OVERCHARGED EXPECTATIONS:
UNMASKING THE TRUE COSTS OF ELECTRIC VEHICLES

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October 2023

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Executive Summary

An in-depth analysis of the comprehensive costs associated with electric vehicle (EV) ownership is crucial for a holistic understanding of the economic landscape surrounding the attempted mass transition from internal combustion engine vehicles (ICEVs) to EVs. Major selling points promoted by EV advocates are lower maintenance and fueling costs over the life of the vehicle and the common claim that reductions in battery prices will eventually make EVs less expensive to own than ICEVs. For example, a study conducted by a group at the Argonne National Laboratory estimated that while an average EV is about $22,000 more expensive to purchase than a comparable ICEV, they cost about $14,000 less to fuel, insure and maintain over a 15-year period, making their lifetime cost only $8,047 more than an ICEV (Burnham et al., 2021, p. 144, Table B.1).

Setting aside some of the questionable assumptions used in deriving such favorable economics for EVs, no one has attempted to calculate the full financial benefit of the wide array of direct subsidies, regulatory credits, and subsidized infrastructure that contribute to the economic viability of EVs. In this paper, we show that the average model year (MY) 2021 EV would cost $48,698 more to own over a 10-year period without $22 billion in government favors given to EV manufacturers and owners.

EV advocates claim that the cost of electricity for EV owners is equal to $1.21 per gallon of gasoline (Edison Electric Institute, 2021), but the cost of charging equipment and charging losses, averaged out over 10 years and 120,000 miles, is $1.38 per gallon equivalent on top of that. Adding the costs of the subsidies to the true cost of fueling an EV would equate to an EV owner paying $17.33 per gallon of gasoline. And these estimates do not include the hundreds of billions more in subsidies in the Inflation Reduction Act (2022) for various aspects of the EV supply chain, particularly for battery manufacturing. It is not an overstatement to say that the federal government is subsidizing EVs to a greater degree than even wind and solar electricity generation and embarking on an unprecedented endeavor to remake the entire American auto industry.

Despite massive incentives, EVs are receiving a tepid response from the majority of Americans who cannot shoulder their higher cost. Car lots are swelling with unsold EVs (Muller, 2023), and the Ford Motor Company is losing over $70,000 on each EV it currently sells (Bryce, 2023). EV enthusiasts are holding out for breakthroughs in battery technology—batteries being the main factor in the high cost of EVs—to reduce prices and make EVs more widespread. But advances in battery technology are measured not in months but in decades, and the downward trend of lithium-ion battery costs over the past decade has largely ended (IEA, 2023a). It's time for federal and state governments to stop

Key Points

- The cost of producing electric vehicles (EVs) is far higher than the prices they are being sold for. Nearly $22 billion in federal and state subsidies and regulatory credits suppressed the retail price of EVs in 2021 by an average of almost $50,000.
- Thanks to an unlawful multiplier, EVs receive nearly seven times more credits under federal fuel efficiency programs than they provide in actual fuel economy benefits.
- Regulatory credits with bonus EV multipliers from federal fuel efficiency and greenhouse gas emissions standards and state EV sales mandates provide an average of $27,881 in benefits per vehicle for producers of EVs.
- Home and public charging stations used by EVs put a significant strain on the electric grid, resulting in an average of $11,833 in socialized costs per EV over 10 years, which are shouldered by utility ratepayers and taxpayers.
- Direct state and federal subsidies for EVs average $8,984 per vehicle over 10 years.

driving the American auto industry off an economic cliff and allow markets to drive further improvements in cost and efficiency.

Introduction

A common argument in favor of electric vehicles (EVs) is that, despite their higher upfront costs, their lifetime ownership costs are comparable to or even lower than gas-powered vehicles, also known as internal combustion engine vehicles (ICEVs). These lower lifetime costs are calculated based on lower maintenance costs resulting from the simplicity of electric motors compared to gasoline engines and the lower cost of charging an EV compared to the cost of gasoline over the lifetime of an ICEV (Harto, 2020; Borlaug et al., 2020).

A group from Argonne National Laboratory attempted to analyze this argument with a detailed 2021 study and projected that a model year 2025 (MY2025) EV with a 300-mile range will cost $96,295 to purchase, insure, fuel, and maintain over 15 years if driven 12,000 miles per year (Burnham et al., 2021, p. 144, Table B.1). A typical light-duty ICEV—the paper uses a small SUV as its base case—costs about $22,000 less to purchase ($28,935 vs. $50,703) but is only $8,047 less expensive over its lifetime ($88,248 vs. $96,295) because ICEV has higher fueling and maintenance costs.

However, even this simplified analysis ignores the hidden and embedded costs that EV owners are not paying directly. When we pay for a gallon of gasoline, we are paying for the entire infrastructure to refine, transport, and market that gasoline. When an EV owner connects to the electric grid, how much are they paying for the extra generation, transmission, and distribution costs that they are imposing on the grid, and will those embedded costs rise over time? And then there are the federal and state taxes imposed on every gallon of gasoline compared with tax rebates for EVs, as well as the indirect subsidies created by the federal Corporate Average Fuel Economy (CAFE) standards and the Environmental Protection Agency's (EPA) greenhouse gas (GHG) emissions standards, which this paper will show are surprisingly large and are being absorbed by buyers of ICEVs.

When we add up these hidden costs, especially if the share of EVs grows from their current 8% market share of new vehicles being sold in the U.S. (IEA, 2023b, "EV sales share, cars, USA, 2010-2022" section), we find that the lifetime cost of a typical EV is far greater than that of an ICEV. Even a significant drop in battery costs is unlikely to close the gap in the near future. **Figure 1** below shows the lifetime embedded costs as well as the direct and indirect subsidy costs of an EV compared to a new ICEV.

The elements of this chart can be broken down into three buckets. First are the direct subsidies paid out by the federal government and many state governments. Most prominent among the litany of direct subsidies is the $7,500 federal tax credit for EVs which was recently extended and modified by the Inflation Reduction Act (H.R. 5376, 2022, Sec. 13401), but many states also gave handouts to EV buyers to the tune of almost $1,500 when averaged across all EVs sold in 2021. There are also federal, state, and utility subsidies for charging infrastructure, which add up to more than $1,300 per EV.

Second are the indirect subsidies, most notably avoided state and federal fuel taxes. Given that fuel taxes are used to fund road construction and maintenance, and EVs are heavier than comparable ICEVs and thus impart more stress on roads, EV owners should be paying more than ICEV owners in fuel taxes. But most states are only slowly catching up to fixing the gap in tax treatment, and the federal government is doing nothing at all. Another piece of hidden subsidies are the extra costs imparted on the electric grid by EVs, of which EV owners are only paying a portion. Generation, transmission, distribution, and overhead costs for utilities are all affected by EVs, and it is crucial for the future of the electric grid that EVs charge at times that reduce demand volatility rather than increase it as is often the case today.

Finally, regulatory mandates, which are the three blue columns on the right side of **Figure 1**, make up the largest chunk of the hidden cost of EVs. The largest contribution is due to the CAFE standards, which in recent years have been made increasingly stringent in order to make ICEVs more expensive and to drive EV adoption. On top of that, the EPA has been empowered to enact GHG emissions standards above and beyond the de facto reductions in GHG emissions created by the CAFE standards. Many states, most notably California, also have zero emissions vehicle (ZEV) mandates that require automakers to sell a certain number of EVs in those states and act as another tax on ICEVs.

