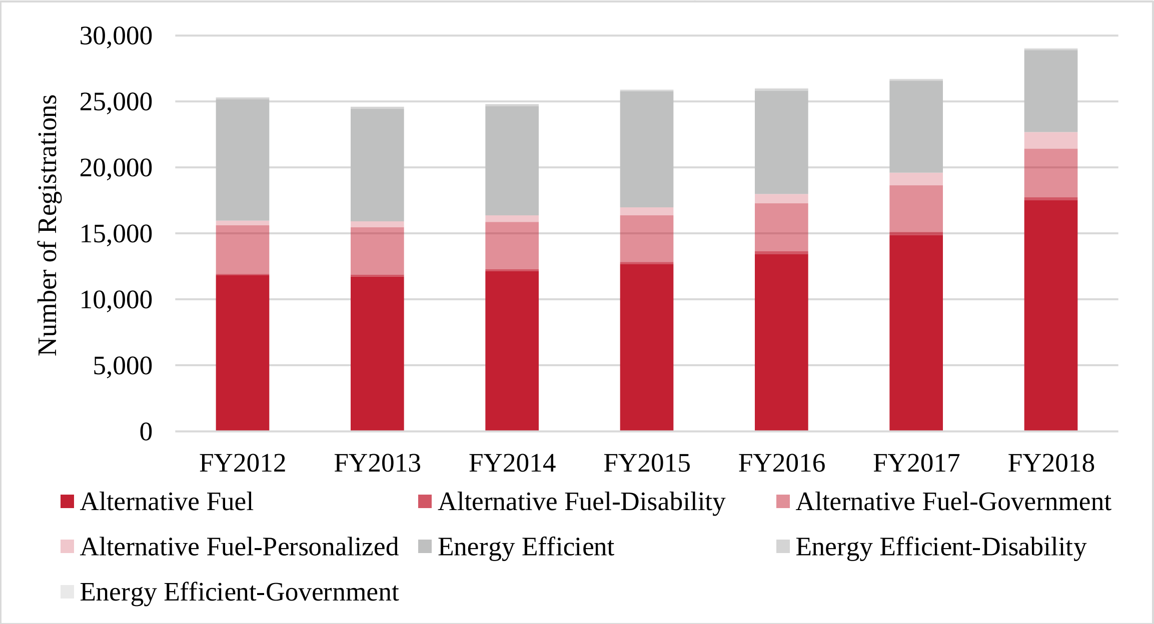
- State and federal policies overpay for the social benefits of EVs by $6,068 over five years (on average);
- The private benefits accrued by EV policies are almost 17 times more than the social benefits that such policies aim to achieve;
- Each year, EV owners pay almost $500 less than ICV owners pay, on average, for road maintenance.

Encouraging an EV policy that allows public utilities to pay for EV charging stations with rate increases charged to all rate payers across the state will exacerbate the status quo, distort the true market for EVs and EV charging stations, and redistribute wealth from the lower and middle classes to the more affluent EV buyers. A better policy would be to encourage public utilities to adopt rate schedules that promote off-peak charging as a way to increase EV ownership. If public utilities are to enter the market for charging stations, they should not be allowed to increase rates on non-EV owners to offset construction costs. Instead, they should be made to recoup those costs only from EV drivers who use their services. Such a policy would keep the competitive playing field for charging stations level for all competitors, and would not effectively tax non-EV owners to benefit EV drivers. Under the proposed ACC policy, however, all Arizonans will be made to subsidize EV drivers, pay for a service they will likely never use, and have little environmental or social benefit to show for it.

Electric Vehicles and Their Government Subsidies

Electric vehicle sales and registrations in Arizona have increased year-over-year. Graph 1 shows that the number of registered "alternative fuel vehicles" and "energy efficient" license plates in Arizona have grown significantly over the past few years.[3]

Graph 1: Alternative Fuel Vehicle Registrations, Arizona[4]



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Sales of new battery electric vehicles, plug-in hybrid electric vehicles (PHEV), and hybrid electric vehicles (HEV) have grown each year in Arizona from about 6,500 in 2011 to over 14,500 in 2018, and new battery electric vehicles started from 0.23 percent of total new vehicle sales in 2013 and have risen to 1.44 percent in 2018.[5]

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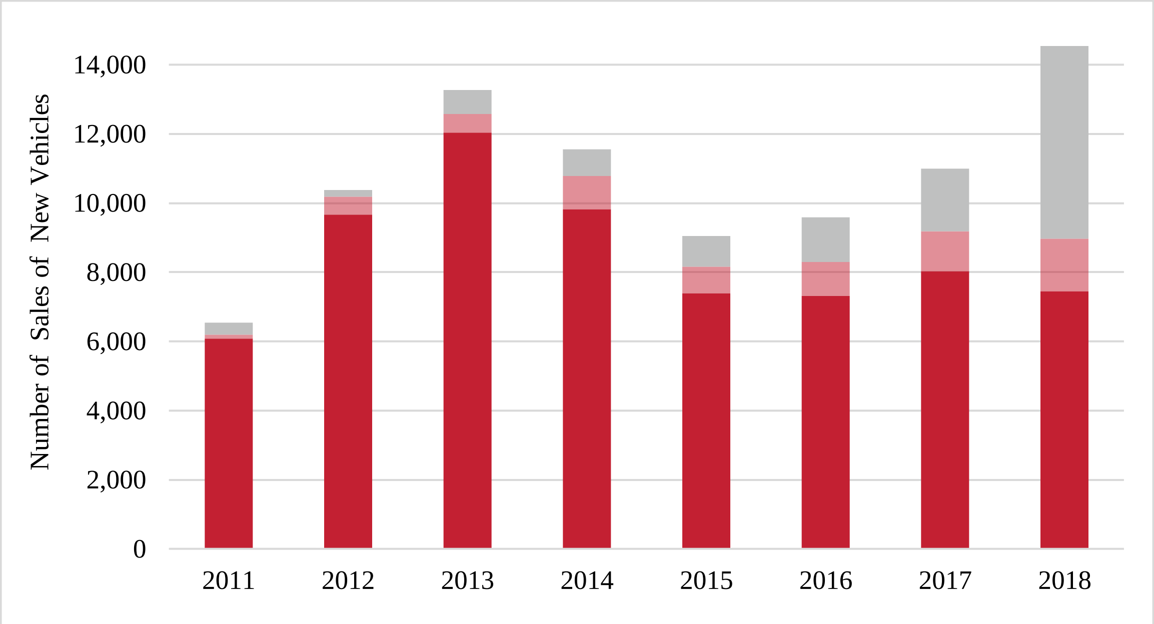
[3] Alternative fuel vehicles include electric vehicles, natural gas engines (compressed natural gas), liquefied natural gas, hydrogen fuel cell vehicles, and solar. Another eligible alternative fuel vehicle in Arizona is a blend of 70 percent alternative fuel and 30 percent gasoline. However, these are currently unavailable in Arizona. Energy efficient license plates were the first role out of registration benefits to EV owners, but was originally capped at 10,000 registrations and no new registrants were permitted to acquire these. New vehicles are now registered with alternative fuel vehicle plates with the same benefits as energy efficient plates. Registrations based on number of alternative fuel, alternative fuel-government, alternative fuel-personalized, alternative fuel-disability, energy efficient, energy efficient-disability, and energy efficient-government license plates on June 30 of each year. **Vehicle Services: Registration, Alternative Fuel Vehicle**, AZdot.gov (Last visited on May 28, 2019); and **Statistics: Motor Vehicle Division Statistical Summary**, AZdot.gov (Last visited on May 28, 2019).

[4] Source: Arizona Department of Transportation, **Statistics: Motor Vehicle Division Statistical Summary, Point-in-Time Plate Counts on Currently Registered Vehicles**, AZdot.gov (Last visited on May 28, 2019).

[5] **Alliance of Automobile Manufacturers, Advanced Technology Vehicle Sales Dashboard**, Data compiled by the Alliance of Automobile Manufacturers using information provided by IHS Markit. Data last updated March 12, 2019 (Last visited on May 28, 2019).

Graph 2: Electric Vehicle Sales, Arizona[6]



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The young market for EVs has grown rapidly during the past few years, with EV and PHEV sales climbing roughly 200 percent nationwide and in Arizona from 2017 to 2018.[7] In California, EVs and PHEVs jumped from 4.92 percent of vehicle sales in 2017 to a staggering 7.84 percent in 2018.[8] With the rising popularity of EVs, almost all car manufacturers offer or soon plan to offer an EV and/or PHEV.

There are financial and environmental benefits to driving certain electric vehicles that help explain their increased popularity even without government interference. Nevertheless, federal and state policies continue to encourage more EV use by offering a variety of monetary and non-monetary incentives to consumers. Government attempts to increase EV use with financial subsidies, however, should be view skeptically. Empirical economic studies show that, even if theoretically

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[6] Source: **Alliance of Automobile Manufacturers, Advanced Technology Vehicle Sales Dashboard**, Data compiled by the Alliance of Automobile Manufacturers using information provided by IHS Markit. Data last updated March 12, 2019 (Last viewed on May 28, 2019).

[7] It remains to be seen how much of this spike in growth is a trend or due to the reduction of the federal electric vehicle tax credit for vehicles manufactured by Tesla Motors that took effect January 2019. It is possible that this caused individuals to preemptively purchase a vehicle early, meaning the increase could be explained by 2019 sales simply being made a few months early. Chris Isidore, **Tesla will cut prices to combat tax credit phase out**, CNN.com, January 2, 2019.

[8] **Alliance of Automobile Manufacturers, Advanced Technology Vehicle Sales Dashboard**, Data compiled by the Alliance of Automobile Manufacturers using information provided by IHS Markit. Data last updated March 12, 2019 (Last viewed on May 28, 2019).

justified, environmental subsidies must be carefully designed to avoid wasting tax dollars, emitting more pollutants overall, or both.[9]

Governments offer various incentives to encourage EV ownership. Some incentives may be justified—especially in Western states with larger portfolios of renewable or nuclear power—if governments can successfully design taxes or subsidies that internalize the "externalities," *i.e.*, the social costs and benefits of a given private transaction, associated with buying particular types of vehicles.[10] Famed economist Ronald Coase explained "internalizing externalities" in terms of ownership, bargaining, and transaction costs. Coase posited that under a system with low transaction costs and clear legal rights, externalities can be reliably resolved through bargaining and compensation for the affected parties.[11] Consistent with Coase's theory, subsidies are not resolving the externalities associated with carbon emissions in the EV-ICV context for several reasons. First, the relevant transaction costs, *e.g.*, ensuring that carbon emitters adequately compensate affected non-emitters, are not low, and they rise as the number of affected parties increase. Second, the parties affected by vehicle pollution generally include entire population areas, and even people living in distant and different legal jurisdictions. Third, it is unclear which laws or rights the externalities may violate, limiting or even eliminating incentives for affected parties to bargain. Thus, with high transaction costs and no clear legal obligations to promote bargained cooperation, governments pursue other artificial solutions to manage externalities—and, as always, the relative success of such solutions will depend on the details.

The current federal approach to subsidizing EV purchases offers federal income tax credits to individuals who buy alternative fuel vehicles. The credits range from $2,500 to $7,500, depending

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[9] Other arguments for subsidizing EVs include that subsidies could increase innovation in EV technology. Since the technology is still in its early stages, proponents of subsidies that encourage consumers to purchase EVs expect these will lead to a faster uptake of EVs and PHEVs, encourage technological progress and ultimately lead to lower emissions than would have occurred without subsidies. Along the same lines, proponents of EV subsidies argue that the immediate practical benefits of these vehicles (in terms of features, convenience, price, etc.) are not yet competitive with ICV, so subsidies will spur learning about the new technology by both consumers and manufacturers, leading to faster technological progress and more purchases than would have happened otherwise.
Joshua Linn and Virginia McConnell, ***The Role of State Policies under Federal Light-Duty Vehicle Greenhouse Gas Emissions Standards***, Resources for the Future, June 22, 2017; David Kelly, **Subsidies to Industry and the Environment**, working paper, National Bureau of Economic Research, May 2009; and Ronald Steenblik, "**Subsidies: the distorted economics of biofuels**," *Biofuels: Linking Support to Performance*, Round Table 138 (OECD Publishing 2008) p. 75-133.

[10] An externality is any effect suffered (e.g. air pollution) or enjoyed (e.g. vaccinations) by a person or business as the result of a transaction conducted by other parties. Economic theory suggests that if externalities are present, the market will either produce too many negative externalities or too few positive externalities because buyers and sellers will not sufficiently account for these costs or benefits. Theoretically, the ideal policy solution is to either tax negative externalities so that fewer are produced or subsidize positive externalities so that more are produced. However, if the externality is not taxed or subsidized at the correct rate, this also risks generating a less optimal outcome compared to no policy intervention. Kenneth J. Arrow, "**The Organization of Economic Activity: Issues Pertinent to the Choice of Market Versus Nonmarket Allocation**," *The Analysis and Evaluation of Public Expenditure: The PPB System*, Volume 1 (May 1969) p. 47-64; Ronald H. Coase, "**The Problem of Social Cost**," *The Journal of Law and Economics*, Volume 3 (October 1960) p. 1-44; A.C. Pigou, ***The Economics of Welfare***, 3rd Edition (The Library of Economics and Liberty, 1928); and William J. Baumol, "**It Takes Two to Tango, or Sind 'Separable Externalities' Überhaupt Möglich?**," *Journal of Political Economy*, Volume 84, Number 2 (April 1976) p. 381-388.

[11] Ronald H. Coase, "**The Problem of Social Cost**," *Journal of Law and Economics*, Volume 3 (October 1960) p. 1-44.

upon the model, make, and other vehicle characteristics.[12] In Arizona, other alternative fuel vehicle benefits include an exemption from emissions checks, reduced registration fees, special license plates with HOV-lane privileges, and income tax credits for installing certain home charging stations.[13] Unfortunately, each of these benefits to the EV consumer over-represents the environmental benefit of EVs, which means that governments are overpaying for them.

