2022

Have Recent Tax Credits and Benefits Affected The Adoption of Plug-In Electric Vehicles in The United States?

Ethan Sutton

Capstone Project

Have Recent Tax Credits and Benefits Affected The Adoption of Plug-In Electric Vehicles in The United States?

Ethan Sutton

Advisor: Arthur Petzel

Abstract

Looking at data from recent surveys showing that electric vehicles take up a meager 2.2% of the market share for passenger vehicles around the world, (Gilbert, 2021) it is safe to say that there is a lot of progress to be made if world governments hope to become carbon neutral within the half-century. This paper focuses on the accumulation of opinions and research regarding the adoption of plug-in electric vehicles in the United States, while focusing primarily on how tax benefits or credits could affect the adoption trends. We will provide information on the current climate of the electric vehicle industry both in the United States and abroad in order to give the reader a perspective on how other countries, whom may be first movers, are tackling this new-age dilemma. By analyzing the past attempts of the U.S. government's electric vehicle incentives, we hope to show the feasibility and effectiveness of proposed and possible incentives on convincing the American public to change their buying habits and make our automotive industry run on electricity.

Introduction to the Problem

Electric and hybrid-electric vehicles had begun their popularization years ago through passenger vehicles. The first mass-produced hybrid vehicle was the Toyota Prius, manufactured by Toyota in 2000, earning an almost instant following upon its release. As for fully electric vehicles, the commercial adoption only began to garner traction at the turn of the previous decade with Nissan's release of the Leaf and Chevrolet's Volt. (The History of the Electric Car, n.d.) However, as with any new invention, problems and inconveniences followed. Electric vehicles (EVs) are expensive. They also require an enormous infrastructure investment for new technology such as charging stations. In addition, electric vehicle adoption represents a hefty up

front cost for the general consumer due to base vehicle pricing and the purchasing of residential charging stations. (Egbue & Long, 2012) Even with all these barriers, the government has mechanisms to combat these initial difficulties. As they have for years, the U.S. government offers tax incentives to encourage companies and regular civilians alike to invest in all sorts of energy sector developments; and yet, ten to twenty years later, most people could likely count on one hand the number of fully electric vehicles they see in one day. It poses the question of whether the tax benefits and credits have really had their intended impact to encourage the general population to make these decisions; and furthermore, if other actions could be taken to better incentivize consumers to make these desired decisions.

What are Electric Vehicles?

Before delving into the history of consumer spending and governmental incentives, it's important to first have the understanding of the basics surrounding hybrid-electric and electric vehicles. The vast majority of vehicles on the road today solely utilize what is considered an internal combustion engine (ICE). In a very basic sense, these vehicles use fuel such as petrol to power the vehicle's motor. Where the first problem arises is the fact that the burning of petrol in these engines produces the release of carbon dioxide. (*How do Gasoline Cars Work?*, 2022) This is important as carbon dioxide (CO2) is released into the atmosphere from each vehicle's exhaust and is thought to be a significant contributor to climate change. Granted, manufacturers have found ways to make these engines as fuel efficient as possible, but when there are more than 280 million cars in the U.S. alone contributing to this environmental problem, there is only so much to be done. (Gilbert, 2021) Then came the Hybrid Electric vehicles (HEVs). While they are a step above the average ICE vehicle, they too use the same