Combining all these hidden subsidies adds $48,698 to the cost of an average MY2021 EV over 10 years, far exceeding the $8,047 difference given by Burnham et al. (2021). Assuming the EV is driven for 10 years and 120,000 miles—an optimistic assumption given that that the average U.S.

Figure 1(a)
Subsidies and Regulatory Credits Accrued by a MY2021 Electric Vehicle Over 10 Years

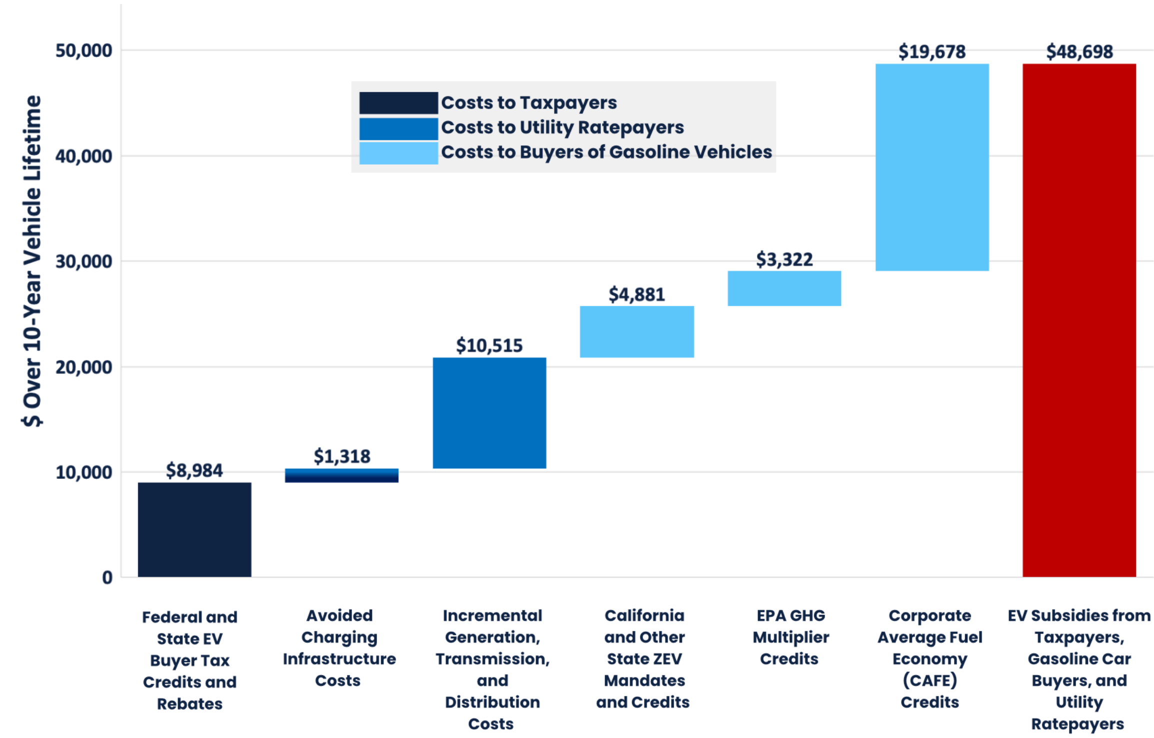
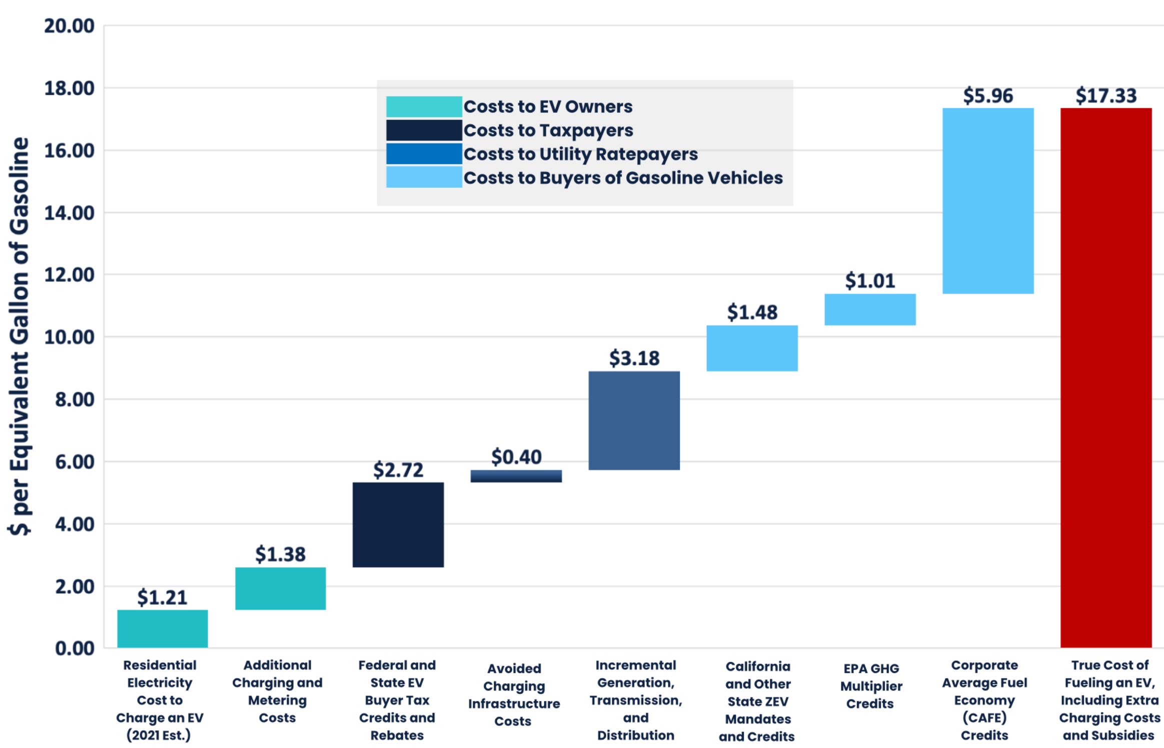


Figure 1(b)
Subsidies and Excess Charging Costs Accrued by a MY2021 Electric Vehicle Over 10 Years, Expressed in Terms of the Cost per Equivalent Gallon of Gasoline



light-duty vehicle is driven 11,467 miles per year (EERE, 2020) and most EVs are used for short-distance trips and commutes—these subsidies and the average of $4,569 in extra costs incurred by EV owners for charging and electricity losses are equivalent to the EV owner paying $53,267 over the lifetime of the vehicle. EV advocates claim the cost of electricity to charge an EV is $1.21/gallon equivalent (Edison Electric Institute, 2021). However, the true cost of fueling a MY2021 EV, including excess charging costs and subsidies, is equal to $17.33 per gallon of gasoline. This analysis shows that electricity is a long way from becoming a cost-effective transportation fuel compared to gasoline.

Federal policy is also pushing EVs over hybrid vehicles, even though hybrids offer a far more efficient way to improve fuel economy and reduce emissions. They use a much smaller battery, offer excellent driving range and performance, and don't require any upgrades to our electric infrastructure. Toyota estimated that 90 hybrid batteries can be made from the same amount of raw materials as one EV battery and that those hybrids will reduce emissions 37 times more over their lifetime than one EV (McParland, 2023). However, hybrids receive far fewer subsidies and regulatory favors than EVs, as the prevailing political consensus is "all EV or nothing."