Stephen Holland, Eric Mansur, Nick Muller, and Andrew J. Yates collaborated on several empirical studies regarding vehicle emissions, the costs they impose on the environment, and the extent to which subsidies and taxes can be used to influence the EV market.[14] They find that the relative "cleanliness" of operating an EV (versus an internal-combustion vehicle) depends on the sources of power used to charge the vehicle. Thus, although replacing an ICV with an EV may reduce air pollution locally, it may also increase coal power plant emissions—which tend to be worse than ICV emissions for the environment—in a neighboring state.[15] Therefore, to promote cleaner air, it may make more sense to tax, rather than subsidize, EVs and PHEVs because they rely on relatively "dirty" sources of power.

Ultimately, Holland and his co-authors find that the appropriate value for EV subsidies in Arizona would be less than $1,000 per EV and presumably less still for PHEVs just to capture the environmental benefits of an EV.[16] According to Holland, *et al.*, the federal government is using taxpayer dollars to overpay for the environmental benefits of EVs and PHEVs in Arizona by a factor of 2.5 or more. That means that much of the EV subsidy—at least $880 million of taxpayer money—has gone only to the private benefit of EV owners.[17]

California is also trying to overpay for the purported environmental benefits of EVs. In 2018, Muehlegger and Rapson took advantage of a "natural experiment" in which some California EV subsidies were means-tested. They find that in order to meet its goal of 1.5 million EVs on the road by 2025, California would need to provide between $9 billion and $14 billion in subsidies over the next seven years, which will require additional tax revenue from increased income or sales

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[12] **Federal Tax Credits for All-Electric and Plug-in Hybrid Vehicles**, FuelEconomy.gov (Last visited May 28, 2019).

[13] **Alternative Fuels Data Center: Arizona Laws and Incentives**, AFDC.energy.gov (Last visited May 28, 2019); **Electric Vehicles: Tax Credits and Other Incentives**, Energy.gov (Last visited May 28, 2019); and **Electric Vehicle (EV) Charging Incentives: Arizona**, ChargePoint.com (Last visited May 28, 2019).

[14] Stephen P. Holland, Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates, "**Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors**," *American Economic Review*, Volume 106, Number 12 (December 2016) p. 3700-3729; Stephen P. Holland, Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates, "**Distributional Effects of Air Pollution from Electric Vehicle Adoption**," *Journal of the Association of Environmental and Resource Economists*, Volume 6, Number S1 (March 2019) p. S65-S94; and Stephen P. Holland, Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates. "**Damages and Expected Deaths Due to Excess NOx Emissions from 2009 to 2015 Volkswagen Diesel Vehicles**," *Environmental Science & Technology* Volume 50, Issue 3 (February 2016) p. 1111-1117.

[15] Their study does not only focus on CO_2 emissions, but also sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM2.5), and volatile organic compounds (VOC), which are emitted by power plants and other vehicles. They further account for the way these compounds interact with one another and provide a county-by-county map showing where EVs do and do not confer environmental benefits.

[16] Stephen P. Holland, Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates, "**Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors**," *American Economic Review*, Volume 106, Number 12 (December 2016) p. 3700-3729.

[17] ***The Plug-In Electric Vehicle Tax Credit***, Congressional Research Service, May 14, 2019.

taxes, or both.[18] These estimated figures dwarf the $2.2 billion in federal subsidies given out between 2011 and 2017.[19] And there is no guarantee that the subsidies would entice enough low- and middle-income consumers to buy EVs.

In competitive economies, subsidies generate "deadweight loss," or overall less wealth, because they distort prices and allocate resources inefficiently. Positive externalities, *i.e.*, the social benefits of a private activity, can require subsidies in order to internalize externalities that the market is not incorporating. But when positive externalities are absent or smaller than the subsidies, then society as a whole pays a social cost.[20]

Large government subsidies are intended to encourage market behavior that the government believes would not have occurred without them. But such subsidies may not be necessary in the case of EVs because EV purchasers tend to pay the premium prices for EVs willingly—even without subsidies—in order to mitigate or avoid participating in the perceived environmental damage that ICVs inflict.[21] One study has even concluded that 70 percent of EV owners would have purchased their EV without any subsidy at all.[22]

EV ownership subsidies tend to benefit more affluent drivers.[23] In 2016, more than 83 percent of tax credit subsidies for EVs went to households earning more than $100,000 (see Table 1).[24] Because tax credits effectively function as government expenditures paid for by available tax revenues, this means that the government's EV tax credits are disproportionately paying wealthier households for making the private choice to purchase electric vehicles. Vehicle ownership includes many private benefits that non-owners do not enjoy. And although non-EV owners may reap some environmental benefits from increased EV use, additional subsidies provide a private benefit to EV owners paid for by all taxpayers.

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[18] Erich Muehlegger and David S. Rapson, **Subsidizing Mass Adoption of Electric Vehicles: Quasi-Experimental Evidence from California**, working paper, National Bureau of Economic Research, December 2018.

[19] ***The Plug-In Electric Vehicle Tax Credit***, Congressional Research Service, May 14, 2019.

[20] Ethanol subsidies, for example, are more harmful than beneficial, costing society $790 million after benefits were considered. See, Xiaodong Du, Dermot J. Hayes and Mindy L. Mallory, "**A Welfare Analysis of the U.S. Ethanol Subsidy**," *Applied Economic Perspectives and Policy*, Volume 31, Issue 4 (January 2009) p. 669-676.

[21] Erich Muehlegger and David S. Rapson, **Subsidizing Mass Adoption of Electric Vehicles: Quasi-Experimental Evidence from California**, working paper, National Bureau of Economic Research, December 2018.

[22] Jianwei Xing, Benjamin Leard, and Shanjun Li, **What Does an Electric Vehicle Replace?**, working paper, Resources for the Future, February 13, 2019.

[23] Erich Muehlegger and David S. Rapson, **Subsidizing Mass Adoption of Electric Vehicles: Quasi-Experimental Evidence from California**, working paper, National Bureau of Economic Research, December 2018.

[24] **SOI Tax Stats – Individual Statistical Tables by Size of Adjusted Gross Income; Individual Income Tax Returns with Tax Computation; All Returns: Tax Liability, Tax Credits, and Tax Payments: 2016**, IRS.gov (Last visited May 28, 2019).

Table 1: Total Value of Federal Electric Vehicle Tax Credits Claimed by Household Adjusted Gross Income[25]

	Qualified Plug-In Electric Vehicle Credit	
Adjusted Gross Income	Total Value (By AGI, in $1000s)	Percent of Total
$1 - $49,999	$2,149	0.57%
$50,000 - $99,999	$60,513	16.14%
$100,000 - $999,999	$282,000	75.20%
$1Million+	$30,334	8.09%
Total	$374,996	100.00%

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ICV owners also subsidize owners of fuel-efficient vehicles, such as EVs and PHEVs, in two less obvious ways: through the federal Corporate Average Fuel Efficiency (CAFE) standards; and by paying a greater share of road maintenance costs through gasoline taxes.

CAFE standards require each manufacturer’s fleet of vehicles to meet an average level of fuel efficiency, weighted by the sales of each model and adjusted for the size (“footprint”) and type of vehicle. Notably, trucks and SUVs are treated more leniently under the standards than other vehicles.[26] Economic studies have demonstrated that CAFE standards raise the prices on fuel-inefficient vehicles and thereby essentially tax fuel-inefficient vehicle owners and subsidize fuel-efficient vehicle owners. The effective tax is regressive and imposes disproportionately high costs on low-income households that tend to buy fuel-inefficient vehicles. Proponents of CAFE standards may argue that the standards are less regressive than a flat tax on gasoline or carbon emissions, but economic studies have shown the standards to be *more* regressive. Because CAFE standards function as a per-vehicle tax, and because wealthier households tend to own more cars (that are not particularly fuel efficient) and purchase more gasoline than poorer households, the higher-income households pay a lower “rate per gallon” for costs imposed by CAFE standards than do poorer households. Adding the footprint requirement to CAFE standards in 2011 made them even more regressive because they reduced the advantage that lower-income households had from driving smaller cars.”[27]

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[25] Source: Economic Research Center calculations using U.S. Internal Revenue Service income tax data for Tax Year 2016; **SOI Tax Stats – Individual Statistical Tables by Size of Adjusted Gross Income; Individual Income Tax Returns with Tax Computation; All Returns: Tax Liability, Tax Credits, and Tax Payments: 2016**, IRS.gov (Last visited May 28, 2019).

[26] **Corporate Average Fuel Economy**, NHTSA.gov, (Last visited May 28, 2019).

[27] Lucas W. Davis and Christopher R. Knittel. “**Are Fuel Economy Standards Regressive?**,” *Journal of the Association of Environmental and Resource Economists*, Volume 6, Number S1 (March 2019) p. S37-S63; Mark R, Jacobsen, “**Evaluating U.S. Fuel Economy Standards in a Model with Producer and Household Heterogeneity**,” *American Economic Journal: Economic Policy*, Volume 5, Number 2 (May 2013) p. 148–187; and Arik Levinson, “**Energy Efficiency Standards Are More Regressive Than Energy Taxes: Theory and Evidence**,” *Journal of the Association of Environmental and Resource Economists*, Volume 6, Number S1 (March 2019) p. S7-S36.

Finally, because many governments use gasoline taxes to pay for road maintenance, EV owners enjoy the benefits of that maintenance while paying little to nothing for it. In Arizona, for example, 31 percent of the state's road-related spending derives from a motor vehicle fuel tax that EV owners do not pay.[28] Thus, Arizona EV owners pay nothing in gasoline taxes and a significantly reduced vehicle license tax for using the same roads as ICV, HEV, and PHEV owners. Our cost-benefit analysis of Arizona EVs and ICVs estimates that the average ICV in Arizona costs owners an annual gasoline tax of $99.76, while the average discount for EV vehicle license taxes is about $382 annually for the first five years. Moreover, an increasingly electrified, fuel-efficient vehicle fleet means that governments may need to adjust their current "user-fee" model for road maintenance in order to capture revenues from EV and PHEV drivers, or else begin to find alternative revenue streams for maintaining roads. But under the current system in Arizona, EV owners pay less than ICV owners do to drive on the same roads.

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[28] Joseph Bishop-Henchman, ***Gasoline Taxes and User Fees Pay for Only Half of State & Local Road Spending***, Tax Foundation, January 3, 2014.

Arizona's New EV Policy: A Bad Solution in Search of a Problem

The Arizona Corporation Commission's new EV policy will encourage public utilities to build their own public charging stations and compete with EV power companies like Blink, Chargepoint, Tesla, and Electrify America.[29] The proposed policy is misguided for several reasons, namely, it is unnecessary, it is unfair to private sector competitors, it imposes regressive costs on non-EV owners, and it may be less effective than advertised at encouraging more EV use. There are better ways for Arizona to encourage EV ownership than imposing a regressive new tax on every Arizona household.

First, public utilities do not need to enter the EV charging station market because the private sector is already meeting the demands of Arizona's EV owners. Currently, EV drivers can charge their cars at home or at public charging stations.[30] According to the United States Department of Energy, Arizona has 443 electric charging stations with 1,181 charging outlets already available.[31] With 13,901 plug-in electric vehicles in Arizona, there are 12 EVs for each public plug—compared to 249 gas-powered vehicles for every gasoline pump in the state.[32] (See Graph 3.) Those ratios indicate that Arizona does not have a shortage of public EV chargers. Private companies, such as Blink and ChargePoint, maintain their own charger networks at various locations across the state.[33] PlugShare and other companies currently monitor hundreds of Arizona chargers.[34] Tesla boasts a network of public charging stations and has taken the lead in installing Level 3 stations with 16 direct current (DC) superchargers in Arizona with plans to build more.[35] Volkswagen funded Electrify America, which expects to build DC charging stations in Arizona as well over the next few years.[36] EV manufacturers and companies that cater to EV drivers, of course, have every incentive to build more charging stations to both meet and increase the demand for their products.

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[29] Arizona Corporation Commission Staff Policy Statement for Electric Vehicles, **Electric Vehicle Infrastructure, and the Electrification of the Transportation Sector in Arizona**, December 12, 2018.

[30] There are publicly available chargers located in a variety of locations, e.g. places of work, grocery stores, restaurants, shopping center. Homeowners also have the ability to charge their electric vehicles at home using a traditional 120-volt outlet, also known as Level 1 charging, or a Level 2 charger with some charging equipment and a 240-volt outlet. Level 1 chargers take eight to 15 hours to charge an empty battery. Level 2 charging stations usually require additional installation costs as they rely on a 240-volt outlet, but the charge time is greatly reduced, taking from three to eight hours for an empty battery to fully charge. Finally, Level 3 charging is the fastest, taking 20 minutes to one hour and more expensive direct current charging equipment. Tesla calls these Superchargers. **2019 Guide On How To Charge Your Electric Car With Charging Stations**, ChargeHub.com (Last visited May 28, 2019).

[31] **Alternative Fueling Station Counts by State**, AFDC.energy.gov (Last visited on May 28, 2019).

[32] There are 5,6,48,505 registered gas-powered vehicles according to Auto Alliance. According to GasBuddy's daily surveys of 2,269 gas stations in Arizona and assuming at least 10 available pumps at each station, this implies about 249 vehicles for each pump, while for electric vehicles, there are about 12 vehicles for every available public charging plug. **State Facts: Autos Drive Arizona Forward**, AutoAlliance.org (Last visited May 28, 2019). Patrick DeHaan, **Arizona Gas Prices Drop 4.9 cents**, Prescottenews.com, February 11, 2019.

[33] **EV Chargers on Blink Network**, BlinkCharging.com (Last visited May 28, 2019); and **ChargePoint: Charging Map**, na.chargepoint.com (Last visited May 28, 2019).