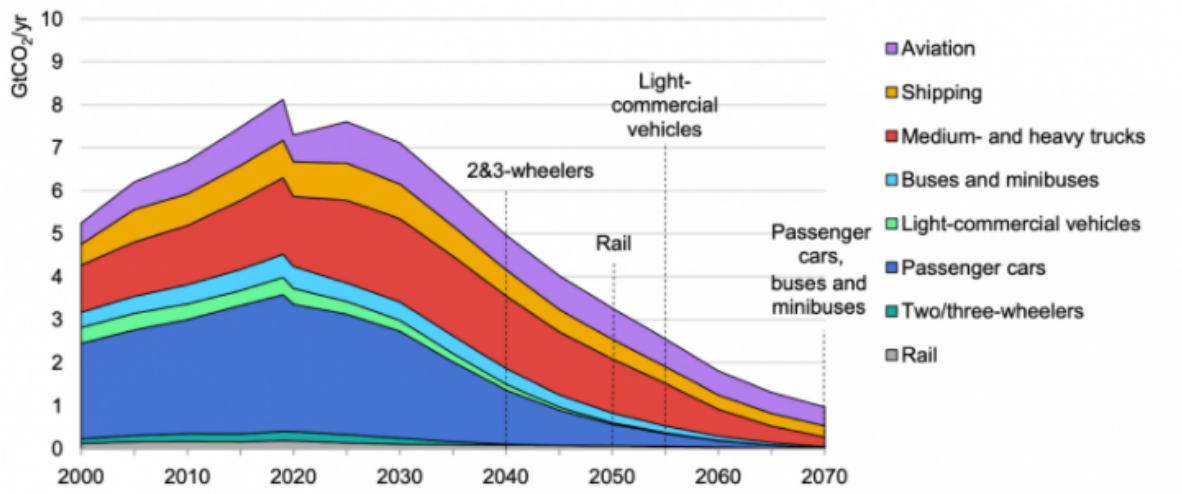
method for the majority of their power. HEVs use regenerative braking to harness energy that will then be redeployed to assist the engine in producing power. (*Hybrid and plug-in electric vehicles,* 2021*)* These vehicles are by far the most common form of hybrid or electric vehicle, but because they are easy to manufacture and contribute the least to solving the climate problem, they are generally overlooked as it comes to tax incentives. Where the government has focused its attention is on plug-in electric vehicles. These are vehicles that prioritize the use of clean battery power over the use of harmful petrol, and if more widely adopted, could contribute massively towards reducing Earth's climate problem. (Cattaneo, 2018)

Earth's Exhausting Problem

The need for a decrease in our carbon footprint has become increasingly evident over recent years. As examined by NASA, the unnatural change in climate is due in part to the significant build-up of gasses such as carbon dioxide that effectively trap heat within Earth's atmosphere. According to NASA, the rate at which carbon dioxide is being released into the Earth's atmosphere is 100 times greater than what would naturally occur. (Berardelli, 2021) Research completed in 2018 shows that the transportation sector alone contributes close to a fourth of CO2 emissions from energy. Of this, 75% comes from road travel, 45% of which comes directly from passenger vehicles. This means that more than 15% of total CO2 emissions globally come from passenger vehicles.

All of this may sound reasonable enough to combat if the right steps are taken, but time is critical. World-wide income and living standards are increasing, the population is increasing, and people around the world are likely to buy more cars and use transportation at increasing

rates. The International Energy Agency (IEA) makes the prediction that passenger vehicles will travel twice as many kilometers by 2060, car ownership will increase by 60%, and aviation travel will triple within the same time period. (Ritchie, 2020) Knowing this, the IEA has created a "net-zero scenario" titled the "Sustainable Development Scenario" that can be seen in Figure 1. You can see from the figure that it is an extremely optimistic scenario in which all sectors decrease at around the same rate post 2025. However, in order to adhere to their ideal scenario, there are a lot of changes that need to be made.



Notes: Dotted lines indicate the year in which various transport modes have largely stopped consuming fossil fuels and hence no longer contribute to direct emissions of CO_2 from fossil fuel combustion. Residual emissions in transport are compensated by negative emissions technologies, such as BECCS and DAC, in the power and other energy transformation sectors.

Figure 1

All of the sub-industries from Figure 1 have very different consumer bases and technologies. Aviation and long-distance freight have shown very little development in terms of emission reduction solutions. Additionally, due to the wide reach and recent focus on the

individual, we will be focusing specifically on tax credits and benefits that have direct effects on the consumer.