The optimistic assumptions from Burnham et al. and other researchers regarding maintenance costs, battery life, etc. are worth noting but are beyond the scope of this study. The focus here will be explaining the different elements of **Figure 1** and showing how EVs are not economical for most drivers without state and federal subsidies and regulatory mandates forcing them into the marketplace and hiding the true costs of manufacturing and using them.

Section 1: Regulatory Credits

The largest source of financial support for EVs comes not from direct subsidies but from hidden costs driven by federal regulations. These regulatory standards are applied on a fleetwide basis and allow for the trading of regulatory credits, the costs of which are passed on to buyers of gasoline and diesel vehicles. What's not hidden is the desire of federal regulators to use these standards to force Americans to buy EVs, and when the latest standards were announced earlier this year the Biden administration prominently noted that they are designed to make 67% of new light-duty vehicles sold in the U.S. all-electric by 2032 (The White House, 2023).

Two sets of federal standards are being used to drive EV adoption, and the CAFE standards are the most prominent. Congress established the CAFE standards in 1975 following the Arab oil embargo and a (now debunked) concern that the U.S. was reaching "peak oil," that is, that it would no longer be able to sufficiently increase oil production to meet growing demand. The CAFE standards require that each auto manufacturer meet a certain minimum average fuel economy across their entire fleet of new vehicles sold in the U.S. (49 U.S.C. 32902). The National Highway Transportation Safety Administration (NHTSA), housed inside the Department of Transportation (DOT), is responsible for setting the standards, while the EPA is responsible for determining the fuel economy of each year's new vehicle models.

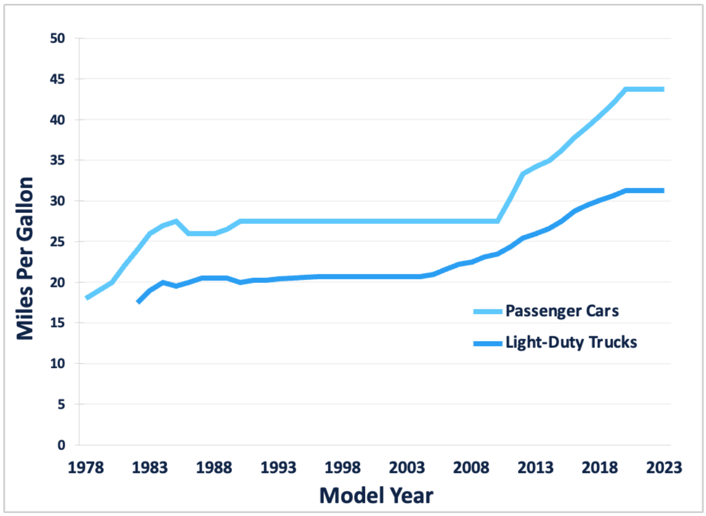
The dubious notion that the public good of reducing oil demand justified a federally mandated minimum fuel economy for all U.S. passenger vehicles—thereby trumping other consumer preferences for safety, vehicle size, performance, and so on—underpinned the existence of the CAFE standards for over three decades. It also drove the expansion of preferential treatment within federal regulations for alternative fuel vehicles, such as ethanol, natural gas, and hydrogen.

The second set of federal standards are the GHG emissions standards established by the EPA. Just as concerns about the U.S. running out of oil abated thanks to the shale revolution that began in the mid-2000s, another dubious public good was rising up to justify improving the fuel economy of the U.S. vehicle fleet: reducing emissions of GHGs from vehicles to appease those who believe it will mitigate climate change. Transportation accounted for 28% of total U.S. GHG emissions in 2021 (EPA, n.d.) and U.S. emissions accounted for a 13% (and declining) share of global emissions in 2020 (Crippa et al., 2021, p. 239), which means U.S. transportation accounts for only a fraction of the global total. Nevertheless, environmental groups have made reducing GHG emissions from U.S. vehicles a priority policy plank for over three decades.

The U.S. Supreme Court granted environmental groups their wish with the *Massachusetts v. EPA* decision (2007), which held that the EPA had the authority under the Clean Air Act to regulate GHG emissions from vehicles. However, the technology does not yet exist to efficiently capture or convert GHGs as they leave the tailpipe. Today, the primary options for reducing GHG emissions from vehicles are to improve engine fuel efficiency, use lower emitting fuels, or convert to all-electric vehicles.

Since the addition of the EPA standards, the DOT and the EPA have worked in tandem to produce coherent GHG and CAFE standards. As described in the rest of this section,

Figure 2
CAFE Standards for Light-duty Vehicles, 1978–2025



Note. Data from CAFE Standards for 1978–2010 from Summary of Fuel Economy Performance, by National Highway Traffic Safety Administration, December 15, 2014 (https://www.nhtsa.gov/sites/nhtsa.gov/files/performance-summary-report-12152014-v2.pdf); CAFE Standards for 2011–2016 from Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Final Rule, 75 Fed. Reg. 25324, May 7, 2010 (https://www.govinfo.gov/content/pkg/FR-2010-05-07/pdf/2010-8159.pdf); and CAFE standards for 2017–2023 from The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 84 Fed. Reg. 24174, April 30, 2020 (https://www.govinfo.gov/content/pkg/FR-2020-04-30/pdf/2020-06967.pdf).

these standards, combined with additional state standards, add an estimated $27,881, or $8.44 per gallon equivalent, to the true cost of an EV, all of which is passed on to consumers of ICEV vehicles. Companies are not required to report the cost of the regulatory credits that EV manufacturers sell to automakers that fall below the standards, and companies may even trade or waive the credits for non-cash compensation. The complexity and lack of transparency of these regulatory regimes obscures the true costs of each EV, reducing accountability to the public for the costs and attendant negative consequences. Nevertheless, we'll make a conservative attempt to estimate the low-end value of the credits on a per vehicle basis.

CAFE Standards

Elon Musk claims to oppose the federal tax credits for EVs (Elliott, 2021), which have not benefited Tesla since the company surpassed the limit on vehicle deliveries to be eligible for the credits. However, Musk never criticizes federal regulatory credits, which added $1.78 billion to Tesla's 2022 revenue and have been a major, if not primary, driver of the company's profitability (L, 2023). Understanding how these credits work and how much they cost is critical to understanding how the CAFE standards are the largest tool the federal government has for driving the adoption of EVs.

Under the current regulations, automakers that do not meet CAFE standards are required to purchase credits from automakers whose fleets exceed the standards. Because the standards are rising so rapidly, far faster than the typical improvement rate of ICEV engines, the market for these credits amounts to billions of dollars every year. Because the average fuel economy of an EV with a 300-mile range in 2021 was appraised at about 113 miles per gallon of gasoline-equivalent (MPGe)[1], compared to a 36.32 MPGe average for all new light-duty vehicles in 2021 (EIA, 2022), these credits represent an enormous incentive for automakers to build more EVs. Improving the fuel efficiency of ICEVs or selling more hybrids does not give them as large of a boost as selling more EVs.