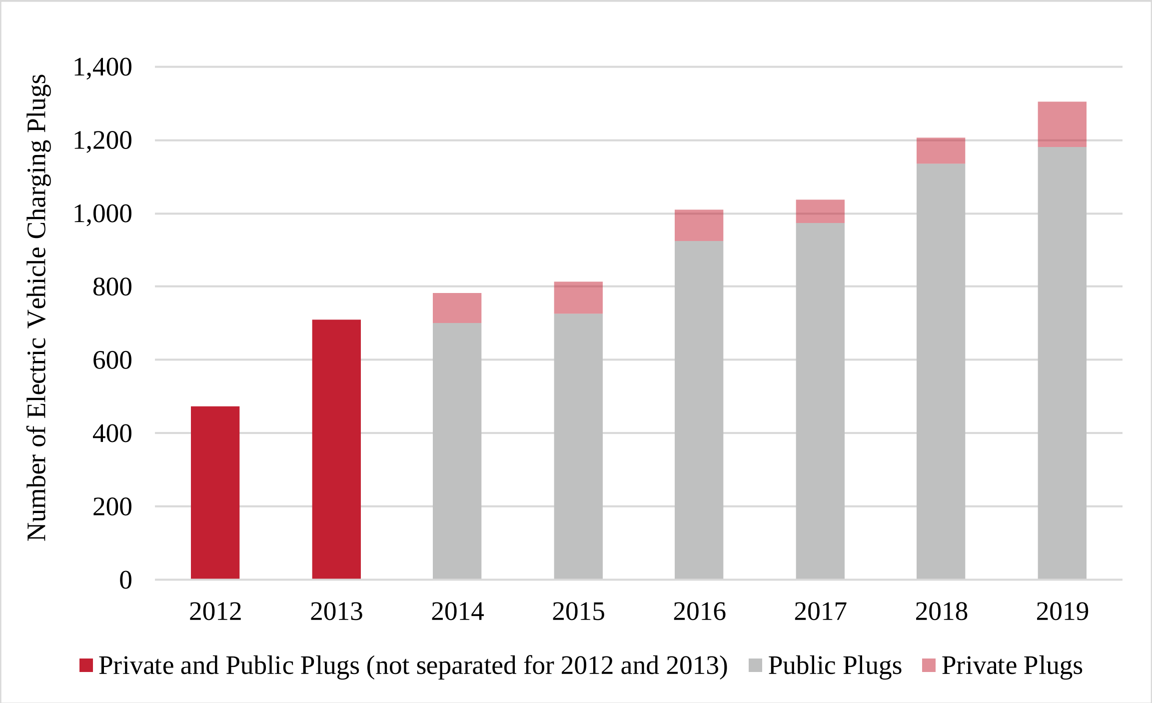
[34] **PlugShare - Find Electric Vehicle Charging Locations Near You**, PlugShare.com (Last visited May 28, 2019).

[35] **Map of Tesla Superchargers**, Tesla.com (Last visited May 28, 2019).

[36] Volkswagen was mandated to fund Electrify America as a part of its diesel emissions scandal settlement. Uravksh Karkaria, **This is Volkswagen's Plan to Electrify America**, AutoWeek.com, October 29, 2018; and **Locate a Charger**, ElectrifyAmerica.com (Last visited May 28, 2019).

With an already extensive network of charging stations, and private investment satisfying EV demands, public utilities may be building a superfluous, unnecessary network.[37]

Graph 3: Electric Vehicle Charging Plugs, Arizona[38]



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Second, as regulated monopolies, public utilities can recoup all of their construction costs—even if the new stations go unused—simply by raising rates across all electricity users. That guarantee gives utilities an unfair advantage against the private businesses that must risk their own capital resources when competing for EV customers. Private sector competition is already meeting demand for charging stations by constantly working to improve technologies and create faster, more efficient charging.[39] But allowing a monopolistic competitor with an unfair advantage to enter the current market for charging stations will distort the market and potentially drive private investment and enterprise from the field. As private sector investment and competitors exit the market, they will take their ingenuity, technology, improvements, efficiencies, and price-pressure with them, thereby reducing the supply of new and improved EV technologies.

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[37] Travis Hoium, **Investing in EV Infrastructure: Where the Money Is Going**, The Motley Fool, March 15, 2017.

[38] Source: Department of Energy Alternative Fuels Data Center: **Alternative Fueling Station Counts by State**, AFDC.energy.gov (Last visited on May 28, 2019). Data for previous years was collected using the Wayback Machine for the Department of Energy Alternative Fuels Data Center website, using the last available date for each year for that year's number of plugs. Data for 2019 was taken from the current site on May 28, 2019. The number of plugs were not separated by public and private categories until 2014. Private chargers are designed for fleet charging and may be accessible to other users based on a business to business arrangement.

[39] Tesla is already selling its Solar Roof, which can be integrated into its Powerwall, and other manufacturers are likely to follow. Luke Richardson, **Tesla Powerwall: the complete battery review**, EnergySage.com, (Last visited May 28, 2019); and Travis Hoium, **Inverter Chargers Could Be the Future for Solar Energy**, The Motley Fool, November 29, 2017.

Third, allowing public utilities to impose a flat charge per kilowatt hour levies a regressive tax on non-EV users, forcing them to pay higher energy bills for a potentially superfluous network of EV charging stations that only helps EV owners. Paying higher energy bills means less money to spend on other family needs such as food, education, and housing. Thus, low-income households will be made to spend a larger share of their income to help subsidize EV owners in high-income households, even though low-income households already spend almost three times as much on electricity (proportionally to their pre-tax earnings) as their high-income counterparts.[40] Artificial rate increases that do not improve service quality or quantity functionally tax those who must pay them. Given the relatively high cost of EVs, less affluent Arizona families who are unlikely to buy EVs or ever use a public EV charging station will be stuck paying a higher energy bill for a service they may never use. So, any increase in the cost of electricity to pay for these charging stations amounts to a regressive tax that costs the lower economic classes proportionally more than the wealthy class, and those costs are not trivial. According to M.J. Bradley & Associates, rising EV use will require investments of over $500 million over ten years to build 31,397 Level 2 chargers and 2,336 DC chargers by 2030 in order to meet demand.[41] If paid for entirely by public utilities, according to current ACC policy, that $500 million would cost all Arizona ratepayers about $1,190 per EV on the road.

Finally, some evidence suggests that subsidizing charging station construction is not especially effective at increasing EV use after early-adopters have already joined the market. Katalin Springel's study of Norwegian data finds that the potential for charging stations to increase demand for EVs tapers off quickly as EV-use rates increase because only so many stations are needed to eliminate "range anxiety," *i.e.*, the concern that a vehicle will lose its charge before the next charging station.[42]

Instead of pursuing the ACC's new, misguided policy, Arizona can take other steps to encourage EV ownership and enhance the EV experience. Arizona, for example, could expand its program that already allows public utilities to encourage at-home EV charging during off-peak hours, which would help EV owners without directly charging non-EV owners extra for their own electricity.[43] Encouraging off-peak home charging would alleviate grid-load concerns more than adding utility-owned charging stations.[44] If public utilities do construct public charging stations, their construction costs should be recouped entirely through user fees at the charging stations, not subsidized by non-EV owners through higher electricity rates. After all, EV owners do not pay a gasoline tax on gasoline that their electric cars do not use. So, too, non-EV drivers should not pay

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[40] According to the Consumer Expenditure Survey from 2017, households earning between $30,000 to $39,999 before taxes, their annual electric bill was $1,371 while those earning between $100,000 and $149,999 before taxes only for $1,666 for electricity for the year. **Consumer Expenditure Surveys**, BLS.gov (Last visited May 28, 2019).

[41] ***Electric Vehicle Cost-Benefit Analysis: Plug-in Electric Vehicles Cost-Benefit Analysis: Arizona***, M.J. Bradley & Associates, December 4, 2018.

[42] Katalin Springel, **Network Externality and Subsidy Structure in Two-Sided Markets: Evidence from Electric Vehicle Incentives**, working paper, March 1, 2019; and ***The State of Electric Vehicles in America***, Volvo Car USA/The Harris Poll, February 26, 2019.

[43] **Electric Vehicles: Tax Credits and Other Incentives**, Energy.gov, (Last visited May 28, 2019).

[44] **Electric Vehicle Price Plan**, SRPnet.com (Last visited May 28, 2019).

for the cost of charging stations that their combustion-engine cars never visit.[45] Moreover, if private companies see the merit and advantage in paying for their own public charging stations, public utilities should have to play on the same level playing field and cover the costs of their public stations with fees collected from their users. Utilities, for example, could assign a special rate to charging station energy that would cover the construction costs, or they could charge membership or access fees for public charging stations, much like Costco and Sam's Club charge membership fees to access their stores and discount gas stations. These are not novel concepts. They have proven track records in the marketplace, and nothing about the EV energy market suggests that they will not also work at EV public charging stations.

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[45] Constance Douris, **Who Should Pay For Electric Vehicle Chargers? Who Should Profit?**, *Forbes*, November 8, 2017.

A Cost-Benefit Analysis of Arizona Vehicles

EV and PHEV owners already receive direct and indirect subsidies from federal and state governments for their vehicle purchases. The motivation for those subsidies—and for subsidizing public charging stations—lies in the government's interest in decreasing the public, environmental costs associated with ICVs. There may be a theoretical justification for "charging" ICV drivers for the environmental benefits gained by EV use, but an accurate cost-benefit analysis must also account for the private benefits accrued by EV owners. This is particularly true if EV subsidies are funded by the entire population of taxpayers, ratepayers, and/or vehicle owners.

To better understand the competing economic and social effects of buying an electric vehicle requires a cost-benefit analysis of comparable EV and non-EV car models that examines the following three factors: the basic cost of ownership for five years without subsidies; the value of subsidies from current EV policy on the cost of ownership; and the social cost of purchasing and operating the vehicle for five years.

Basic Cost of Ownership: We estimate the cost of ownership for each model in the absence of any qualifying tax credits or other incentives. Cost of ownership includes not only the price of the vehicle but also most of the costs associated with owning a vehicle over the course of five years, such as insurance, gasoline (for HEVs, PHEVs, and ICVs), electricity and a Level 2 home charger (charging infrastructure for PHEVs and EVs), maintenance, and repairs. We also estimate vehicle depreciation over five years, which we factor into the estimated resale value. (See Appendix A for details.)

Subsidies to Owners: We deduct subsidies from state and federal policies, as well as programs offered by utilities, that offset the cost of owning and operating PHEVs and EVs. These subsidies may include tax credits and reduced vehicle registration fees. On several vehicles, these subsidies help lower the cost of PHEVs and EVs well below their original prices.

Social Cost of Ownership: The costs of owning and operating a vehicle are not only private. Vehicle production, manufacturing, and operation impose environmental costs on society at-large through carbon emissions during these processes. Commonly, to estimate the "social cost" of vehicle ownership, researchers estimate the carbon emissions for producing and operating the vehicle, and then add a dollar value ascribed to the social cost of carbon for a given amount of CO_2 produced. That value attempts to account for social harms such as increased mortality, higher risks of health problems, higher healthcare costs, and other costs caused by carbon emissions. The social cost tries to capture the external "harms" associated with vehicle ownership that are not included in the private costs of purchasing and operating vehicles. We estimate the social costs in two components: manufacturing and vehicle operation. We base manufacturing costs on estimates of production emissions from researchers Nuri Cihat Onat, Murat Kucukvar, and Omer Tatari.[46] To estimate the social cost of operation, we use carbon emission estimates for each vehicle, either

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[46] These costs tend to be higher for vehicles with a battery intended as the fuel source.
Nuri Cihat Onat, Murat Kucukvar, and Omer Tatari, "**Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States**," *Applied Energy*, Volume 150 (July 2015) p. 36-49.

through gasoline consumed or electricity used while charging, combined with an estimate of the social cost of carbon.

We assume that each vehicle is driven 15,000 miles per year, and we assume a social cost of carbon of $45.51 per metric ton of CO_2.[47] The social costs of operating an EV are mainly determined by the pollutants emitted by the source of electricity used to charge the vehicle's battery. For ICVs and HEVs, the biggest environmental impact in operation comes from tailpipe emissions. In daily operation, PHEVs are likely to cause emissions from both sources. (See Appendix A for more details.)

It is difficult to account for all the personal benefits associated with owning a particular vehicle. Therefore, we compare similar models, either within make and model but by different engine type or across best-selling models within vehicle size. We assume that best-selling vehicles compete on similar features. When controlling for make and model, we can exclude comparisons across different vehicle characteristics that could also factor into the decision to buy a car. The attached appendices include the full methodology and data sources for our cost-benefit analysis, allowing other researchers to assess our conclusions.

Within the Same Model, Arizona EV Policy Overpays for Social Benefits

Within make and model comparisons, the difference in the basic cost of ownership between ICVs, HEVs, PHEVs, and EVs, varies considerably. For the 32 direct model comparisons that involve an ICV, there were 16 cases in which an electric vehicle or hybrid had a lower five-year basic cost of ownership than the comparable ICV. In four cases, the cheapest basic cost to own option was the PHEV, and in the remaining 12 the HEV was cheapest. In the 16 cases in which the ICV was not the cheapest option, the hybrid version was 3.6 percent less expensive to own over five years. These figures indicate that many potential hybrid owners would be better off buying one of these 16 hybrid vehicles on the basis of cost-savings alone. An EV never had a lower basic cost of ownership than the other vehicle types (see Appendix B).