Understanding the EV's Dilemma

Individuals, organizations, and governments around the world are beginning to realize the benefits presented by electric vehicle adoption. Although, with any great new idea comes a plethora of hurdles that governments and the industry as whole are going to have to overcome. Electric vehicles are a tremendous idea for the general consumer and the environment. Refueling can be done from your place of residence in the majority of cases, and the vehicles and systems used to run them are less prone to maintenance issues and provide many more benefits. However, this scenario is similar to when you buy a new car. The salesman talks up all the great points, gets you really attached to the amazing piece of machinery in front of you, even gives you a test drive. Then, when you're most set on it, they show you the cost. Although, for EVs it may not necessarily be the price of the vehicle that turns people away. Rather, it is the total down payment of the vehicle and charging stations required to use the vehicle that turn people away. However, seeing that the average American consumer holds a new car for 8.4 years before trading it in, owning a car is certainly a long-term investment. (*How Long Do People Keep Their Cars?*, n.d.) So, let us look at the monetary values in the long-run.

Where EVs Get It Right

Commercials published by Tesla, Ford, Chevy, etc. all say that owning an EV can save the consumer so much money, and they all focus on the one thing consumers think of everyday when driving their car, gas. It is true EVs can save the consumer money, but just how much? This

question depends on two values, the efficiency of energy use by the car or battery, and the cost of the energy itself. Sadly, the efficiency of use is dependent on far too many uncontrollable factors such as driving style and battery type to examine in a broad view, so we will be focusing on the base cost of energy. The energy used to power the cars is measured in kilowatt-hour (kWh). Looking at the U.S. market, the national average cost is 10 cents per kWh. A middle of the pack battery may give an EV approximately 3 miles per kWh. Therefore, an EV that gives 3 mi/kWh would make the energy cost come out to about 4 cents per mile. If we compare that to an ICE vehicle that gets 22 miles per gallon on average, with a knowingly unrealistic gasoline price of $3.00 per gallon, that would come out to about 14 cents per mile. These numbers get even more impressive when you look at the currently skyrocketing gasoline prices due to the Russia-Ukraine conflict. (*How Do Gasoline & Electric Vehicles Compare?, n.d.*)