Figure 2 shows just how rapidly the situation is changing for automakers. After many years of relative stability, the Obama administration began to rachet up the CAFE standards, starting in 2010 for MY2012 to MY2016 (Light-Duty Vehicle Greenhouse Gas Emission Standards, 2010, p. 25330). The standards were raised again in 2012 for MY2017 to MY2025 (2017 and Later Vehicle Gas Emissions, 2012, p. 62640), but the standards for MY2021 to MY2026 were lowered by the Trump administration in 2020 through the Safer Affordable Fuel-Efficient (SAFE) Vehicles rule (2020, p. 24186). However, the Biden administration moved quickly to overturn the Trump-era rule and raise the standard for MY2024 to MY2026 (Corporate Average Fuel Economy Standards for Model Years 2024–2026, 2022, p. 25735), and the NHTSA is currently working on aggressive new standards for 2027 and beyond in tandem with new GHG emissions standards from the EPA (Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027-2032, 2023).

EVs also improperly benefit from an erroneous interpretation by the U.S. Department of Energy of a series of laws Congress passed that use the CAFE standards to promote alternative fuel vehicles over gas-powered vehicles. First

1 Note that the EPA's estimates for EV fuel economy are based on a completely different and much easier test than is applied to ICEVs. For example, the EPA requires ICEVs to be tested at high speeds and high acceleration, with the air conditioning and heat operating at both very high and very low ambient temperatures (fueleconomy.gov, n.d.). while EVs are tested in a laboratory setting at ideal temperatures for battery performance, without operating at high speeds or rapid acceleration, and without running any heat or air conditioning that would rapidly drain the EV battery (Good, 2017). In this paper we do not account for the EPA's preferential fuel economy testing and ratings for EVs and the additional transfer of wealth from ICEV buyers to EV buyers that results.

came the Alternative Motor Fuels Act (S. 1518, 1988, Sec. 8), which promoted the commercialization of alternative motor fuel vehicles (fueled with ethanol, methanol, natural gas) by giving a bonus multiplier of 6.67, or 667%, to their actual fuel economy.[2] Then, the Energy Policy Act (H.R. 776, 1992, Sec. 403) expanded the definition of "alternative fuels" to also include hydrogen, coal-derived liquid fuels, other non-alcohol biofuels, and electricity. It also enabled "dedicated automobiles," that is, vehicles that run solely on alternative fuels, to receive the favorable fuel economy treatment. Subsequently, a July 1994 transportation law specified the multiplier would only apply to "liquid alternative fuel" (H.R. 1758, 1994, Sec. 32905).

Despite the law clearly excluding electric vehicles, DOE issued a rulemaking in June 2000 to establish a petroleum equivalency factor for EVs that applies the 6.67 multiplier to EVs. That rule continues in place today, despite a statutory requirement for DOE to update its estimate annually. Thus, an EV manufacturer is given 6.67 MPG of credits for every 1 MPG of actual fuel economy improvement.

That bonus makes an enormous difference in the value of the CAFE credits EVs can earn. Assuming the marginal cost of increasing the fuel economy of a vehicle by 1% is $48 (Leard et al., 2019, p. 32), an ICEV manufacturer whose MY2021 fleet averaged about 30 MPG (EIA, 2022)[3] would spend $48 to improve fuel economy by 0.3 MPG (1% of 30 MPG). That means they would pay up to $48 / 0.30 MPG = $160 to an EV manufacturer for 1 MPG worth of credits before deciding to invest in improvements to their vehicles. Given the fleetwide CAFE standard of 37 MPG for MY2021, a MY2021 EV rated at 113 MPG could earn roughly (113 MPG – 37 MPG) * 6.67 = 507 MPG worth of credits. Therefore, the value of the credits to the EV manufacturer could be as high as ($48 / 0.30 MPG) * (113 MPG – 37 MPG) * 6.67 = $81,107 per EV.

However, the CAFE regulations allow automakers to pay a fixed penalty per 0.1 MPG for each vehicle that is short of the standard. That penalty puts a cap on the marginal cost an automaker is willing to pay to meet the standard and a corresponding cap on the value of the regulatory credits. The penalty was $5.50 per 0.1 MPG shortfall per vehicle for decades before being raised in 2016 to $14 per 0.1 MPG shortfall per vehicle (Civil Penalties, 2016, p. 43529). The effective date of the increase was delayed indefinitely, and the changes were subject to multiple rounds of litigation, casting significant ambiguity on how much automakers were actually paying until the Biden administration made the $14 penalty final last year (Civil Penalties, 2022, pp. 18994–18997). The penalty is set to rise to $16 this year (Revisions to Civil Penalty Amounts, 2023, p. 1132), but since this analysis covers vehicles sold in 2021, we make a conservative assumption that automakers continued to pay the $5.50 penalty in 2021. The higher penalty will need to be accounted for in later editions of this work, which will significantly increase the assumed value of the CAFE credits.

Assuming a penalty amount of $5.50 per 0.1 MPG per vehicle in 2021, we place the value of the credits at $5.50 / 0.1 MPG = $55 per MPG, with the caveat that the value of the credits is likely higher now and rising quickly due to the rising standards and penalty amounts. Therefore, an EV manufacturer whose MY2021 vehicles averaged 113 MPG would earn ($55 / 1 MPG) * (113 MPG – 37 MPG) * 6.67 = $27,881 in credits per EV. After we subtract out the cross-subsidies from the EPA GHG standards and state mandates (covered in the next two sections), we arrive at a total subsidy from the CAFE standards of $19,678 for every EV sold. Assuming an EV is driven 120,000 miles over a lifetime of 10 years, that subsidy comes out to $5.96 per equivalent gallon of gasoline an ICEV would consume during that time.[4]

2 See *49 U.S.C. 32905(a)*: "A gallon of a liquid alternative fuel used to operate a dedicated automobile is deemed to contain .15 gallon of fuel." Therefore, an EV rated at 100 MPGe is counted as if it is rated at 100 miles per 0.15 gallons-equivalent, or 667 MPGe. Hence, the statute is creating a 667% multiplier to the vehicle's true fuel economy.

3 Arriving at an estimate of the fleetwide efficiency of ICEVs is difficult because the fleetwide numbers given in the EIA data include EVs and other alternative fuel vehicles that receive large ratings plus the bonus multipliers. Also, the estimate of $48 to improve fuel economy by 1% is based on an analysis of MY2012 to MY2015 vehicles, and the cost is likely higher now. Because of these factors, we reduce the 36.32 MPG rated efficiency for new MY2021 vehicles down to 30 MPG for the fleetwide ICEV efficiency.

4 The formula to convert total cost to cost per gallon-equivalent is $23,822 / (120000 miles / 36.32 MPG) = $7.21/gallon-equivalent, where 36.32 MPG is the average rated efficiency for new light-duty vehicles in 2021 (EIA, 2022). This same conversion factor will be used throughout the paper. Note, however, that the average U.S. light-duty vehicle is driven 11,467 miles per year (EERE, 2020), which is probably well above the typical EV, making the estimate of 12,000 miles per year quite generous. Therefore, if the average EV does not last for 120,000 miles, then the costs of these credits are greater per EV mile driven. Also, the fleetwide fuel economy average of 36.32 MPG will increase over time, thereby increasing the cost per gallon equivalent obtained using this conversion factor. The bottom line is that this conversion factor is generous toward EVs in almost every aspect imaginable.

Billions in credits for EVs translate into negligible real-world fuel economy improvements

Tesla does not disclose its vehicle sales by country, but multiple industry sources place 2021 U.S. Tesla sales at about 302,000 vehicles (Wozniak, n.d.; GoodCarBadCar, n.d.). Assuming $27,881 in regulatory credits per EV, Tesla could have earned more than $8 billion in credits in 2021. Tesla only reported $1.5 billion in "automotive regulatory credits" in 2021 (Tesla, Inc., 2022), but because there is no required reporting or public tracking of these credits, it is entirely possible that Tesla is trading credits for parts or other in-kind favors that may not show up on income statements. Regardless of the value of the credits, it is instructive to consider how much Tesla's EVs are actually improving the fuel economy of the U.S. fleet compared to how much they are receiving in credits.