Luxury brands tend to have higher social costs than non-luxury brands, even when comparing hybrids to gas-powered vehicles.[48] For example, when comparing the Toyota RAV4 and the Mercedes-Benz GLC, two compact SUVs, the determining factor in the social cost was brand, with the PHEV Mercedes-Benz GLC having worse overall emissions than either the Toyota ICV or HEV, even though neither Toyota receives preferential tax incentives (see Table 2). This means that despite receiving financial incentives, the Mercedes-Benz GLC PHEV does more harm socially than other ICVs on the market. Overall, 40 percent of the 20 vehicles that receive a federal

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[47] The value of the social cost of carbon is sensitive to methodology where different models with different assumptions produce a wide range of estimates; for further discussion see Kevin Dayaratna and Nicolas Loris, ***Rolling the DICE on Environmental Regulations: A Close Look at the Social Cost of Methane and Nitrous Oxide***, The Heritage Foundation, January 19, 2017. The estimate we use comes Nordhaus (2017), which finds a value closely in line with the average, using a common model design. William D. Nordhaus, "**Revisiting the social cost of carbon**," *Proceedings of the National Academy of Sciences of the United States of America*, Volume 114, Number 7 (February 14, 2017) p. 1518-1523; and ***Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide***, Consensus Study Report by the National Academies of Sciences, Engineering, and Medicine, 2017.

[48] For the purposes of this analysis, luxury brand refers to the following makes: Acura, Audi, BMW, Cadillac, Infiniti, Land Rover, Lexus, Lincoln, Mercedes-Benz, Porsche, and Volvo.

tax credit in our analysis are luxury brands. Of those, only the BMW i3 (the only luxury EV) has lower social costs than available non-luxury *gasoline burning* vehicles, indicating that tax incentives fail by treating all battery-powered vehicles equally.

Table 2: Five-Year Cost of Ownership Comparison
Toyota RAV4 and Mercedes-Benz GLC Class[49]

Make	Toyota	Toyota	Mercedes-Benz	Mercedes-Benz
Model	2019 RAV4	2019 RAV4 Hybrid	2019 GLC	2019 GLC
Type	ICV	HEV	ICV	PHEV
	Basic Cost of Ownership			
Basic Sub-Total	$31,030	$30,188	$47,738	$50,736
	Subsidies to Owners			
Subsidy Sub-Total	$0	$0	$0	($4,755)
	Social Cost of Ownership			
Social Sub-Total	$1,866	$1,631	$2,198	$2,129
Total	$32,896	$31,819	$49,936	$48,110

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HEVs are often less costly than ICVs without owners receiving any subsidies. In 11 out of the 19 direct model comparisons between ICVs and HEVs, the five-year basic cost of ownership was $1,686 less for the HEV, on average, even though in eight cases the HEV was more expensive by an average of $2,229. HEVs also have lower social costs than their ICV counterparts in all 19 comparisons, despite owners not qualifying for any subsidies.

Differences in the basic cost of ownership are notable because, once subsidies are added, the cheapest cost to own cars are almost always PHEVs or EVs when compared to their HEV and ICV equivalents. The five-year subsidy values for most PHEVs and EVs are significant. Subsidies for the Hyundai Ioniq EV and PHEV, for example, total $9,438 and $7,701, respectively, bringing their costs well below the Ioniq HEV and Elantra ICV, which have nearly the same basic cost of ownership of about $30,000. These subsidies bring the cost of the battery-equipped options below that of either the HEV or ICV options (to $28,375 for the EV and $25,103 for the PHEV). (See Table 3). Only the Kia Soul EV and Volvo XC90 remain more expensive than their ICV versions once their respective $9,675 and $5,342 subsidies are included in the five-year cost to own estimates.

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[49] Source: Economic Research Center calculations. There are four vehicle types: internal combustion engine (ICV); a hybrid engine with battery and internal combustion, where the battery is only charged when the vehicle is in operation (HEV); plug-in hybrid with battery and internal combustion, where the vehicle can operate on battery only for a given range (PHEV); and battery electric, which is a vehicle that runs only on a battery where the battery must be charged externally between trips (EV).

Table 3: Five-Year Cost of Ownership Comparison
Hyundai Elantra/Ioniq[50]

Make	Hyundai	Hyundai	Hyundai	Hyundai
Model	2018 Elantra	2018 Ioniq Electric	2018 Ioniq Hybrid	2018 Ioniq Plug-in Hybrid
Type	ICV	EV	HEV	PHEV
	Basic Cost of Ownership			
Basic Sub-Total	$30,021	$37,813	$30,526	$32,804
	Subsidies to Owners			
Subsidy Sub-Total	$0	($9,438)	$0	($7,701)
	Social Cost of Ownership			
Social Sub-Total	$1,676	$1,328	$1,333	$1,319
Total	$31,697	$29,703	$31,902	$26,422

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When comparing ICVs to its direct PHEV or EV model counterpart, subsidies reduce the cost of ownership for the entire subset of 13 qualifying PHEVs and EVs by an average of $6,083. And although the subsidies to the owners are substantial, they are only worthwhile if PHEVs and EVs produce significantly lower social costs that match the subsidy amounts. Comparing the social cost relative to the subsidies reveals that the value of the subsidies is poorly calibrated to incorporate the social cost they seek to address. In every case in which an ICV was compared to any type of electric vehicle (PHEV, HEV, or EV), the five-year social cost was lower for the non-ICV, but only marginally. This suggests that the benefits of electrifying vehicles currently remain quite limited. The HEV, for example, receives no special tax incentive, despite having a nearly identical social cost of ownership as both battery-equipped options that such policies favor.

In the 35 comparisons between battery-equipped electric vehicles (all HEVs, PHEVs, and EVs) and their ICV counterparts, the average value of the reduced social cost over five years was $330, or $66 per year. Depending on the model, the benefit values ranged anywhere from $69 (2019 Mercedes-Benz GLC PHEV to the GLC ICV) to $677 (2019 Ford Fusion Energi PHEV to the Fusion ICV) over five years. Such negligible differences underscore that the higher social cost of manufacturing battery-equipped electric vehicles offsets some of the benefits of their lower social cost of daily operation, and how upstream emissions from electricity production further limit operational benefits.

It remains unclear, however, whether these differences are economically or environmentally significant. The small difference draws attention to the importance of the assumptions in our analysis, which are both technical (*e.g.*, battery life, battery range, time period for measuring costs

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[50] Source: Economic Research Center calculations. There are four vehicle types: internal combustion engine (ICV); a hybrid engine with battery and internal combustion, where the battery is only charged when the vehicle is in operation (HEV); plug-in hybrid with battery and internal combustion, where the vehicle can operate on battery only for a given range (PHEV); and battery electric, which is a vehicle that runs only on a battery where the battery must be charged externally between trips (EV).

and benefits) and behavioral (*e.g.*, aggressive vs. passive driving, driving patterns influenced by vehicle type).

Significantly, our comparison only covers new cars. A new car leaves a larger carbon footprint than the comparable used car. This becomes an important factor, for example, in cases in which an EV is "totaled" in an accident after only three years. In such cases, the small difference in social costs among these *new* car models suggests that the lowest social cost option would be a *used* car because it would not impose additional social costs from manufacturing. This holds true regardless of the fuel required for the used car, but it turns out that EVs may prove particularly good used car deals. According to Consumer Reports, a three-year old 2015 Nissan Leaf (EV) was more than 30 percent cheaper than the average, three-year old non-luxury car.[51]

Another way to evaluate subsidies for PHEVs and EVs compares the aggregate value of the social cost of ownership to the aggregate subsidy values to owners across models that have an ICV option. Such a comparison gives a fuller picture of the social impact of these policies. To pass a cost-benefit test the social benefits should be greater than or equal to the private benefits. That is, the value of the subsidies to EV and PHEV owners should be equal to the lower social cost of ownership they have relative to their ICV equivalents. Subtracting the value of subsidies from the basic cost of ownership for ICVs and HEVs provides a measure of the private, financial benefit that buyers receive from these vehicles. Similarly, subtracting the environmental costs of EVs and PHEVs from the comparable ICV model gives the social (environmental) benefit of these vehicles.

In our comparison of ICVs to similar PHEV or EV models (including comparing the Hyundai Elantra to the PHEV and EV versions of the Hyundai Ioniq, adding up subsidies and comparing them to the lower social costs of PHEVs and EVs reveals the extent to which buyers of new EVs or PHEVs are "over-subsidized." Across these 15 vehicles, the private benefits to PHEV and EV owners from these subsidies total $96,214, while the lower social costs only amount to $5,187, a difference of more than $91,000.

With federal and states subsidies and utility discounts, across our comparisons of ICVs to similar EVs and PHEVs, electric vehicle owners are paid $6,068 more (on average) than the reduced social costs achieved by their vehicles ($6,414 in subsidies with only $346 in reduced social cost). Thus, EV subsidies do not pass the cost-benefit test because they have an average "over-subsidy" of $6,068 per EV and PHEV over five years, paid for by all households.

Even Among Best-Sellers, EVs Are Still Over-Subsidized

Direct comparisons can be informative, but they may not be relevant if consumers do not consider the same models of different engine types side-by-side when buying a car. Would-be car buyers may choose the size of car they want, then compare reliability, gas mileage, and cost-of-ownership across all makes and models or within a particular make that they prefer. Alternatively, buyers who strongly prefer EVs or hybrids may compare them to one another, ignoring ICVs altogether, and then simply select the most popular EV or hybrid, deferring to more experienced consumers.

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[51] Jeff Plungis, **It's a Great Time to Buy a Used Electric Vehicle**, ConsumerReports.org, August 31, 2018.

According to manufacturers' data, the best-selling battery-equipped model(s), by far, is the Toyota Prius line, which includes two HEVs and one PHEV.[52] The Prius PHEV is $2,000 to $3,500 more expensive than either of the HEV models before incentives, but incentives for the PHEV total $4,675, lowering its price below the HEV's. Since all Priuses are hybrids, the difference in social costs is even smaller than if Toyota offered an ICV version—equivalent to between just $100 and $144 in lower social costs over the course of five years.

Costs and benefits must be considered at the margin—that is, compared to the next closest option—and subsidies for battery-equipped vehicles vastly overstate the marginal benefit gained by switching when the availability of HEVs (which do not receive tax credits) is considered. The Ford Fusion line illustrates this inefficiency perfectly. Despite no meaningful difference in paid subsidies, the HEV Fusion's five-year social cost is 25 percent less than the ICV Fusion, and is even cheaper overall. When going from the unsubsidized HEV to the PHEV Fusion Energi, the social benefit is marginal, at $140 less in social costs of ownership, but the subsidy gain is $4,840. The environmental gains primarily come from switching from gasoline to a conventional hybrid, with very little to justify incentivizes for moving to a plug-in vehicle.

Table 4: 5 Year Cost of Ownership Comparison, Ford Fusion[53]

Make	Ford	Ford	Ford
Model	2019 Fusion	2019 Fusion	2019 Fusion Energi
Type	ICV	HEV	PHEV
	Basic Cost of Ownership		
Basic Sub-Total	$42,207	$41,324	$41,536
	Subsidies to Owners		
Subsidy Sub-Total	$0	$0	($4,840)
	Social Cost of Ownership		
Social Sub-Total	$2,132	$1,595	$1,455
Total	$44,339	$42,919	$38,151

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Among ICV compacts from all manufacturers, the Nissan Leaf EV compares most favorably to the 2018 Ford Focus ICV. The purchase price for the Leaf is about $5,700 higher than for the Focus, but after five years the difference in the basic cost of ownership shrinks to approximately $1,500, because Leaf drivers pay a lower price per mile. Once subsidies are added, however, the

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[52] We treat the Toyota Prius HEV as two vehicles because two different battery materials are available for different trims, one with a Li-ion battery, and another with a Ni-MH battery, which makes a difference when calculating the environmental impact from battery manufacturing.

[53] Source: Economic Research Center calculations. There are four vehicle types: internal combustion engine (ICV); a hybrid engine with battery and internal combustion, where the battery is only charged when the vehicle is in operation (HEV); plug-in hybrid with battery and internal combustion, where the vehicle can operate on battery only for a given range (PHEV); and battery electric, which is a vehicle that runs only on a battery where the battery must be charged externally between trips (EV).

Leaf becomes a no-brainer from a private cost of ownership perspective, even though the lower social cost of the Leaf's reduced emissions is only $372 over five years.

Rounding out the top-five best-selling EVs or PHEVs are the Chevy Bolt, Chevy Volt, and the Hyundai Ioniq. *Car and Driver* magazine called the Bolt the "benchmark for mainstream electric vehicles."[54] Before incentives, the Bolt's basic cost of ownership is $5,912 more than the Leaf, but $457 less than the Volt over five years. The federal tax credits for both Chevy vehicles, however, are now only worth half that of the Leaf's $7,500 even though the Leaf's social cost is $33 lower than the Volt. Worse still, the Bolt's social cost is about $50 lower than the Leaf's over five years.

Hyundai is the only manufacturer to offer a model, the Ioniq, with PHEV, EV and HEV options. Hyundai's most comparable compact ICV model is the Elantra in Eco trim (the Elantra line's most fuel-efficient version). (See Table 3.) Without subsidies, the Elantra's basic cost of ownership over five years is $505 cheaper than the Ioniq HEV, $2,783 cheaper than the PHEV, and $7,792 cheaper than the EV. Because the PHEV and EV versions both qualify for the $7,500 federal tax credit, their cost of ownership is several thousand dollars less than the Elantra once the credit is included. Their reduced social cost compared to the Elantra ranges from $348 for the Ioniq EV to $357 for the Ioniq PHEV, after five years. The government is again overpaying for the reduced social cost of EV ownership, making the extra subsidy value merely a private benefit to EV owners.

A careful cost-benefit analysis reveals that the government's tax incentives mostly benefit new buyers of EVs and PHEVs without much social benefit to the public. Depending on the price that buyers would pay without subsidies, the government is likely increasing consumer surplus—that is, roughly the difference between the price consumers are willing to pay and the price they actually pay. A small portion of the consumer surplus benefits the public, but the remainder simply transfers wealth from one group of taxpayers/ratepayers to another.[55]

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[54] Eric Stafford, **Chevrolet Bolt EV**, CarAndDriver.com, December 2018.

[55] **SOI Tax Stats – Individual Statistical Tables by Size of Adjusted Gross Income; Individual Income Tax Returns with Tax Computation; All Returns: Tax Liability, Tax Credits, and Tax Payments: 2016**, IRS.gov (Last visited May 28, 2019).