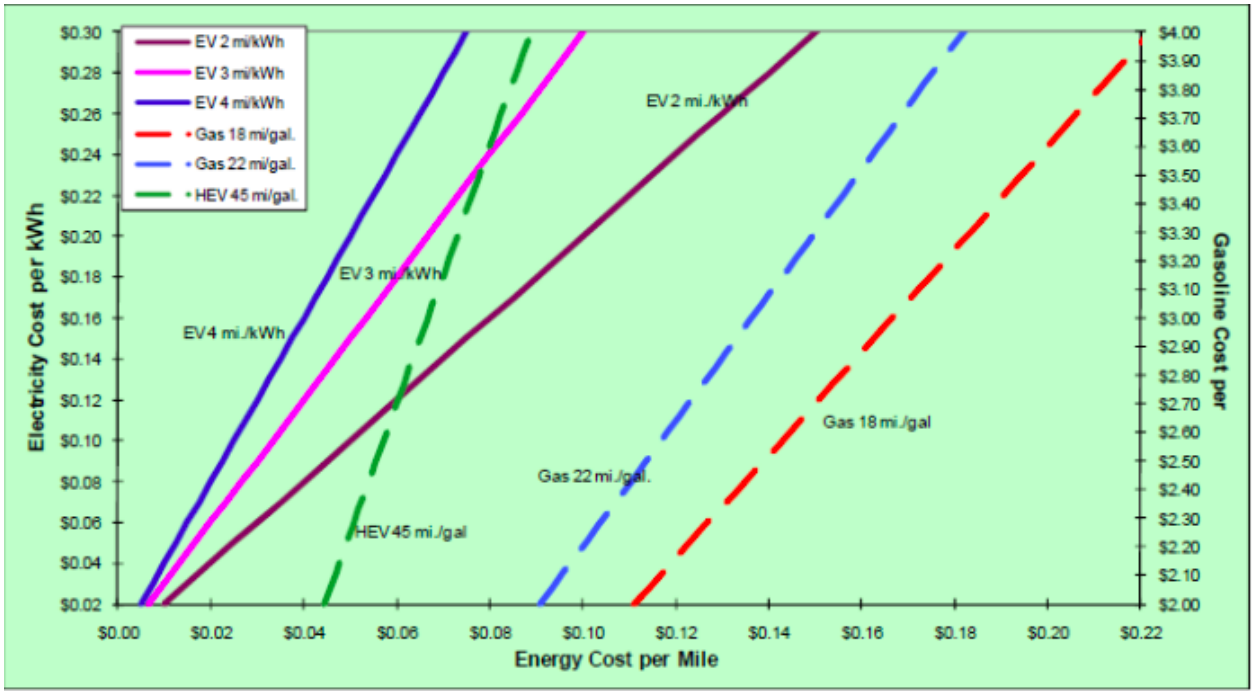


Figure 2

This sounds like a meaningless number when looking at these small values, but cars are long term investments. The average American drives over 14,000 miles per year according to the Federal Highway Administration. To put it in perspective, the average American could save $1,400 in one year, or almost $12,000 throughout the life of your newly purchased car. It sounds like EVs are perfect for the average consumer. They are great for the environment, they save you money while you drive, but what they're hiding is the massive start-up cost. (*Average Miles Driven per Year in the U.S., 2022)*

Individual Start-Up Costs

Buying an electric vehicle isn't quite as easy as driving straight off the lot like we're used to. First of all, the United States Resources Defense Council found that the average MSRP for a new electric vehicle is close to $19,000 more than those powered by ICEs. However, this number includes outlier cars like Tesla's Roadster model that is more of a luxury sports car than what the average American may drive. In addition, this number is dropping every year as engine manufacturers find new ways to build their electric engines in more cost effective ways. But base price isn't the only thing consumers are blindsided by when purchasing an EV.

The Charging Problem

This is the exact point where the majority of consumers make the decision not to pursue an EV. To understand why there is such a problem let's examine the three types, Level 1, Level 2, and Level 3 chargers. Level 1 chargers are the most affordable and easy to install option. These are primarily intended for residential use. Level 1 chargers typically provide about 5 miles of driving per every hour of charging. For someone outside of city limits driving 50+ miles to and

from work these cars are automatically off the list. Next we have Level 2. These can be for residential or commercial use and provide 20-60 miles per hour of charging depending on the unit. Finally, we have level three. These units are the gold standard that companies like Tesla have been using to build a network of stations around the U.S. They can provide upwards of 100 miles per 20 minutes of charge time meaning they really start to bridge the gap to the fuel pump. (Monkman, 2022) As with every economic problem, however, it all comes back to cost. Surveys completed by the ICF show that in the last few years the average cost of installing a Level 2 charger at home reaches a whopping $14,914 as you can see below in Figure 3a put together by the ICF. If you remember only the gasoline savings of $12,000 over the life of your new car, which seems like a great amount, it still fails to cover the initial start up costs. Of course, not everyone who owns an EV necessarily has to have a charging station at home. If office buildings had them or there were locations similar to a gas station where you could stay for a brief time and charge-up the problem might lessen, but these initial investment costs are going to have to be covered by somebody. To buy and install a Level 3 charger costs over $100,000 on average as can be seen in Figure 3b. (Pournazeri, 2022)