Let's assume that the average fuel economy of Tesla's 2021 fleet is 113 MPG, the same as the average efficiency of the 300 mile range EVs noted above, and that Tesla's 302,000 vehicles sold in the U.S in 2021 were 2% of the total vehicles sold in the U.S. in 2021 (EERE, 2022). Therefore, Tesla's sales raised the fuel economy of the total fleet sold in 2021 by (113 MPG – 36 MPG) * 0.02 = 1.54 MPG. However, new vehicles are only a small portion of the total vehicles on the road. Given that there were 281 million registered vehicles in 2021 (EERE, n.d.-b) with an average on-road fuel economy of 24 MPG (EIA, 2022), the vehicles Tesla sold in 2021 raised the fuel economy of the entire U.S. fleet by only (113 MPG – 24 MPG) * (302,000 vehicles / 281,000,000 vehicles) = 0.1 MPG.

It is important to note that this marginal improvement is predicated upon EVs actually displacing fuel consumption to an extent that is commensurate with their rated fuel economy, a topic that is beyond the scope this paper but is nonetheless a subject of much debate. Policymakers should be aware that the 6.67 multiplier and other favors given to EVs, such as the EPA's preferential fuel economy testing, vastly exaggerate the benefits EVs provide in terms of fuel efficiency and emissions. The primary motivation for this paper is to persuade policymakers to carefully consider whether the benefits of EVs are worth the billions in spending needed to achieve those benefits.

EPA Multiplier Credits for EVs

In addition to the multiplier of 6.67 that EVs are eligible for under the CAFE standards, EV manufacturers are also given extra credits under the EPA's banking system for meeting its GHG emission standards. As with the CAFE standards, the subsidy created by this program is difficult to calculate because automakers are not required to disclose the cost of the credits.

The GHG emissions standards work as follows. If an automaker sells a vehicle, call it Model A, that emits 300 grams of CO_2 per mile driven and then sells the same number of Model B vehicles that emit 200 grams, that MY performance would be 250 grams (or the average between the two models). The EPA has also created a credit system whereby, assuming in this example that the standard is 300 grams, the automaker whose model year performance is 250 grams can sell 50 grams to another automaker whose model year performance is above the 300-gram standard. The EPA has no explicit authority to create this market and to allow the monetization of billions of dollars in GHG credit trading each year.

It is important to understand that while the EPA is coordinating its rulemakings with the NHTSA, the GHG standards are separate from the CAFE standards. Gasoline has a fixed carbon content and roughly fixed CO_2 emissions when burned, so the CAFE standards are effectively CO_2 standards. However, the EPA is setting its standard above and beyond what the CAFE standards dictate. Therefore, the EPA credits have additional value beyond the CAFE credits.

Because of the opacity of the GHG credit markets, we must extrapolate from limited public information to discern their value. Leard and McConnell, in a 2017 report for Resources for the Future, use two examples of Tesla credit sales to estimate a range from $36 to $63 per metric ton (p. 12). The EPA's Light-Duty Vehicle GHG Program Technical Amendments proposed in 2018 provide three examples of how to calculate the credits for a manufacturer that produces 5,000 EVs for a MY (p. 49347). The first example, which does not use the EPA's preferential 2x multiplier for MY2017 EVs, results in 205,027 megagrams, or metric tons, of credits. Using the multiplier results in two times as many credits, 410,054 metric tons. Multiplying 205,027 tons by $36/ton gives a low-end value

Despite the current incentives in place, the Ford Motor Company is losing over $70,000 on each EV it currently sells and inventory is stacking up in dealer lots for several brands as sales are not keeping pace with government-mandated production. Therefore, it is likely that automakers will be requesting even more direct subsidies in the coming years.

of the credits for the manufacturer of $7,380,972, and multiplying 410,054 tons by $63/ton gives $25,833,402 for a high-end value. Dividing those totals by 5,000 EVs gives a range of $1,476–$5,167 per EV.[5] The midpoint of that range is $3,322 per EV, which, using the same conversion formula as above, is $1.01 per equivalent gallon of gasoline.

California and Other State Mandates

Currently, 16 states have what are commonly referred to as zero emission vehicle (ZEV) mandates (Center for Climate and Energy Solutions, 2022),[6] where the state sets a number or percentage of new vehicles sold that must be zero-emissions. The EPA is currently granting California a waiver under Section 209 (42 U.S.C 7543) of the Clean Air Act to adopt stricter standards for motor vehicle emissions than the national standards, which has allowed it to create its Advanced Clean Cars Program (California Air Resources Board, n.d.-a) that aims to make 100% of new light-duty vehicles ZEVs by 2035. In turn, Section 177 (42 U.S.C 7507) allows other states to mirror California's policies, and these 15 states—along with Delaware, Pennsylvania, and the District of Columbia, which have adopted California's low emission vehicle (LEV) mandate—are collectively called "Section 177 states." An overview of state level EV policies—including mandates, taxes and fees, and incentives—will soon be provided in a separate supplement to this paper.

Of course, the cost to meet these mandates is not limited to the states that impose them but spread out over the entire fleet of each automaker trying to meet them. Similarly, the subsidy given to EV manufacturers by these policies accrues nationally since those vehicles are not just sold in the states with ZEV mandates, effectively allowing California and other Section 177 states to impose hidden fees on gasoline vehicles nationwide. Therefore, the cost of these mandates should be factored into any national study of EV subsidies like this one.

To be sure, the effect is not negligible. Joshua Linn (2022), a professor at the University of Maryland, estimates the average price of ZEV credits to be $3,236 (p. 37). Linn assumed each EV received two and a half credits under California's program, but EVs in California received on average over three credits per vehicle in 2021 (California Air Resources Board, n.d.-b, p. 5). We conservatively assume three credits per vehicle and assume the same applies to the other Section 177 states. Multiplying $3,236 by three gives a total credit value of $9,708 per EV sold in Section 177 states.

However, since not all EVs are sold in Section 177 states, that credit value per vehicle needs to be spread out among all the EVs sold in the U.S. in 2021. Although EV sales data by state is not publicly available, such sales for 2021 can be approximated by comparing the change in registrations by state from 2020 to 2021, assuming that relatively few EVs are being discarded at this point. Of the 435,320 MY21 and MY22 EVs sold in the U.S. in 2021, 218,879 were registered in Section 177 states (EERE, n.d.-b). Multiplying the total state credit cost of $9,708 per EV sold in ZEV states by the percentage of registered EVs in EV sales mandate states results in state credits of $4,881 per EV sold in the U.S, or $1.48 per gallon equivalent.

Section 2: Direct Subsidies

The CAFE and GHG mandates send a clear signal to automakers: Sell a requisite number of EVs or go bankrupt. Because EVs are still significantly more expensive to make than comparable ICEVs, direct credits to consumers are essential for automakers to price vehicles high enough to cover their costs while still attracting consumers. Despite the current incentives in place, the Ford Motor Company is losing over $70,000 on each EV it currently sells (Bryce, 2023) and inventory is stacking up in dealer lots for several brands as sales are not keeping pace with government-mandated production (Muller, 2023). Therefore, it is

5 See the comments submitted by the American Fuel & Petrochemical Manufacturers (2018) for further explanation of how these values are calculated.