Conclusion

Arizona's nascent electric vehicle market has surged along with the country's in the past several years. The recent popularity in "green" vehicles is not surprising in light of government subsidies, perceived social benefits, and actual personal benefits accrued by their owners. Some EVs, in fact, are more economical to own than traditional ICVs even without environmental impacts and associated purchase incentives. But governments should tread more carefully as they expand subsidy and incentive programs for EV buyers. A careful cost-benefit analysis reveals that government policies are currently overpaying for the social benefits presented by EV use, and much of the subsidies simply benefit affluent EV owners who may be inclined to purchase such vehicles even without such incentives.

The Arizona Corporation Commission's new EV policy encouraging public utilities to pay for EV charging stations with rate increases charged to all rate payers across the state is yet another unnecessary government EV program that will exacerbate the status quo, distort the true market for EVs and EV charging stations, and redistribute wealth from the lower and middle classes to the more affluent EV buyers. Under the proposed ACC policy, all Arizonans will be made to subsidize EV drivers, pay for a service they will likely never use, and have little environmental or social benefit to show for it.

The private sector already meets the EV market's demand for charging stations with a broad network of publicly available stations to assuage the EV driver's "range anxiety." Adding monopolistic competitors with unfair advantages like public utilities to the EV market risks upsetting that market's balance and efficiency. If public utilities are to enter the market for charging stations, they should not be allowed to increase rates on non-EV owners to offset construction costs. Instead, they should be made to recoup those costs only from EV drivers who use their services. Such a policy would keep the competitive playing field for charging stations level for all competitors, and would not effectively tax non-EV owners to benefit EV drivers.

Arizona, like all governments, should proceed with caution in this burgeoning area and allow the market for new vehicle technologies to grow organically with little interference from politicians and bureaucrats. Future EV policies and programs would be well-served by thorough cost-benefit analyses that take a fuller view of the actual social costs and benefits associated with purportedly "green" vehicles.

Appendix A: Methodology and Data Sources

Economists and policy analysts at The Buckeye Institute's Economic Research Center developed a methodology for performing a cost-benefit analysis of the private and social costs and benefits associated with vehicle ownership in Arizona. This analysis surveys the costs of owning and operating select vehicles with comparable characteristics that vary only by fuel type. Our cost-benefit analysis relied upon publicly available data and other empirical studies regarding the basic cost of vehicle ownership, the value of subsidies to EV ownership, and the social costs of ownership across all selected vehicles. Our methodology and sources are provided here so that others may validate our analysis and conclusions.

Vehicle Selection

We selected the vehicles in this analysis in order to compare vehicles with different fuel types and to provide a comprehensive view of the current automobile market. To account for the difficulty of assessing the range of personal benefits associated with owning a particular car, we compare similar models, either within make and model but with different engine types or across best-selling models within vehicle size. We assume that best-selling vehicles are competing on similar features. Controlling for make and model allows us to exclude comparisons across different vehicle characteristics and features that could also affect the car-buying decision. For best-selling vehicles, we used all vehicle models that were among the top five best-selling in their category in 2018, according to manufacturer data.[56]

Basic Cost of Ownership

We relied on data from Kelley Blue Book and Edmunds.com's cost of car ownership metrics to generate a majority of our basic cost of ownership values.[57] Kelly Blue Book is the preferred source due to the quantity of available data. We use Edmunds.com data when Kelly Blue Book data is unavailable for the compared models, or when Edmunds.com provides data for a more recent model year. We gathered information for the cost of purchase, maintenance costs, costs of repairs, insurance premiums, and resale value for all models examined. We take the cost of purchase value from the fair purchase price in Kelley Blue Book or the true market value in Edmunds.com.[58] We calculated resale value by subtracting the sum of five years of depreciation from the cost of purchase. Both sources adjust results per location and we used the Phoenix zip code 85004.

Various models were among the five best-selling in their category, or had an alternative-fuel version, that were missing at least one or more of these basic cost of ownership measures from both websites; such models were dropped from our analysis.[59]

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[56] **Automotive Sales Data by Segment: Monthly Sales Reports in America (December 2018)**, GoodCarBadCar.net (Last visited May 28, 2019).

[57] **Get a New Car Price**, KBB.com and **Cost of Car Ownership**, Edmunds.com (Data collected over the period from April 5, 2019 through April 23, 2019).

[58] **Frequently Asked Questions: New Car**, KBB.com (Last visited May 28, 2019); and **Edmunds.com TMV – True Market Value**, Edmunds.com (Last visited May 28, 2019).

[59] The complete list of excluded vehicles is the following by fuel type. ICVs: 2019 Hyundai Kona, 2019 Land Rover Range Rover Sport, 2019 Lexus LC, 2018 Mercedes-Benz C-Class, 2018 Mercedes-Benz GLE-Class, 2019 Subaru

Fuel costs for gasoline and electricity were calculated using fuel mileage data by model, and gasoline and electricity costs in Arizona. To estimate the costs of gasoline and electricity, we assume 15,000 miles driven each year, the same assumption made by Kelley Blue Book and Edmunds.com. Fuel mileage for gasoline and electricity use derive from the FuelEconomy.gov database, a joint endeavor of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, and the Environmental Protection Agency.[60] For ICV, HEV, and PHEV models, miles per gallon data were gathered. For PHEV and EV models, kilowatts per 100 miles and the all-electric range (AER) was gathered.

We base the cost of gasoline on prices at a specific gas station in the Phoenix zip code 85004, on April 1, 2019, found at GasBuddy.com.[61] The station selected was nearest the zip code according to GasBuddy.com.

Table A-1: Gas Price Data[62]

Fuel Grade	Cost
Regular	$2.71
Midgrade	$2.89
Premium	$3.11

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To determine the cost of gasoline and electricity for PHEVs, we assume that daily driving is split between electric and gas-powered driving. We use the utility factor (the percent of total driving done purely on electricity) to determine this division. We use 2017 data from the National Household Travel Survey to find the distribution of driving distances among Arizona residents.[63] Using intervals of five miles, we sort the survey respondents into groups based on driving distance. For each PHEV, we calculate the utility factor for that distance (using the upper limit of the range, *e.g.*, 10-15 miles in a day is treated as 15 miles driven).[64] We assume drivers utilize the full AER before switching to the vehicle's hybrid/gas-powered function. For short enough daily distances and certain PHEVs, utility factors can be valued at one. For longer distances that are not feasible for an available PHEV's AER, however, utility factors for these distances are lower because the

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Crosstrek, 2019 Volkswagen Golf; HEVs: 2019 Lexus LC, Toyota Corolla Hybrid; PHEVs: 2018 Honda Clarity, 2019 Land Rover Range Rover Sport, 2018 Mercedes-Benz C-Class, 2018 Mercedes-Benz GLE-Class, 2019 Subaru Crosstrek; EVs: 2018 Honda Clarity, 2019 Hyundai Kona Electric, 2018 Tesla Model 3, 2018 Tesla Model S, 2019 Volkswagen e-Golf.

[60] **Find and Compare Cars**, FuelEconomy.com (Data collected over the period from April 5, 2019 through April 23, 2019); and **Detailed Test Information**, FuelEconomy.gov (Last visited May 28, 2019).

[61] **Circle K - 602 N 1st Ave - Phoenix, AZ**, GasBuddy.com (Data collected from April 1, 2019). GasBuddy is a service that crowdsources two to three million gas prices per day at more than 150,000 gas stations across the country. The database can be accessed via the company's website or its free app. The company gives incentives to users for reporting prices, however to ensure accuracy, prices can only be reported if the user is geolocated in range of the gas station in question. **About – GasBuddy.Com**, GasBuddy.com (Last visited May 28, 2019).

[62] Source: **Circle K - 602 N 1st Ave - Phoenix, AZ**, GasBuddy.com (Data collected from April 1, 2019).

[63] **National Household Travel Survey 2017**, NHTS.ornl.gov (Last visited May 28, 2019).

[64] For the top range (more than 120 miles driven in a day), we use 257 miles which is the median of the values in that range.

vehicle must then switch to its hybrid/gas-powered setting. From this distribution of distance driven, we create a weighted average of the daily utility factor for each PHEV model. That weighted average tells us how much gasoline and/or electricity is used for daily driving.

For the cost of electricity for PHEVs and EVs, we use electricity prices from plans offered by SRP, a utility that serves much of the Phoenix metro area. SRP offers pricing plans designed for electric vehicle owners, which allows for such plans to factor in our analysis.[65] For the cost of electricity value, we assume that EV and PHEV owners minimize what they pay to charge their vehicles by only charging when electricity is cheapest (between 11:00pm and 4:00am) using the electric vehicle plan. We calculate the discount to EV and PHEV owners by comparing what they pay with what they would pay under the next cheapest rate plan, the time-of-use plan.

Table A-2: Salt River Project
Electricity Rate Plan Comparison[66]

Charging Rate	Off-Peak Charging	Super Off-Peak Charging
Price Plan	Time-of-Use	Electric Vehicle
	Cost Per kWh by Month	
January	\$0.0691	\$0.0575
February	\$0.0691	\$0.0575
March	\$0.0691	\$0.0575
April	\$0.0691	\$0.0575
May	\$0.0727	\$0.0611
June	\$0.0727	\$0.0611
July	\$0.0730	\$0.0614
August	\$0.0730	\$0.0614
September	\$0.0727	\$0.0611
October	\$0.0727	\$0.0611
November	\$0.0691	\$0.0575
December	\$0.0691	\$0.0575
Average	\$0.0710	\$0.0594

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[65] **SRP Time-of-Use Price Plan**, SRPnet.com (Last visited May 28, 2019); and **Electric Vehicle Price Plan**, SRPnet.com (Last visited May 28, 2019).

[66] Source: **SRP Time-of-Use Price Plan**, SRPnet.com (Last visited May 28, 2019); and **Electric Vehicle Price Plan**, SRPnet.com (Last visited May 28, 2019).

We base registration fee estimates on the Arizona Vehicle License Tax (VLT). For the basic cost of ownership, we assume all models' VLT is $2.80 for every $100.00 of assessed value, where assessed value is 60 percent of the purchase price, decreased by 16.25 percent every year after purchase to account for depreciation.[67] Significantly, EVs receive a discount for registration, which is discussed in the "Subsidies to Owners" section below.

Charging infrastructure is based on installing a Level 2 Blink home charging station. We rely on a study conducted by the Idaho National Laboratory (INL) for the estimated home installations costs (permitting, labor, and materials) in the Phoenix area, combined with the retail price of a Level 2 Blink home charging station used in the INL study.[68]

Subsidies to Owners

Arizona EV owners receive federal tax credits and several subsidies and discounts from some costs that ICV owners normally must pay, such as vehicle registration costs.[69] We base registration estimates on the Arizona VLT. For new ICVs, HEVs, and PHEVs, the VLT is $2.80 for every $100.00 of assessed value, where assessed value is 60 percent of the purchase price, decreased by 16.25 percent every year after purchase to account for depreciation.[70] For new EVs, however, the VLT is $4.00 for every $100.00 of assessed value, where assessed value is one percent of the purchase price, discounted each year by 15 percent.[71] We base the estimate for registration discount on the difference between EV's VLT under each formula.

Federal tax credits are taken from the complete list of credits by vehicle make, model, and year, maintained on FuelEconomy.gov.[72]

We estimate the discounted cost of electricity based on the electric vehicle service plan for the SRP and the number of kilowatt-hours needed to charge the battery for PHEVs and EVs using a Level 2 in-home charging station, based on daily driving.[73]

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[67] **ServiceArizona Fees Page**, ServiceArizona.com (Last visited May 28, 2019).

[68] Cost values are brought forward to 2018 dollars.
How do Residential Level 2 Charging Installation Costs Vary by Geographic Location?, The EV Project and Idaho National Laboratory, April 2015. **Blink HQ 30-Amp Home Electric Vehicle (EV) Charger**, Amazon.com (Last visited April 22, 2019).

[69] Although any owner of a vehicle that uses gasoline is also required to get their vehicle's emissions tested in the Phoenix and Tucson areas while EVs do not, most new cars are exempt from these tests within the first five years of operation, so this cost is excluded from the analysis.
Federal Tax Credits for All-Electric and Plug-in Hybrid Vehicles, FuelEconomy.gov (Last visited May 28, 2019); and **Types of Emissions Inspection Exemptions**, MyAZCar.com (Last visited May 28, 2019).

[70] **ServiceArizona Fees Page**, ServiceArizona.com (Last visited May 28, 2019).

[71] **Vehicle Services: Registration: Alternative Fuel Vehicle (AFV)**, AZdot.gov (Last visited May 28, 2019).

[72] **Federal Tax Credits for All-Electric and Plug-in Hybrid Vehicles**, FuelEconomy.gov (Last visited May 28, 2019).

[73] **Electric Vehicle Price Plan**, SRPnet.com (Last visited May 28, 2019).

Social Cost of Ownership

The production, manufacture, and operation of vehicles impose social costs on society at-large measured by the carbon quantities emitted during these processes. To estimate this social cost, researchers commonly combine an estimate of carbon emissions for producing and using the vehicle with a dollar value of the social cost of carbon for a given amount of CO_2 produced.