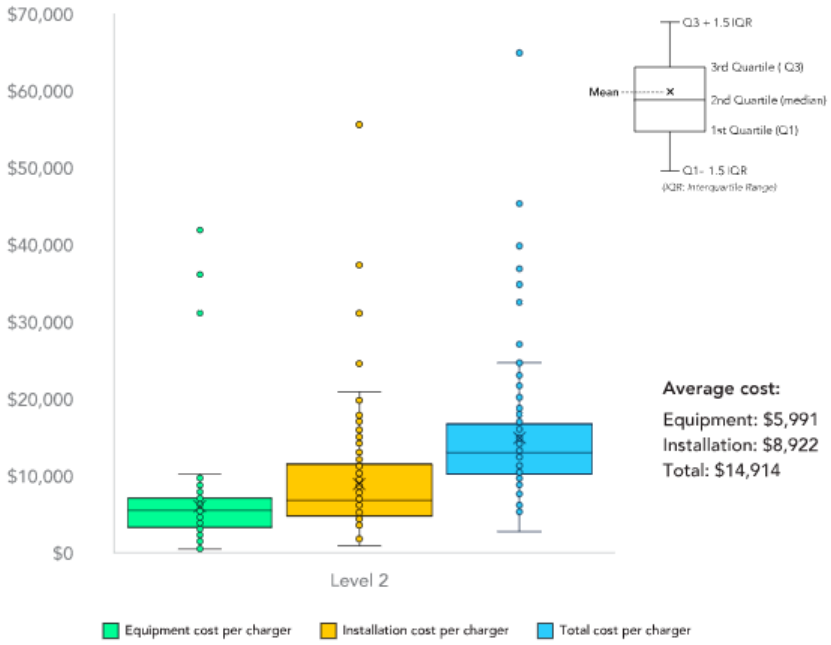


Figure 3a.

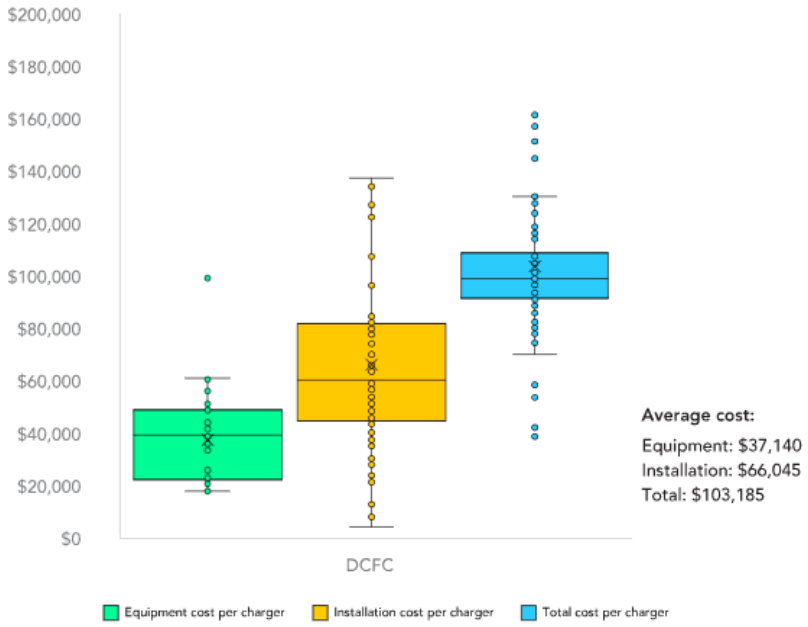


Figure 3b.

Non-Tax Influences for PEV Purchase

It is clear that overall cost is likely the most important factor in the decision-making process of a consumer, but it is also important to see not only what other factors may have an

influence, but also the level of influence they may have. To address this issue, we will look at a couple of previous surveys conducted both at home and abroad to try to understand whether the current incentives will have a strong effect going forward. First, a number of faculty from Savannah State University and Texas Tech University conducted a survey of California car owners and developed a model to test the influence that a variety of factors had on the purchase of PEVs. This study was conducted in the hopes of developing an established model for surveying the influencing factors of PEV purchasing in different parts of the world. The faculty hoped to use the initial survey of the State of California as a base test and then proceed to use the same model to analyze other cities, states, or countries. The model used both logit and probit models, which are specifically designed to predict the likelihood of events (purchasing a EV) occurring. To conduct their research, they would survey the effect of 17 variables within the following three categories, consumer related variables, vehicle related variables, and context variables. Importantly, the survey did not analyze the impact of tax incentives on PEV purchase. The analysis of this study is specifically to analyze how factors not directly related to cost impact PEV purchasing.