6 The states with ZEV mandates are California, Colorado, Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, New Mexico, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington. The Office of Energy Efficiency & Renewable Energy (EERE) has a full list of laws and incentives that apply to "alternative fuels and advanced vehicles" (EERE, n.d.-a, para. 1). The EV enthusiast website Electrek has a more digestible list of incentives solely for EVs, which is current as of July 2023 (Doll, 2023).

likely that automakers will be requesting even more direct subsidies in the coming years.

Direct subsidies are more visible to the average American compared to the complexities of the CAFE standards and ZEV mandates, but when it comes to EVs, the large and varied regime of subsidies and rules at the federal and state levels obscures the full costs to taxpayers and consumers. Direct subsidies for EVs come in two forms: federal and state tax rebates and the ability to avoid federal and state gasoline taxes and fees. We'll cover each of these items in turn.

Federal Tax Rebate for EV Buyers

Federal tax credits for EVs were initiated by the Energy Improvement and Extension Act (2008, Sec. 205), which created a $7,500 credit for light-duty EVs but capped the program at 250,000 vehicles and ended it in 2014. The American Recovery and Reinvestment Act (2009, Sec. 1141) took out the sunset date but capped the credit at 200,000 vehicles per manufacturer.

The eligibility requirements underwent some minor changes over the ensuing years, but the Inflation Reduction Act (IRA; H.R. 5376, 2022) changed the game significantly. While the new law maintains the Section 30D $7,500 credit for new vehicles, the vehicles must undergo final assembly in the U.S., the battery pack must have 50% of its components manufactured or assembled in the U.S., which rises 10% each year until reaching 100% in 2029, and certain critical minerals used in the vehicle must be extracted and processed domestically or in a country that has a free-trade agreement with the U.S. (Sec. 13401). Vehicles not meeting these requirements will have their tax credit reduced.

The law takes out the 200,000-vehicle cap for automaker eligibility, but it adds a consumer income cap of $150,000 for single filers and $300,000 for joint filers and a price cap on the vehicles: $55,000 for cars and $80,000 for trucks and SUVs. Used vehicles valued below $25,000 and more than two years old are eligible for a $4,000 credit if the buyer makes less than $75,000 for single filers and $150,000 for joint filers. The law also added a panoply of subsidies for domestic EV battery manufacturing, most notably a production tax credit for battery cells and modules that will provide hundreds of millions annually to every Gigafactory that is eligible (Sec. 13502).

In addition, the IRA includes a $7,500 tax credit for commercial electric vehicles (Sec. 13403). The IRS, despite public protestations from Sen. Manchin and other lawmakers involved in writing the bill, has generously interpreted this credit to apply to any leased EV, effectively circumventing the restrictions on the Section 30D credit and resulting in a rapid increase in the number of leased relative to purchased EVs (Voelcker, 2023). Because of these recent changes in statute and IRS guidance, it is not yet known exactly how much the typical EV will receive in credits going forward. However, the way the law is currently being enforced, buyers of the vast majority of EV models receive the full value of the credit as long as they meet the income eligibility requirements (EERE, n.d.-c). Many EV buyers will not meet the income eligibility requirements, but since this analysis covers the average EV, irrespective of the location or situation of the buyer, we assume the EV receives the full $7,500 credit.

State Tax Rebates for EV Buyers

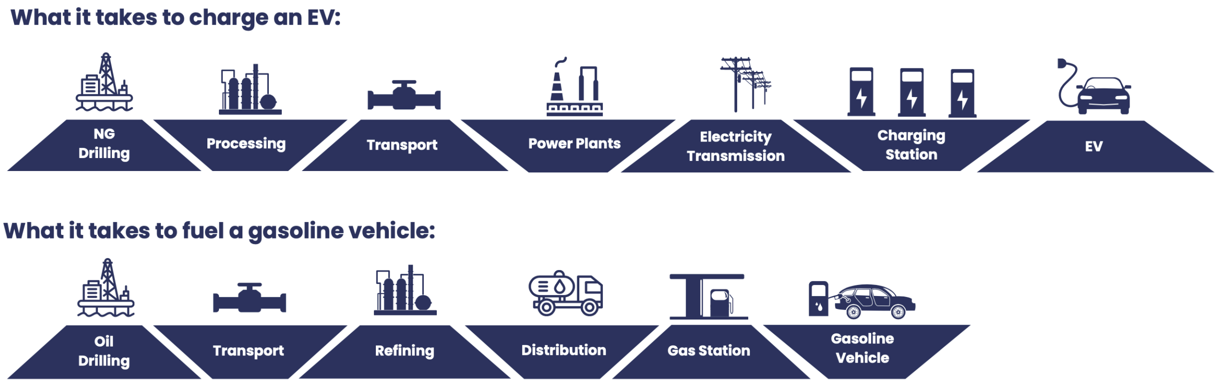
There are numerous credits available to EV buyers (EERE, n.d.-a), and while not every state offers direct incentives or rebates, utilities and municipalities in every state also offer direct and indirect incentives. Given the number and complexity of local laws and utility credits, this analysis only considers state incentives, and 2021 is the most recent year of complete data. Several states have rebate programs that are not as simple as a flat credit regardless of the buyer's income level, cost of the vehicle, etc. Also, some states had programs that did not run for the entire 2021 calendar year, so the rebates must be reduced in proportion to the percentage of time the program was not in effect.

As of the time of publication, we have not completed a full analysis of state incentives, and we will provide that analysis in a later supplement to this paper. Our preliminary analysis indicates that states handed out over $646 million in taxpayer subsidies to EV buyers in 2021. Dividing by the 435,320 EVs sold in 2021, the average EV buyer received state credits totaling $1,484. In total, the average EV receives $8,984 in state and federal credits, or $2.72 per gallon equivalent of gasoline.

Avoided Federal and State Gasoline Taxes and Fees

Gasoline and diesel drivers pay significant liquid fuel taxes to fund the building and maintenance of federal and state roads, bridges, and even bicycle lanes. Federal gasoline taxes are $0.184/gallon and federal diesel taxes are $0.244/gallon (EIA, 2023). The American Petroleum Institute (2022) estimates the average state taxes/fees on gasoline are $0.3869/gallon and $0.4024/gallon for diesel. Therefore, combined federal/state taxes and fees on gasoline average $0.5709/gallon and on diesel average $0.6464/gallon.

Figure 3
Infrastructure Needed to Charge an Electric Vehicle Compared to Infrastructure Needed to Fuel a Gasoline Vehicle



Of course, EVs are not subject to gasoline taxes, which is ironic given that EVs are heavier than the equivalent ICEVs and exert more wear and tear on roads and infrastructure. Some states are adding fees to EVs to recoup lost gasoline taxes and ensure that EV drivers pay for road maintenance (Igleheart, 2023). These include special registration fees or annual fees for EVs to account for the loss in revenue due to the avoided gas taxes. However, not only do these fees generally fall short of accounting for the full tax avoided, but the states enacting such fees do not constitute a large share of the EV market. Therefore, it is safe to assume these fees have a negligible impact on the cost of an average EV.