We calculate the estimated social cost of each vehicle by combining emissions estimates for the manufacturing of each vehicle, the operation of each vehicle in Arizona, and an estimated value for the social costs of such emissions. For emissions from burning gasoline, we use the calculated gasoline requirements, multiplied by the conversion factor of 8,887 grams of CO_2 per gallon used by the U.S. EPA.[74] We also use the estimate from Onat, et al. (2015) for upstream emissions from gasoline production, that is, emissions produced from finding, refining, and transporting gasoline so that vehicle owners can use it.[75]

For upstream emissions produced by electricity generation for charging EVs and PHEVs, we multiply the electricity requirements by the per kilowatt-hour emissions of energy production in Arizona's North American Electricity Reliability Corporation (NERC) region, as described in Onat, et al.[76] Based on Onat, et al.'s analysis, we estimate upstream emissions from the scenario that considers the interconnectedness of the energy grid with out-of-state generation and best represents the mixture of electricity used for marginal increases in demand, such as home charging.[77]

We also draw the manufacturing social costs from the estimates in Onat, et al. (2015) that examined the manufacturing emissions for five sample vehicles of various fuel types. (See Table A-3.) The study included the Nissan Leaf (EV), Chevrolet Volt (PHEV, long range), Toyota Prius Plug-in (PHEV), Toyota Prius (HEV), and the Toyota Corolla (ICV). Thus, the manufacturing emissions numbers may be over- or underestimates depending on the vehicle. Emissions from vehicle and material production increase with materials needed, so these numbers will be underestimates for larger vehicles, and overestimates for smaller ones. Emissions from battery manufacturing increase and decrease with battery capacity. Numbers from the Chevrolet Volt were only used for the Volt itself because no other PHEV examined has a comparable AER.

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[74] ***Questions and Answers: Greenhouse Gas Emissions from a Typical Passenger Vehicle***, U.S. Environmental Protection Agency, March 2018.

[75] Nuri Cihat Onat, Murat Kucukvar, and Omer Tatari, "**Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States**," *Applied Energy*, Volume 150 (July 2015) p. 36-49.

[76] Arizona's NERC region is known as the Western Electricity Coordinating Council-Rocky Mountain Power Authority/Arizona New Mexico.

[77] In their paper, Onat and co-authors label this scenario as "Scenario 2."
Nuri Cihat Onat, Murat Kucukvar, and Omer Tatari, "**Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States**," *Applied Energy*, Volume 150 (July 2015) p. 36-49.

Table A-3: Manufacturing Emissions by Vehicle Type[78]

Fuel Type	Li-ion Electric	Li-ion Plug-in Hybrid (long range)	Li-ion Plug-in Hybrid	Ni-MH Hybrid	Internal Combustion
	Manufacturing emissions, tonsCO_2				
Vehicle Production	10.52	9.71	8.88	8.88	7.11
Material Production	1.80	2.09	1.89	1.89	1.74
Battery Manufacturing	1.34	1.36	0.48	0.24	-
Maintenance and Repairs	2.05	2.34	2.34	2.93	2.93
Fixed Emissions	15.71	15.50	13.59	13.94	11.78

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Battery materials affect the environmental impact of battery production. We therefore use the battery manufacturing emissions from the Ni-MH hybrid (Toyota Prius) for both HEVs and PHEVs with nickel-metal hydride batteries, and the emissions for the Li-ion plug-in hybrid (Toyota Prius plug-in) for both hybrids with lithium-ion batteries. The emissions of the plug-in hybrid (long range) are only used for the Chevrolet Volt, which has emissions from battery manufacturing more like an all-electric vehicle than other plug-in hybrids, and was also the exact model used to estimate the emissions.

The social costs are calculated by multiplying these emissions numbers by an estimate for the social cost of carbon dioxide emissions. We use the value estimated in Nordhaus (2016), which estimates the social cost of CO_2 (SCC) at $45.51 per metric ton of CO_2 in 2015, increasing at three percent per year.[79] Nordhaus (2016) updates the most widely-used model for calculating the SCC, the Dynamic Integrated Model of Climate and the Economy model. Nordhaus' value for the social cost of carbon is also in line with the average estimate found in similar studies examined by the National Academies of Sciences, Engineering, and Medicine (2017).[80]

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[78] Source: Nuri Cihat Onat, Murat Kucukvar, and Omer Tatari, "**Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States**," *Applied Energy*, Volume 150 (July 2015) p. 36-49.

[79] William D. Nordhaus, "**Revisiting the social cost of carbon**," *Proceedings of the National Academy of Sciences of the United States of America*, Volume 114, Number 7 (February 14, 2017) p. 1518-1523.

[80] ***Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide***, Consensus Study Report by the National Academies of Sciences, Engineering, and Medicine, 2017.

Appendix B: Five-Year Comparisons

The complete values of the cost-benefit analysis for each vehicle are listed in the table below to allow for comparisons across any vehicle type. Vehicles were selected in order to compare vehicles with different fuel types but sharing similar vehicle characteristics, and to provide a view of the current automobile market. We compare similar vehicle models (same make and model) by different engine type and best-selling models of a certain vehicle size by different engine type. We assume that best-selling vehicles are competing on similar features. By comparing the same makes and models with different engine types, we do not have to compare vehicles with different characteristics and features that could influence the car-buying decision. For best-selling vehicles, we used all vehicle models that were among the top five best-selling by vehicle size in 2018, according to manufacturer data.[81] Vehicles are presented in alphabetical order.

Economists and policy analysts at the Economic Research Center made the calculations in the charts below using the methodology described in Appendix A. Our analysis includes four vehicle types: internal combustion engine (ICV); a hybrid engine with battery and internal combustion, in which the battery is only charged when the vehicle is in operation (HEV); plug-in hybrid with battery and internal combustion, in which the vehicle can operate on battery for only a given range (PHEV); and battery electric, which is a vehicle that runs only on a battery that must be charged externally between trips (EV).

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[81] **Automotive Sales Data by Segment: Monthly Sales Reports in America (December 2018)**, GoodCarBadCar.net (Last visited May 28, 2019).

Table B-1: Five-Year Ownership Estimates

Make	Acura	Acura	Acura	Audi	Audi	BMW	BMW	BMW	BMW	BMW
Model	2019 MDX	2019 MDX	2019 RDX	2019 A4	2019 Q5	2018 3-Series	2018 3-Series	2019 4-Series	2018 5-series	2018 5-series
Type	HEV	ICV	ICV	ICV	ICV	ICV	PHEV	ICV	ICV	PHEV
	Basic Cost of Ownership									
Cost of Purchase	$51,121	$48,174	$38,819	$34,820	$39,629	$37,743	$42,448	$42,444	$49,272	$49,444
Cost of Gas	$8,639	$10,602	$10,141	$7,775	$9,719	$8,639	$2,634	$8,639	$8,639	$2,439
Cost of Electricity	$0	$0	$0	$0	$0	$0	$1,654	$0	$0	$1,705
Maintenance Cost	$2,323	$2,551	$2,367	$4,008	$4,303	$2,411	$2,477	$2,736	$2,595	$2,560
Cost of Repairs	$1,091	$1,091	$963	$1,377	$1,608	$999	$1,934	$2,616	$999	$999
Insurance Premiums	$5,745	$5,225	$5,615	$4,320	$4,275	$6,045	$6,045	$6,175	$6,865	$6,865
Resale Value	($19,366)	($17,780)	($13,330)	($10,750)	($15,380)	($9,073)	($9,784)	($11,854)	($9,656)	($10,192)
Registration Fees	$3,108	$2,928	$2,360	$2,117	$2,409	$2,294	$2,580	$2,580	$2,995	$3,006
Charging Infrastructure	$0	$0	$0	$0	$0	$0	$1,669	$0	$0	$1,669
Basic Sub-Total	$52,661	$52,791	$46,935	$43,667	$46,563	$49,058	$51,657	$53,336	$61,709	$58,495
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	$0	$0	$0	$0	$0	($4,001)	$0	$0	($4,668)
Discount Cost of Electricity	$0	$0	$0	$0	$0	$0	($270)	$0	$0	($279)
Subsidy Sub-Total	$0	$0	$0	$0	$0	$0	($4,271)	$0	$0	($4,947)
	Social Cost of Ownership									
Manufacturing	$645	$536	$536	$536	$536	$536	$618	$536	$536	$618
Operation	$1,478	$1,814	$1,735	$1,330	$1,662	$1,478	$1,213	$1,478	$1,478	$1,204
Social Sub-Total	$2,122	$2,350	$2,271	$1,866	$2,198	$2,014	$1,831	$2,014	$2,014	$1,822
Total	$54,783	$55,141	$49,206	$45,533	$48,761	$51,072	$49,217	$55,350	$63,723	$55,370

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Table B-1: Five-Year Ownership Estimates (continued)

Make	BMW	BMW	BMW	BMW	Cadillac	Cadillac	Chevrolet	Chevrolet	Chevrolet	Chevrolet
Model	2018 7-series	2018 7-series	2018 i3	2019 X3	2019 Escalade	2019 XT5	2019 Bolt	2019 Cruze	2019 Equinox	2019 Impala
Type	ICV	PHEV	EV	ICV	ICV	ICV	EV	ICV	ICV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$73,725	$77,619	$41,900	$39,336	$75,849	$40,021	$34,412	$18,647	$23,267	$27,039
Cost of Gas	$10,141	$2,927	$0	$8,971	$13,721	$9,239	$0	$6,352	$7,259	$8,130
Cost of Electricity	$0	$1,830	$1,543	$0	$0	$0	$1,490	$0	$0	$0
Maintenance Cost	$2,732	$2,732	$2,447	$3,842	$2,629	$3,119	$2,199	$4,989	$2,585	$2,562
Cost of Repairs	$2,282	$1,890	$1,662	$1,285	$1,156	$1,113	$2,527	$957	$1,798	$1,884
Insurance Premiums	$8,120	$9,500	$6,565	$5,570	$9,240	$6,650	$7,210	$4,756	$4,835	$6,350
Resale Value	($12,193)	($11,920)	($6,362)	($11,338)	($29,411)	($11,526)	($8,623)	($8,481)	($7,498)	($8,668)
Registration Fees	$4,482	$4,718	$2,547	$2,391	$4,611	$2,433	$2,092	$1,134	$1,414	$1,644
Charging Infrastructure	$0	$1,669	$1,669	$0	$0	$0	$1,669	$0	$0	$0
Basic Sub-Total	$89,289	$90,965	$51,971	$50,057	$77,795	$51,049	$42,976	$28,354	$33,660	$38,941
	Subsidies to Owners									
Registration Discount	$0	$0	($2,485)	$0	$0	$0	($2,041)	$0	$0	$0
Federal Tax Credits	$0	($4,668)	($7,500)	$0	$0	$0	($3,750)	$0	$0	$0
Discount Cost of Electricity	$0	($299)	($252)	$0	$0	$0	($244)	$0	$0	$0
Subsidy Sub-Total	$0	($4,967)	($10,237)	$0	$0	$0	($6,035)	$0	$0	$0
	Social Cost of Ownership									
Manufacturing	$536	$618	$715	$536	$536	$536	$715	$536	$536	$536
Operation	$1,735	$1,344	$711	$1,535	$2,347	$1,814	$687	$1,247	$1,425	$1,596
Social Sub-Total	$2,271	$1,962	$1,426	$2,071	$2,883	$2,350	$1,402	$1,783	$1,961	$2,132
Total	$91,560	$87,960	$43,160	$52,128	$80,678	$53,399	$38,343	$30,137	$35,621	$41,073

Table B-1: Five-Year Ownership Estimates (continued)

Make	Chevrolet	Chevrolet	Chevrolet	Chevrolet	Chevrolet	Chevrolet	Chrysler	Chrysler	Chrysler	Dodge
Model	2019 Malibu	2019 Malibu	2019 Silverado	2019 Suburban	2019 Tahoe	2019 Volt	2018 300	2019 Pacifica	2019 Pacifica Hybrid	2019 Charger
Type	HEV	ICV	ICV	ICV	ICV	PHEV	ICV	ICV	PHEV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$26,554	$25,491	$33,285	$48,002	$45,474	$34,412	$27,481	$33,016	$39,771	$28,590
Cost of Gas	$4,418	$6,352	$11,956	$11,292	$11,292	$452	$8,837	$9,239	$1,085	$8,837
Cost of Electricity	$0	$0	$0	$0	$0	$1,495	$0	$0	$1,832	$0
Maintenance Cost	$2,584	$2,584	$5,294	$2,586	$3,472	$2,199	$2,616	$3,693	$3,581	$2,290
Cost of Repairs	$1,769	$1,649	$915	$1,853	$1,733	$2,527	$2,143	$915	$915	$1,817
Insurance Premiums	$6,955	$5,700	$5,170	$5,960	$6,260	$7,210	$7,170	$5,073	$5,073	$7,990
Resale Value	($8,683)	($8,475)	($19,093)	($19,720)	($19,718)	($8,623)	($8,124)	($12,137)	($15,525)	($10,332)
Registration Fees	$1,614	$1,550	$2,023	$2,918	$2,764	$2,092	$1,671	$2,007	$2,418	$1,738
Charging Infrastructure	$0	$0	$0	$0	$0	$1,669	$0	$0	$1,669	$0
Basic Sub-Total	$35,211	$34,851	$39,550	$52,891	$51,277	$43,433	$41,794	$41,806	$40,819	$40,930
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	$0	$0	$0	$0	($3,750)	$0	$0	($7,500)	$0
Discount Cost of Electricity	$0	$0	$0	$0	$0	($244)	$0	$0	($300)	$0
Subsidy Sub-Total	$0	$0	$0	$0	$0	($3,994)	$0	$0	($7,800)	$0
	Social Cost of Ownership									
Manufacturing	$645	$536	$536	$536	$536	$706	$536	$536	$618	$536
Operation	$867	$1,247	$2,347	$2,217	$2,217	$778	$1,735	$1,814	$1,058	$1,735
Social Sub-Total	$1,512	$1,783	$2,883	$2,753	$2,753	$1,484	$2,271	$2,350	$1,676	$2,271
Total	$36,723	$36,634	$42,433	$55,644	$54,030	$40,923	$44,065	$44,156	$34,695	$43,201

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Table B-1: Five-Year Ownership Estimates (continued)