To begin, the findings of this study were quite eye opening as a way to understand what variables had little to no impact on consumer's decisions to purchase a PEV. First and foremost, they found no difference in decision-making between men and women, or age groups. Two other surprising non-influential factors were employment status, (0,1, or 2 jobs) and trip duration. In the survey, the average trip duration was 52.4 minutes, which is just within the range where most PEVs do not face any real limitations in terms of drive time or refueling. The final notable non-impactful factor was the price of energy in the surveyed region. This was most

likely due to the fact that energy prices vary minutely from region to region and are always significantly below the high fluctuating price of gasoline.

As for the variables that have significant influence on consumer's decisions, it seems that the results could be refined to 5 factors having the most significance. The following are the most significant factors in order: education level, income, car sharing status, charging station per capita, and gas price in increasing order of influence. The model they produced found that sharing a vehicle actually increased the probability of purchasing a PEV by approximately 2%. Additionally, the model predicted that the probability of a consumer purchasing a PEV increases by 1.9% for each additional charging station per capita, and a very significant 5.4% for each additional dollar in gas price per gallon. (Javid & Nejat, 2012)

Current Federal Tax Incentives in the U.S.

Due to the significant initial investment required by every entity involved, the government has felt an increasing urgency to incentivize the adoption through the means of tax incentives. As it stands, the U.S. Federal government provides a federal tax credit of between $2,500-$7,500 for the purchase of new PEVs. The way this works is that an individual would save up to $7,500 on their tax return in the year of their purchase. A tax incentive, however, is different from tax deductions. While deductions reduce the taxable income a taxpayer has, a tax credit is a definitive amount that a taxpayer can directly deduct from the taxes owed on the previous year. Additionally, this tax credit is non-refundable. Meaning that if the individual owes less tax on their return than the credit provides they will not receive credit for the full amount.

There are other problems with this tax credit as well. The exact value depends on the individual capabilities used to power the vehicles. For instance, the new Volkswagen ID.4 qualifies for the entire $7,500 tax credit. (Federal tax credits for electric and plug-in hybrid Cars, n.d.) On top of this, there is an additional tax credit of up to $1,000 dollars for individuals who purchase alternative fuel infrastructure for their residency, or more simply, a home charging station. (EV Incentives, n.d.) Even with these incentives, plug-in electric vehicle sales have paled in comparison to ICE vehicles since 2013. From the years of 2013 to 2017, the U.S. sold 651,972 PEVs (plug-in electric vehicles). Which brought the overall market share to a whopping 1.19 percent. Most intriguingly, approximately half of these sales can be attributed to the state of California. (Cattaneo, 2018)

California Tax Incentives

Looking at just the number of incentives alone, an individual living in Los Angeles county has the ability to make use of 11 additional incentives compared to those offered federally. For the purchase of a PEV, they have access to the federal tax credit along with, interest rates of 8% or lower for participants in the Clean Vehicle Assistance Program, an up to $4,500 rebate from The California Clean Vehicle Rebate Project, a $750 point of sale reward for PEVs, and between $2,500 to $9,500 for consumers who replace their old vehicle with a new PEV. California, however, does not stop with the direct vehicle incentives either. They also have rebates, cash incentives, preferred financing for the purchase and installment of charging stations, reductions to the cost of electricity when charging PEVs, and lastly an exemption that allows single drivers to use the carpool lane on California highways when driving an electric vehicle even without a passenger. (*EV Incentives*. Electric For All, 2021)

All of these additional incentives and big dollar amounts appear to make the decision a no-brainer, but, like for the federal tax credit, the significant majority of consumers would be receiving dollar amounts on the lower end of the spectrum for each incentive. Additionally, most of these incentives are what could be considered indirect. This is to say that tax credits and rebates do not actually affect the dollar amount paid by the consumer at the point of sale. Meaning that if consumers don't know of these incentives or do not want to wait for their savings, they may have no to little effect. Even so, considering the intense lack of incentives in the rest of the U.S., it is still no wonder why California outpaces the competition in the U.S. in terms of PEV ownership. California alone contributes over 48% of the total PEV purchases made in the U.S. from 2011-2015. (Javid & Nejat, 2012)