A volume-weighted average of gasoline and diesel taxes for light-duty vehicles comes out to approximately \$0.59/gallon, comprising roughly 20% of the cost of the fuel. For a light-duty vehicle that gets 36.32 MPG over 120,000 miles, \$0.59/gallon adds up to \$1,949 of federal and state fuel and road taxes, which an equivalent EV avoids paying entirely. Many states also impose differing registration fees on gasoline vehicles and EVs. These fuel taxes and registration fees need to be compared to the taxes EV owners pay on electricity. While there are no federal taxes on electricity, some states impose sales taxes on electricity. Our preliminary analysis indicates that, on average, these states taxes come out to about 1.7% of the cost of electricity and that EV owners avoid approximately \$300 per year in liquid fuel taxes and registration fees, after paying any electricity taxes and EV registration fees. A complete state-by-state analysis of fuel taxes, electricity taxes, and registration fees on gasoline and electric vehicles will be provided in a supplement to this study.

Section 3: Indirect Subsidies and Socialized Infrastructure Costs

It is hard to conceptualize the amount of infrastructure needed to deliver gasoline to your vehicle and electricity to your home. Starting with extracting oil from the ground, transporting it, refining it, transporting it to a gas station, and finally building and maintaining the gas station, a tremendous amount of work is included in the price of the gas you buy at the pump. Similarly, bringing electricity to an EV charging port involves extracting the base fuel, converting it to electricity at a power plant, and transporting that electricity long distances to the charger. **Figure 3** is an attempt to put all that infrastructure onto a single diagram, although it far understates the complexities of these operations.

While some of the infrastructure used to create gasoline is used to create other products, whose margins support the maintenance of the shared infrastructure, by and large, what you pay at the pump reflects the cost to deliver the gas to the pump. This is not the case when you charge an EV, which exerts an enormous electrical load on the grid infrastructure it is utilizing. Despite the need for extra infrastructure to serve this load, an EV owner usually pays the same flat rate for electricity as a normal load.

A typical 80 kWh EV charging from 50% to 100% over 8 hours at your home consumes power at a rate of 5 kW, but it could consume up to 10 kW at any given time, or about 8 times as much power as a U.S. home draws on average

(EIA, n.d.-a).[7] An EV charging that same amount in 20 minutes at a fast charging station pulls down 120 kW, about as much electricity as an average grocery store consumes (EIA, n.d.-b, Table C22).[8] The cost to the utility to serve this load—including replacement and upgrade of transformers, circuits, feeders, and transmission lines, as well as extra overhead costs like metering and billing required to service the charging stations—is socialized across all the utility's ratepayers and not directly charged to the EV owners.

These socialized costs add up to $11,883 per EV over 10 years, and EV owners incur an additional $4,569 in costs over 10 years to charge their vehicles—including residential and private charging equipment, electricity losses behind the meter, and billing/overhead—above and beyond the cost of the electricity that goes into their vehicles. These extra charging costs for EV owners equate to $1.38 per gallon equivalent over the life of the EV, which alone exceeds the $1.21 per gallon equivalent that EV advocates claim that it costs to charge an EV.

Charging Infrastructure, Billing Fees, and Electricity Losses

EV owners, utility ratepayers, and taxpayers accrue many extra costs related to the charging and use of EVs that are not accounted for in most total cost of ownership models. The study by Burnham et al. (2021) does not consider the cost of charging infrastructure in its base case nor any extra fees on the electricity the EV owner purchases, and only in its sensitivity analysis does it account for a cost of $800 to purchase and install a residential EV charging unit (p. 62). Burnham et al. and other studies of EV costs also do not account for the cost of public charging stations. The capital costs for the vast majority of public charging stations are subsidized by taxpayers, utilities, or the entities hosting the stations and are not accrued to EV owners.

A group from the National Renewable Energy Laboratory recently projected that by 2025 the U.S. will need 1,000,000 public Level 2 charging stations and 182,000 public Level 3 (fast charging) stations to serve an EV fleet of 33 million vehicles (Wood et al., 2023, p. vi). That is on top of 26.8 million private charging ports. The total cost of the public infrastructure ranges from $32–$55 billion (p. vii). Taking the midpoint of that range and dividing by 33 million vehicles comes out to $1,318 per EV. The private infrastructure has an even wider cost range of $22–$72 billion, but taking the midpoint, the average cost per EV is $1,424.

Another point to consider here are electricity losses from the underperformance of EVs in the real world compared to their efficiency metrics calculated under the EPA's ideal testing conditions. These losses are accrued by EV owners and so do not count as subsidies, but they do add to the cost of fueling an EV. EVs can lose up to 47% of their equivalent fuel economy at 20°F—due in large part to the energy needed to run the car's heater—and up to 22% at 95°F—again mostly due to the energy used by the air conditioning system—compared to their performance at 75°F (American Automobile Association, 2019, pp. 3–4).

There are also significant losses in the charging process, both in the power electronics and in the battery itself. A comprehensive study in the journal *Energy* found that such losses usually add up to about 20% of the power supplied to the charging outlet (Apostolaki-Iosifidou et al., 2017, p. 736, Table 6). Burnham et al. (2021) calculate $8,770 in fueling costs for an average EV over its lifetime (p. 144), but they assume that there are no electricity losses in the process of charging the vehicle. A conservative estimate of 20% of electricity lost during charging adds $1,754 to this estimate.

We also add $4.95/month, which comes out to $591 over a 10-year vehicle life, for the cost of a utility to meter the extra power consumed by an EV and bill the customer for it. There is not a national standard for how to meter the power consumed by EVs, which can draw much more power than the rest of the home they sit in when charging. However, Xcel Energy (2018) provides the best documentation for how to account for this cost and assesses the cost at $4.95/month (p. 2). This cost will likely need to be updated as more utilities across the country begin to assess for it.

Adding up these three sets of costs—residential and private charging equipment, electricity losses behind the meter, and billing/overhead—results in a total cost per EV of $4,569, or $1.38 per gallon equivalent. This cost usually does accrue to the EV owner and is therefore not included in **Figure 1**. Subsidized public charging stations account

7 The EIA estimates that the average monthly electricity consumption of a U.S. residence in 2021 was 886 kWh. Dividing by the average number of hours in a month, 730 hours, results in an average power draw of 1.2 kW. An 80 kWh EV battery recharging 50% of its capacity, 40 kWh, over the span of 4 hours would draw 40 kWh / 4 hours = 10 kW. If that amount of electricity is delivered in 20 minutes, the draw is 40 kWh / 0.33 hours = 121 kW.

8 In Table C.22, the EIA estimates the average annual electricity consumption of a grocery store or food market in 2018 was 1,035,000 kWh. Dividing that annual consumption by the number of hours in a year, 8,760 hours, gives an average power draw of 118 kW.

for another $1,318, or $0.40 per gallon equivalent, and that number is included in **Figure 1** since that cost is not paid by the EV owner.

Incremental Power Capacity, Transmission and Distribution Infrastructure Costs

Returning to the discussion at the beginning of this section about the demand on the electric grid created by EV charging, particularly fast charging, there is a cost to the extra transmission and distribution infrastructure needed to serve those large loads. Utilities have historically assessed what is known as a "demand charge" on commercial and industrial consumers based on their usage during peak hours. That charge accounts for the extra infrastructure costs required to serve those customers. Currently, most utilities are socializing that cost for EV owners by not assessing demand charges on residential EV chargers, even though those chargers can use as much power at certain times as several homes.