Make	Dodge	Ford	Ford	Ford	Ford	Ford	Ford	Ford	Ford	Ford
Model	2019 Grand Caravan	2019 Escape	2019 Expedition	2019 Explorer	2019 F-150	2018 Focus	2018 Focus	2019 Fusion	2019 Fusion	2019 Fusion Energi
Type	ICV	ICV	ICV	ICV	ICV	EV	ICV	HEV	ICV	PHEV
	Basic Cost of Ownership									
Cost of Purchase	$25,994	$23,546	$50,607	$31,024	$27,789	$27,394	$23,108	$32,977	$33,208	$33,314
Cost of Gas	$10,163	$8,469	$10,163	$9,239	$9,239	$0	$6,556	$4,839	$8,130	$948
Cost of Electricity	$0	$0	$0	$0	$0	$1,650	$0	$0	$0	$1,412
Maintenance Cost	$2,187	$2,219	$2,366	$2,341	$5,391	$2,297	$2,297	$3,065	$2,214	$3,065
Cost of Repairs	$1,853	$1,610	$1,776	$1,752	$915	$1,802	$1,802	$1,730	$1,591	$1,730
Insurance Premiums	$4,920	$4,705	$5,745	$5,440	$5,249	$6,650	$5,400	$6,260	$5,615	$6,955
Resale Value	($7,450)	($7,308)	($21,945)	($11,342)	($14,062)	($3,599)	($5,029)	($9,552)	($10,570)	($9,582)
Registration Fees	$1,580	$1,431	$3,076	$1,886	$1,689	$1,665	$1,405	$2,005	$2,019	$2,025
Charging Infrastructure	$0	$0	$0	$0	$0	$1,669	$0	$0	$0	$1,669
Basic Sub-Total	$39,247	$34,672	$51,788	$40,340	$36,210	$39,528	$35,539	$41,324	$42,207	$41,536
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	($1,625)	$0	$0	$0	$0
Federal Tax Credits	$0	$0	$0	$0	$0	($7,500)	$0	$0	$0	($4,609)
Discount Cost of Electricity	$0	$0	$0	$0	$0	($270)	$0	$0	$0	($231)
Subsidy Sub-Total	$0	$0	$0	$0	$0	($9,395)	$0	$0	$0	($4,840)
	Social Cost of Ownership									
Manufacturing	$536	$536	$536	$536	$536	$715	$536	$645	$536	$618
Operation	$1,995	$1,662	$1,995	$1,814	$1,814	$761	$1,287	$950	$1,596	$837
Social Sub-Total	$2,531	$2,198	$2,531	$2,350	$2,350	$1,475	$1,823	$1,595	$2,132	$1,455
Total	$41,778	$36,870	$54,319	$42,690	$38,560	$31,608	$37,362	$42,919	$44,339	$38,151

Table B-1: Five-Year Ownership Estimates (continued)

Make	Ford	GMC	GMC	Honda	Honda	Honda	Honda	Honda	Hyundai	Hyundai
Model	2019 Taurus	2019 Sierra	2019 Yukon	2019 Accord	2019 Accord Hybrid	2019 Civic	2019 CR-V	2019 Odyssey	2018 Elantra	2018 Ioniq Electric
Type	ICV	ICV	ICV	ICV	HEV	ICV	ICV	ICV	ICV	EV
	Basic Cost of Ownership									
Cost of Purchase	$27,201	$35,390	$50,863	$30,802	$30,227	$19,705	$23,897	$28,669	$20,020	$29,002
Cost of Gas	$9,679	$10,163	$11,956	$6,159	$4,234	$6,159	$7,259	$9,239	$5,807	$0
Cost of Electricity	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,330
Maintenance Cost	$2,154	$2,521	$2,575	$1,944	$1,917	$1,937	$2,182	$2,375	$2,322	$1,477
Cost of Repairs	$1,632	$1,795	$1,956	$1,579	$1,579	$1,579	$1,618	$1,745	$703	$739
Insurance Premiums	$4,320	$5,830	$6,565	$4,535	$6,350	$6,090	$4,835	$4,535	$5,525	$6,390
Resale Value	($7,801)	($18,323)	($21,518)	($12,545)	($12,067)	($8,035)	($10,391)	($12,123)	($5,573)	($4,557)
Registration Fees	$1,653	$2,151	$3,092	$1,872	$1,837	$1,198	$1,453	$1,743	$1,217	$1,763
Charging Infrastructure	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,669
Basic Sub-Total	$38,838	$39,527	$55,489	$34,346	$34,077	$28,633	$30,853	$36,183	$30,021	$37,813
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	($1,720)
Federal Tax Credits	$0	$0	$0	$0	$0	$0	$0	$0	$0	($7,500)
Discount Cost of Electricity	$0	$0	$0	$0	$0	$0	$0	$0	$0	($218)
Subsidy Sub-Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	($9,438)
	Social Cost of Ownership									
Manufacturing	$536	$536	$536	$536	$645	$536	$536	$536	$536	$715
Operation	$1,900	$1,995	$2,347	$1,209	$831	$1,209	$1,425	$1,814	$1,140	$613
Social Sub-Total	$2,436	$2,531	$2,883	$1,745	$1,476	$1,745	$1,961	$2,350	$1,676	$1,328
Total	$41,274	$42,058	$58,372	$36,091	$35,553	$30,378	$32,814	$38,533	$31,697	$29,703

Table B-1: Five-Year Ownership Estimates (continued)

Make	Hyundai	Hyundai	Hyundai	Hyundai	Hyundai	Infiniti	Infiniti	Infiniti	Infiniti	Jeep
Model	2018 Ioniq Hybrid	2018 Ioniq Plug-in Hybrid	2018 Sonata	2018 Sonata Hybrid	2018 Sonata Hybrid	2018 Q50	2018 Q50	2019 QX60	2019 QX80	2019 Grand Cherokee
Type	HEV	PHEV	ICV	HEV	PHEV	HEV	ICV	ICV	ICV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$21,385	$24,026	$21,416	$24,506	$31,776	$46,140	$35,925	$40,306	$60,088	$31,175
Cost of Gas	$3,504	$690	$7,009	$4,839	$954	$8,043	$10,141	$10,602	$14,578	$9,679
Cost of Electricity	$0	$1,227	$0	$0	$1,478	$0	$0	$0	$0	$0
Maintenance Cost	$2,286	$2,286	$2,286	$1,784	$1,784	$8,141	$7,649	$3,123	$3,131	$3,369
Cost of Repairs	$739	$739	$703	$759	$759	$1,042	$1,252	$866	$866	$1,831
Insurance Premiums	$6,390	$6,390	$6,090	$6,825	$4,320	$7,277	$6,703	$5,400	$6,565	$5,485
Resale Value	($5,078)	($5,683)	($7,109)	($7,915)	($8,875)	($13,040)	($11,265)	($14,398)	($22,042)	($12,612)
Registration Fees	$1,300	$1,460	$1,302	$1,490	$1,932	$2,805	$2,184	$2,450	$3,653	$1,895
Charging Infrastructure	$0	$1,669	$0	$0	$1,669	$0	$0	$0	$0	$0
Basic Sub-Total	$30,526	$32,804	$31,697	$32,288	$35,797	$60,408	$52,589	$48,349	$66,839	$40,822
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	($7,500)	$0	$0	($4,919)	$0	$0	$0	$0	$0
Discount Cost of Electricity	$0	($201)	$0	$0	($242)	$0	$0	$0	$0	$0
Subsidy Sub-Total	$0	($7,701)	$0	$0	($5,161)	$0	$0	$0	$0	$0
	Social Cost of Ownership									
Manufacturing	$645	$618	$536	$645	$618	$645	$536	$536	$536	$536
Operation	$688	$701	$1,376	$950	$869	$1,376	$1,735	$1,814	$2,494	$1,900
Social Sub-Total	$1,333	$1,319	$1,912	$1,595	$1,487	$2,020	$2,271	$2,350	$3,030	$2,436
Total	$31,859	$26,422	$33,609	$33,883	$32,123	$62,428	$54,860	$50,699	$69,869	$43,258

Table B-1: Five-Year Ownership Estimates (continued)

Make	Jeep	Kia	Kia	Kia	Kia	Kia	Kia	Kia	Kia	Land Rover
Model	2019 Wrangler	2019 Niro	2019 Niro Plug-in Hybrid	2018 Optima	2018 Optima Hybid	2018 Optima Plug-In Hybrid	2019 Sedona	2018 Soul	2018 Soul EV	2019 Range Rover Sport
Type	ICV	HEV	PHEV	ICV	HEV	PHEV	ICV	ICV	EV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$27,749	$23,072	$27,386	$23,350	$28,798	$32,458	$26,615	$16,330	$32,130	$89,777
Cost of Gas	$10,163	$4,148	$866	$7,259	$4,839	$897	$9,679	$7,528	$0	$12,958
Cost of Electricity	$0	$0	$1,369	$0	$0	$1,446	$0	$0	$1,650	$0
Maintenance Cost	$1,761	$2,461	$2,461	$2,585	$2,461	$2,461	$2,728	$2,762	$1,477	$4,935
Cost of Repairs	$1,860	$729	$729	$715	$771	$771	$672	$731	$731	$1,394
Insurance Premiums	$5,095	$5,140	$5,140	$6,565	$6,605	$6,605	$5,050	$4,835	$6,955	$6,565
Resale Value	($17,724)	($8,713)	($10,028)	($7,978)	($8,608)	($9,748)	($8,473)	($5,982)	($6,620)	($34,097)
Registration Fees	$1,687	$1,402	$1,665	$1,419	$1,751	$1,973	$1,618	$993	$1,953	$5,457
Charging Infrastructure	$0	$0	$1,669	$0	$0	$1,669	$0	$0	$1,669	$0
Basic Sub-Total	$30,591	$28,239	$31,257	$33,915	$36,617	$38,532	$37,889	$27,197	$39,945	$86,989
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	($1,905)	$0
Federal Tax Credits	$0	$0	($4,543)	$0	$0	($4,919)	$0	$0	($7,500)	$0
Discount Cost of Electricity	$0	$0	($224)	$0	$0	($236)	$0	$0	($270)	$0
Subsidy Sub-Total	$0	$0	($4,767)	$0	$0	($5,155)	$0	$0	($9,675)	$0
	Social Cost of Ownership									
Manufacturing	$536	$645	$618	$536	$645	$618	$536	$536	$715	$536
Operation	$1,995	$814	$801	$1,425	$950	$843	$1,900	$1,478	$761	$2,217
Social Sub-Total	$2,531	$1,459	$1,419	$1,961	$1,595	$1,461	$2,436	$2,014	$1,475	$2,753
Total	$33,122	$29,698	$27,909	$35,876	$38,212	$34,838	$40,325	$29,211	$31,745	$89,742

Table B-1: Five-Year Ownership Estimates (continued)

Make	Lexus	Lexus	Lexus	Lexus	Lexus	Lexus	Lexus	Lexus	Lexus	Lexus
Model	2019 ES	2019 ES	2019 LS	2019 LS	2019 NX	2019 NX	2019 RX	2019 RX	2019 UX	2019 UX
Type	HEV	ICV	HEV	ICV	HEV	ICV	HEV	ICV	HEV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$39,960	$38,113	$77,577	$72,638	$38,061	$37,264	$44,495	$43,315	$33,725	$30,941
Cost of Gas	$4,619	$7,817	$8,330	$10,141	$6,556	$9,719	$7,775	$9,239	$5,212	$6,159
Cost of Electricity	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Maintenance Cost	$3,552	$3,491	$4,491	$4,491	$6,904	$6,964	$3,279	$4,168	$3,722	$3,722
Cost of Repairs	$991	$927	$980	$1,060	$1,175	$1,385	$1,040	$963	$1,045	$829
Insurance Premiums	$6,435	$6,865	$8,680	$8,680	$5,887	$5,652	$5,485	$5,960	$4,320	$4,320
Resale Value	($15,663)	($14,589)	($25,058)	($24,424)	($16,794)	($16,086)	($19,790)	($18,898)	($11,908)	($10,898)
Registration Fees	$2,429	$2,317	$4,716	$4,415	$2,314	$2,265	$2,705	$2,633	$2,050	$1,881
Charging Infrastructure	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Basic Sub-Total	$42,323	$44,941	$79,716	$77,001	$44,103	$47,163	$44,989	$47,380	$38,166	$36,954
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Discount Cost of Electricity	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Subsidy Sub-Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Social Cost of Ownership									
Manufacturing	$634	$536	$645	$536	$634	$536	$634	$536	$634	$536
Operation	$907	$1,535	$1,425	$1,735	$1,287	$1,662	$1,330	$1,814	$1,023	$1,209
Social Sub-Total	$1,541	$2,071	$2,070	$2,271	$1,921	$2,198	$1,964	$2,350	$1,657	$1,745
Total	$43,864	$47,012	$81,786	$79,272	$46,024	$49,361	$46,953	$49,730	$39,823	$38,699

Table B-1: Five-Year Ownership Estimates (continued)

Make	Lincoln	Lincoln	Lincoln	Mercedes-Benz	Mercedes-Benz	Mercedes-Benz	Mercedes-Benz	Mercedes-Benz	Mercedes-Benz	Mercedes-Benz
Model	2018 MKZ	2018 MKZ	2019 Navigator	2018 C-Class	2019 E-Class	2019 GLC-Class	2019 GLC-Class	2019 GLE-Class	2019 GLS-Class	2019 S-Class
Type	HEV	ICV	ICV	ICV	ICV	ICV	PHEV	ICV	ICV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$34,294	$34,250	$75,066	$36,543	$49,290	$39,277	$45,328	$54,169	$65,133	$84,791
Cost of Gas	$5,081	$8,469	$10,697	$8,639	$9,330	$9,719	$3,971	$11,663	$12,958	$10,602
Cost of Electricity	$0	$0	$0	$0	$0	$0	$1,803	$0	$0	$0
Maintenance Cost	$2,951	$1,964	$3,426	$4,599	$4,776	$4,420	$4,420	$8,136	$4,431	$5,087
Cost of Repairs	$1,233	$1,132	$1,526	$1,236	$1,236	$1,527	$1,527	$3,210	$1,527	$1,236
Insurance Premiums	$5,915	$6,910	$4,746	$6,305	$6,305	$5,700	$6,305	$5,968	$4,320	$9,155
Resale Value	($8,401)	($8,036)	($31,632)	($9,898)	($14,713)	($15,293)	($17,042)	($17,985)	($20,632)	($25,828)
Registration Fees	$2,085	$2,082	$4,563	$2,221	$2,996	$2,388	$2,755	$3,293	$3,959	$5,154
Charging Infrastructure	$0	$0	$0	$0	$0	$0	$1,669	$0	$0	$0
Basic Sub-Total	$43,158	$46,771	$68,392	$49,645	$59,220	$47,738	$50,736	$68,454	$71,696	$90,197
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	$0	$0	$0	$0	$0	($4,460)	$0	$0	$0
Discount Cost of Electricity	$0	$0	$0	$0	$0	$0	($295)	$0	$0	$0
Subsidy Sub-Total	$0	$0	$0	$0	$0	$0	($4,755)	$0	$0	$0
	Social Cost of Ownership									
Manufacturing	$645	$536	$536	$536	$536	$536	$618	$536	$536	$536
Operation	$997	$1,662	$2,100	$1,478	$1,596	$1,662	$1,511	$1,995	$2,217	$1,814
Social Sub-Total	$1,642	$2,198	$2,636	$2,014	$2,132	$2,198	$2,129	$2,531	$2,753	$2,350
Total	$44,800	$48,969	$71,028	$51,659	$61,352	$49,936	$48,110	$70,985	$74,449	$92,547