Evidence from Norway's Tax Incentives

For the purposes of this paper and the analysis of the situation in the U.S., California is the perfect example. However, there is one place that has caught the eyes of many researchers for their PEV adoption rate, the country of Norway. In the four-year period from 2012 to 2015 the number of PEVs increased by over 500%. (Bjerkan et al., 2016) In order to make this happen, Norway prioritized pull incentives. These are incentives which directly lure the customer into buying PEVs rather than incentives pushing individuals to retire ICE vehicles like many of California's policies. From research done in 2016, they narrowed down the most influential incentives to just three. First, Norwegians who purchase electric vehicles are exempt from the vehicle registration tax. Second, consumers are also exempt from Norway's Value Added Tax of 25%. In simple terms, this tax is levied on the difference between the cost to the consumer and the cost to manufacture the good. Lastly, PEV owners also pay the lowest rate of a vehicle

licensing fee. Of course, since this whole discussion is about monetary incentives, what are some examples of the real dollar cost reductions for PEV purchasers? In 2014, the price of Tesla's high-end S performance in U.S. dollars would have been $140,000. Now, with the exemption from just the vehicle registration tax and Value Added Tax this number plummets to $70,000. Still, certainly the majority of consumers still wouldn't be paying $70,000 for their vehicle. Looking at one of the most popular PEV models of the decade, the Nissan Leaf, the price before exemptions is 35,000, while after exemptions is 27,000. (Bjerkan et al., 2016, p. 171-172) Norwegian EV users are looking at an up-front purchase price reduction of between 20%-50% off MSRP compared to a maximum of $750 off point-of-sale price for Californians. (*EV Incentives*. Electric For All, 2021)

Norway's Additional Non-Tax Based Incentives and Relative Effectiveness

Much like California, Norway doesn't stop at just monetary incentives. California offers the sole perk of using the HOV lane for single drivers, and Norway offers the use of their bus lane, which we can consider as a near equivalent incentive. In addition, they offer free parking in all municipal parking areas, exemption from ticket fees on ferries, and exemption from tolls on roads and highways. Now it is beginning to become clear why Norway had such rapid success in shifting consumers decision-making in such a short amount of time, but the real important question still must be answered. How effective are these incentives?

To help answer these questions, SINTEF Technology and Society conducted a survey of EV owners in Norway to get a better understanding for which of these incentives had the greatest effect on their decision-making. The survey respondents included individuals of all age

groups, varying levels of income, and from various regions in Norway. The only significant statistical bias is that 76% of the respondents had at least attained a college degree, which coincides with what researchers noticed about Californian EV owners as well. This survey asked EV owners to declare if the incentive was critical for purchase, and to rate the various incentives on a scale of 1 to 10 based on the strength of influence each of them had on the owner's purchase decision. The results of the survey can be found in figure 4 below. (Bjerkan et al., 2016, p. 175)