We can use a hypothetical demand charge for a residential EV charging station to place an upper bound on the cost to the utility of charging that EV. Demand charges average about $15/kW (McLaren et al., 2022, "Demand charge rate data.xlsm") and are based on the maximum amount of demand (measured in kilowatt or kW of power) that a customer used in any interval (typically 15 minutes) during the billing cycle. A common residential charging unit on a dedicated 40-ampere circuit at 240 volts draws 9.6 kW (40 A * 240 V = 9.6 kW). A $15/kW monthly demand charge on this unit equates to $1,728 per year and $17,280 over 10 years. As noted earlier, public fast charging stations use more than 10 times that amount of power, but we assume those costs are recouped in the rates those stations charge their users.

In 2019, Boston Consulting Group estimated the costs of infrastructure upgrades to serve EVs at $1,700–$5,800 per EV (Baker et al., 2019). If we take the midpoint of that range, which is $3,750 as a lower bound to our estimate, then we can place these additional infrastructure costs for EVs somewhere between $3,750 and $17,280 over 15 years. That is a wide range but likely accurately reflects the wide range of costs to utilities depending on their infrastructure and the location of EVs in their service areas. The midpoint of this range, which we consider to be an appropriate estimate for an average EV, is $10,515, or $3.18 per gallon equivalent.

It is important to note that there can be many cross-subsidies and variable impacts on the electric grid depending on where and when charging occurs. Fast-charging installations for large vehicles and public transit can exceed 300 kW, and adding a residential EV charger in a dense urban area near public charging stations and other large loads may not add as much infrastructure costs as adding one in a rural area. Charging an EV when an owner gets home during the 5–9 p.m. peak demand hours adds to grid volatility and resource adequacy problems, but charging late at night or into the morning may reduce overall system volatility and strain. Many utilities across the country, particularly in California, are beginning to charge variable rates to EV owners based on time of use. For example, San Diego Gas & Electric rates for EV households range from $0.14/kWh to $0.81/kWh, in addition to a $16 monthly fee (San Diego Gas & Electric, n.d.). Therefore, EV owners may incur much higher costs than noted here, particularly if they charge at times when rates are higher. Figuring out how and when EVs should charge is a critical problem for policymakers and utilities to solve if the federal government is going to continue to mandate EV adoption.

Section 4: Items Excluded From This Study

It is important to emphasize that the total subsidy per EV calculated by this study, $54,778, is actually a conservative estimate given the assumptions made and the items we excluded from this study.

First and foremost are the tax credits, grants, and loans for domestic battery manufacturing, which is by far the most expensive component of an EV. The Inflation Reduction Act (2022, Sec. 13502) provides billions in grants and loans for battery manufacturing and research, plus the aforementioned tax credit that provides $45 million per gigawatt-hour for battery modules made in the U.S.A. To put that dollar amount in perspective, *one battery plant* the size of Tesla's Gigafactory, which produces more than 37 gigawatt-hours of batteries annually (The Tesla Team, 2023), could receive nearly $1.7 billion in federal tax credits *every year*. That comes out to about $3,600 for an average EV battery. State and local subsidies are also significant. Tesla received $1.3 billion from the state of Nevada for its Gigafactory outside of Reno (Whaley, 2014), and Ford may receive up to $1 billion in state and local incentives to build an EV battery factory in south-central Michigan (Eggert, 2023).

This analysis also does not include battery replacement or disposal costs. The typical EV battery is only warrantied for 8 years (Fischer, 2022), yet Burnham et al. (2021, p. 34) assume no replacement or repair costs over 15 years. An EV battery can cost up to $20,000 to replace (Recurrent, 2023), so whether that cost is incurred during the 15-year window of this lifecycle cost analysis is a significant unknown variable. Because most EVs are relatively young, it is not yet known how long the average EV battery will last and whether it makes more sense to replace it or to scrap the whole vehicle. For the same reason, the disposal and recycling costs of EV batteries, and who will pay those costs, are not yet well-known.

Recent data suggest that the EV scrappage rate is substantially higher than that of gasoline vehicles. S&P determined that despite EVs having an average age of 3.6 years and gasoline vehicles having an average age of 12.5 years, during "the 10-year period from 2013-2022, 6.6% of BEVs in operation were pulled out of commission. During the same period, just 5.2% of combustion vehicles left the fleet" (Leinert, 2023, para. 7). Therefore, the EV scrappage rate is already higher than that of gasoline vehicles and is likely going to increase in future years as the average age of the EV fleet increases. Of course, a higher EV scrappage rate and, in turn, fewer miles traveled compared to gasoline vehicles should also be accounted for in any cost-benefit analysis.

Other issues excluded from this analysis include:

- Billions of dollars in taxpayer-funded subsidies for electric buses, trucks, and truck stops, plus the addition of charging infrastructure at public facilities such as ports and airports.
- Billions in state and city taxpayer-funded subsidies other than state buyer credits.
- Credits from California's low-carbon fuel standard, which is a cross-subsidy from gasoline buyers to subsidize EVs in California.
- The unaccounted cost of EVs in terms of additional emissions from power plants, and the embedded environmental costs of the EV supply chain.
- The cost of allowing EVs to use managed lanes, such as high-occupancy vehicle lanes, and the cost of parking spaces given to EVs and EV charging stations.
- The cost to consumers of additional time spent charging EVs relative to fueling gasoline/diesel vehicles.
- Disproportionately high road damage from heavier EVs compared to gasoline/diesel vehicles.
- Disproportionately high EV recall costs compared to gasoline/diesel vehicles, which are socialized to buyers of gasoline and diesel vehicles from the company initiating the recall.
- Building construction costs as some municipalities are beginning to require "EV-ready" construction in new homes and buildings.

Conclusion

The stark reality for proponents of EVs and for the dreamers in the federal government, who are using fuel economy regulations to force manufacturers to produce ever more EVs, is that the true cost of an EV is in no way close to a comparable ICEV. Our conservative estimate is that the average EV accrues $48,698 in subsidies and $4,569 in extra charging and electricity costs over a 10-year period, for a total cost of $53,267, or $16.12 per equivalent gallon of gasoline[9]. Without increased and sustained government favors, EVs will remain more expensive than ICEVs for many years to come. Hence why, even with these subsidies, EVs have been challenging for dealers to sell and why basic economic realities indicate that the Biden administration's dream of achieving 100% EVs by 2040 will never become a reality.

EV apologists continue to claim that technology breakthroughs and economies of scale will rapidly bring down these costs, but there is no Moore's law for batteries, which are a fundamentally different technology than semiconductors. The benefits of economies of scale have largely been reached by most lithium-ion battery manufacturers, costs for those batteries have largely ended their downward trend of the past decade (IEA, 2023a), and additional cost improvements will be hard won. Lithium prices are nearly quadruple what they were in 2019 (Trading Economics, n.d.), and fluctuations in raw materials costs will play a significant role in the cost of EV batteries going forward.

The lesson to be learned from this study is that markets, not government, drive innovation and efficiency. Despite the massive financial and regulatory advantages being offered to EVs, there are more than four times more hybrid and plug-in hybrid vehicles than full EVs registered in the U.S. (EERE, n.d.-b). Toyota estimated that the amount of materials to make one EV battery can be used to make 90 hybrid batteries and that those 90 hybrids will result in 37 times more emissions reductions over their lifetime than one EV (McParland, 2023). Perhaps if D.C. politicians and bureaucrats stop trying to force Americans to build and buy their preferred types of vehicles, the cleaner and brighter future that they imagine will actually materialize.

9 See footnote 4 for more information on how the cost per equivalent gallon of gasoline is calculated.

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