Table B-1: Five-Year Ownership Estimates (continued)

Make	Nissan	Nissan	Nissan	Nissan	Nissan	Nissan	Nissan	Porche	Porche	Porche
Model	2019 Altima	2019 Armada	2019 Leaf	2019 Maxima	2019 Rogue	2019 Rogue	2019 Sentra	2018 Cayenne	2018 Cayenne	2018 Panamera
Type	ICV	ICV	EV	ICV	HEV	ICV	ICV	ICV	PHEV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$22,858	$44,581	$28,815	$32,562	$26,619	$25,323	$17,918	$71,311	$72,288	$83,978
Cost of Gas	$6,352	$12,703	$0	$9,719	$5,978	$7,009	$6,352	$11,663	$3,592	$10,141
Cost of Electricity	$0	$0	$1,596	$0	$0	$0	$0	$0	$2,463	$0
Maintenance Cost	$2,219	$2,817	$1,936	$2,615	$2,719	$2,719	$2,162	$6,498	$4,829	$6,032
Cost of Repairs	$1,598	$1,649	$1,610	$2,498	$1,656	$1,630	$1,598	$2,695	$2,829	$1,934
Insurance Premiums	$6,350	$6,435	$6,480	$7,600	$5,140	$4,965	$5,875	$5,225	$5,225	$8,120
Resale Value	($8,182)	($16,973)	($6,794)	($11,150)	($10,598)	($9,815)	($5,618)	($24,319)	($21,047)	($24,475)
Registration Fees	$1,389	$2,710	$1,752	$1,979	$1,618	$1,539	$1,089	$4,335	$4,394	$5,105
Charging Infrastructure	$0	$0	$1,669	$0	$0	$0	$0	$0	$1,669	$0
Basic Sub-Total	$32,584	$53,922	$37,064	$45,823	$33,132	$33,370	$29,376	$77,408	$76,242	$90,835
	Subsidies to Owners									
Registration Discount	$0	$0	($1,709)	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	$0	($7,500)	$0	$0	$0	$0	$0	($5,336)	$0
Discount Cost of Electricity	$0	$0	($261)	$0	$0	$0	$0	$0	($403)	$0
Subsidy Sub-Total	$0	$0	($9,470)	$0	$0	$0	$0	$0	($5,739)	$0
	Social Cost of Ownership									
Manufacturing	$536	$536	$715	$536	$645	$536	$536	$536	$618	$536
Operation	$1,247	$2,494	$736	$1,662	$1,173	$1,376	$1,247	$1,995	$1,750	$1,735
Social Sub-Total	$1,783	$3,030	$1,451	$2,198	$1,818	$1,912	$1,783	$2,531	$2,368	$2,271
Total	$34,367	$56,952	$29,045	$48,021	$34,950	$35,282	$31,159	$79,939	$72,871	$93,106

Table B-1: Five-Year Ownership Estimates (continued)

Make	Porche	Ram	Subaru	Toyota	Toyota	Toyota	Toyota	Toyota	Toyota	Toyota
Model	2018 Panamera	2019 Pickup	2019 Outback	2019 Avalon	2019 Avalon	2019 Camry LE	2019 Camry LE	2019 Camry SE	2019 Camry SE	2019 Corolla
Type	PHEV	ICV	ICV	HEV	ICV	HEV	ICV	HEV	ICV	ICV
	Basic Cost of Ownership									
Cost of Purchase	$93,191	$34,537	$25,235	$33,865	$33,213	$26,880	$22,863	$28,616	$23,971	$17,913
Cost of Gas	$3,216	$10,838	$7,259	$4,619	$7,817	$3,909	$6,352	$4,418	$6,352	$6,352
Cost of Electricity	$2,187	$0	$0	$0	$0	$0	$0	$0	$0	$0
Maintenance Cost	$4,829	$3,492	$3,196	$2,012	$2,231	$2,228	$2,523	$2,228	$2,523	$2,382
Cost of Repairs	$2,829	$1,793	$1,735	$1,716	$1,591	$1,716	$1,579	$1,716	$1,579	$1,591
Insurance Premiums	$8,120	$7,040	$5,570	$6,045	$6,780	$6,390	$6,605	$6,390	$6,605	$6,000
Resale Value	($27,175)	($16,559)	($11,201)	($11,990)	($11,670)	($9,626)	($8,879)	($10,187)	($9,299)	($7,259)
Registration Fees	$5,665	$2,099	$1,534	$2,059	$2,019	$1,634	$1,390	$1,739	$1,457	$1,089
Charging Infrastructure	$1,669	$0	$0	$0	$0	$0	$0	$0	$0	$0
Basic Sub-Total	$94,531	$43,240	$33,328	$38,326	$41,981	$33,131	$32,433	$34,920	$33,188	$28,068
	Subsidies to Owners									
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	($6,670)	$0	$0	$0	$0	$0	$0	$0	$0	$0
Discount Cost of Electricity	($358)	$0	$0	$0	$0	$0	$0	$0	$0	$0
Subsidy Sub-Total	($7,028)	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Social Cost of Ownership									
Manufacturing	$618	$536	$536	$634	$536	$645	$536	$634	$536	$536
Operation	$1,558	$1,995	$1,425	$907	$1,535	$767	$1,247	$867	$1,247	$1,247
Social Sub-Total	$2,177	$2,531	$1,961	$1,541	$2,071	$1,412	$1,783	$1,501	$1,783	$1,783
Total	$89,680	$45,771	$35,289	$39,867	$44,052	$34,543	$34,216	$36,421	$34,971	$29,851

Table B-1: Five-Year Ownership Estimates (continued)

Make	Toyota	Toyota	Toyota	Toyota	Toyota	Toyota	Toyota	Toyota	Toyota	Volvo	Volvo
Model	2019 Highlander	2019 Highlander	2018 Prius (Two Eco)	2018 Prius (One)	2018 Prius Prime	2019 RAV4	2019 RAV4 Hybrid	2019 Sienna	2019 Tacoma	2019 XC90	2019 XC90
Type	HEV	ICV	HEV	HEV	PHEV	ICV	HEV	ICV	ICV	ICV	PHEV
	Basic Cost of Ownership										
Cost of Purchase	$35,528	$33,428	$23,716	$21,862	$26,476	$26,429	$27,851	$29,554	$25,125	$52,170	$63,997
Cost of Gas	$7,009	$8,837	$3,629	$3,909	$762	$6,775	$5,081	$9,239	$9,679	$10,602	$2,701
Cost of Electricity	$0	$0	$0	$0	$1,061	$0	$0	$0	$0	$0	$2,079
Maintenance Cost	$2,565	$2,281	$2,098	$2,098	$2,098	$5,163	$3,901	$2,395	$2,322	$2,284	$2,284
Cost of Repairs	$1,798	$1,702	$1,898	$1,898	$1,898	$841	$841	$1,591	$1,610	$1,415	$1,415
Insurance Premiums	$5,485	$5,525	$6,650	$6,650	$6,650	$4,815	$5,963	$4,920	$5,485	$4,835	$4,835
Resale Value	($17,578)	($15,987)	($7,564)	($7,318)	($8,183)	($14,600)	($15,142)	($11,667)	($14,737)	($20,977)	($22,880)
Registration Fees	$2,160	$2,032	$1,442	$1,329	$1,609	$1,607	$1,693	$1,797	$1,527	$3,171	$3,890
Charging Infrastructure	$0	$0	$0	$0	$1,669	$0	$0	$0	$0	$0	$1,669
Basic Sub-Total	$36,967	$37,818	$31,869	$30,428	$34,040	$31,030	$30,188	$37,829	$31,011	$53,500	$59,990
	Subsidies to Owners										
Registration Discount	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credits	$0	$0	$0	$0	($4,502)	$0	$0	$0	$0	$0	($5,002)
Discount Cost of Electricity	$0	$0	$0	$0	($173)	$0	$0	$0	$0	$0	($340)
Subsidy Sub-Total	$0	$0	$0	$0	($4,675)	$0	$0	$0	$0	$0	($5,342)
	Social Cost of Ownership										
Manufacturing	$634	$536	$645	$634	$618	$536	$634	$536	$536	$536	$618
Operation	$1,376	$1,735	$712	$767	$639	$1,330	$997	$1,814	$1,900	$1,814	$1,421
Social Sub-Total	$2,010	$2,271	$1,357	$1,401	$1,257	$1,866	$1,631	$2,350	$2,436	$2,350	$2,039
Total	$38,977	$40,089	$33,226	$31,829	$30,622	$32,896	$31,819	$40,179	$33,447	$55,850	$56,687

About the Authors

Rea S. Hederman Jr. is the executive director of the Economic Research Center and vice president of policy at The Buckeye Institute. In this role, Hederman oversees Buckeye's research and policy output. A nationally recognized expert in healthcare policy and tax policy, Hederman has published numerous reports and papers looking at returning health care power to the states, the impact of policy changes on a state's economy, labor markets, and how to reform tax systems to spur economic growth.

Prior to joining Buckeye, Hederman was director, and a founding member of the Center for Data Analysis (CDA) at the Heritage Foundation, where he served as the organization's top "number cruncher." Under Hederman's leadership, the CDA provided state-of-the-art economic modeling, database products, and original studies.

While at Heritage, Hederman oversaw technical research on taxes, health care, income and poverty, entitlements, energy, education, and employment, among other policy and economic issues, and he was responsible for managing the foundation's legislative statistical analysis and econometric modeling.

In 2014, Hederman was admitted into the prestigious Cosmos Club as a recognition of his scholarship. He graduated from Georgetown Public Policy Institute with a Master of Public Policy degree and holds a Bachelor of Arts degree in history and foreign affairs from the University of Virginia.

Andrew J. Kidd, Ph.D. is an economist with the Economic Research Center at The Buckeye Institute. In this position, Kidd conducts and produces original economic research that looks at and analyzes the impact of state and federal policies on peoples' lives and on the economy.

Prior to joining The Buckeye Institute, Kidd worked in litigation consulting, providing expert testimony related to economic damages in legal cases. Kidd also served as a research assistant at the UW Population Health Institute at the University of Wisconsin-Madison, which, through its health policy group, performs research and analysis projects on health care access, cost, financing, health system performance, and quality. During his time at the University of Wisconsin-Madison, Kidd's research focus was in demography, education, labor outcomes, and the effects of public policy on labor, education, and health outcomes. He was a College of Letters and Science teaching fellow and was awarded the Anna Morris Ely Teaching Award from the Department of Economics. While there, he taught classes in wages and the labor market, analytical public finance, the principles of microeconomics, and the principles of macroeconomics.

Kidd continues to study questions regarding labor markets and the effects of public policy and demographics on labor market outcomes and behaviors, as well as evaluating health care policy and education policy. A native of Lima, Ohio, Kidd received his bachelor's degree in economics and mathematics from the University of Notre Dame before completing his master's degree and his doctorate in economics from the University of Wisconsin-Madison.

Tyler Shankel is an economic policy analyst with The Buckeye Institute's Economic Research Center. In this role, he analyzes the economic impacts of government policies on government budgets and taxpayers.

Prior to joining Buckeye's Economic Research Center, Shankel was a research contractor at the Institute for Humane Studies at George Mason University. In that role, he reviewed the works of scholars from around the world and provided recommendations on how to best work with them to forward the organization's mission.

Shankel attended the University of Colorado Boulder's economics doctorate program before returning to Columbus. While at the University of Colorado, he worked on a project that examined the causal factors relating to internal migration patterns within Canada, to be compared with their effects on new immigrants settling throughout Canada.

Shankel earned his bachelor's degree in economics and a minor in Persian from The Ohio State University. There, he worked on a comprehensive policy analysis project examining land tenure reform on Indian reservations, and other policy issues relating to economic development in Native American communities.

James B. Woodward, Ph.D. is an economic research analyst with the Economic Research Center at The Buckeye Institute. In this position he collects economic data, performs research, and writes about economic policy issues.

Prior to joining The Buckeye Institute, Woodward earned his Master of Public Policy and a Ph.D. in public policy from the University of Kentucky. During his time there, Woodward worked for the commonwealth's Hazard Mitigation Grant program, helping to verify the quality of regional emergency preparedness plans. He also performed policy-related research for the Commonwealth Council on Developmental Disabilities, contributing to a paper on possible, new treatment options for those with disabilities.

Woodward has also spent time researching public economics, health economics, and occupational licensing. His dissertation, *American Obesity: Rooted in Uncertainty, Institutions, and Public Policy*, looked at the role bad public policy (as opposed to consumers and/or market forces) may have played in the rapid increase in obesity rates.

A native of Athens, Ohio, Woodward received his bachelor's degree in economics from Ohio University before going on to complete his graduate studies.

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