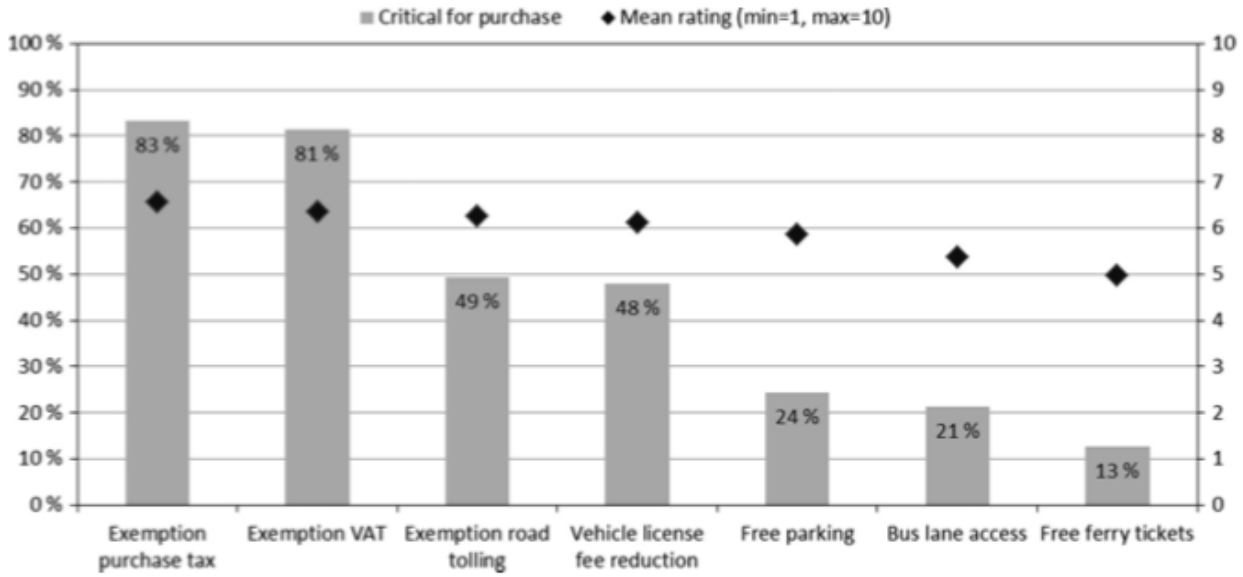


Figure 4. Effectivenss of Individual Incentives

As we can see from the data the purchase tax exemption and VAT exemption had the most significant impact on consumers decisions. Just as we mentioned above, these two incentives are the up-front purchase price reduction incentives that consumers can see in their savings as soon as the vehicle is purchased. In fact, the research showed that almost a quarter of respondents declared that these two incentives alone were the only ones that made any

difference in their decision-making. Interestingly enough, road tolling was the next highest rated incentive. I would assume this relates to the fact that it would be the most commonly used incentive for the average consumer. To relate this to the U.S. market, toll roads are becoming more and more common across the country. Many cities are beginning to make them a common part of everyday travel from suburbs to downtown areas. Considering 23% of respondents who claimed that only one of the seven incentives was influential and chose exemption from road tolling makes me believe that this incentive would transfer extremely well to the U.S. (Bjerkan et al., 2016, p. 177)

An original paper analyzing the same set of facts from Norway found that the cost per year of owning an electric car rather than an ICE is lower in every category from financing, to annual taxes, to energy costs (electricity vs. gas), and of course to parking and road tolls. (Aasness & Odeck, 2015) The more research we uncover the more it shows evidence that when implemented to a certain extent, incentives of varying forms can be effective in changing consumers purchasing decisions, but there is yet another factor. All of these incentives must actually be voted for and put in place by the governing bodies.

Will making changes actually be effective in the U.S. market?

We have now analyzed the situations in the California market and used Norway to garner ideas for what additional incentives could be implemented in the U.S. market. Before we end with possible counter arguments for not incentivizing or developing a conclusion, I would like to analyze the changes in consumer behavior when HEV incentives were introduced to the U.S. market a decade and a half ago. In 2006 the U.S. introduced a new federal tax credit for the

purchase of hybrid electric vehicles. A study written and described by David Diamond and published by the LMI Research Institute describes a cross-sectional analysis that examines the changes in hybrid vehicle adoption due to the changes in federal incentives in 2006 and directly following. In order to do so, it uses hybrid registration records for the period and compares the U.S. average to analyze how the federal incentives combined with state incentives impacted adoption rates in certain states.

As seen from previous studies, factors such as miles traveled, income, gas prices, and monetary incentives all have varying effects on consumers' willingness to buy clean fuel vehicles. In Diamond's write up from the study, he helps to reaffirm much of what the other studies analyzed in this paper say. He says quite bluntly that the price of gas appears to be the most directly influential factor for consumers to shift their mindset towards cleaner fueled vehicles. By examining Figure 5, pulled from LMI Research Institutes work, we can come to relatively the same conclusion. With the blue line depicting the changes in gas prices, and bar chart depicting the levels of HEV market share, it can easily be argued that the market share trends simply followed those of gasoline. In fact, there is even a 4 month drop off in HEV purchasing immediately following the beginning of the new Hybrid tax credits in 2006. (Diamond, 2008, p. 974)

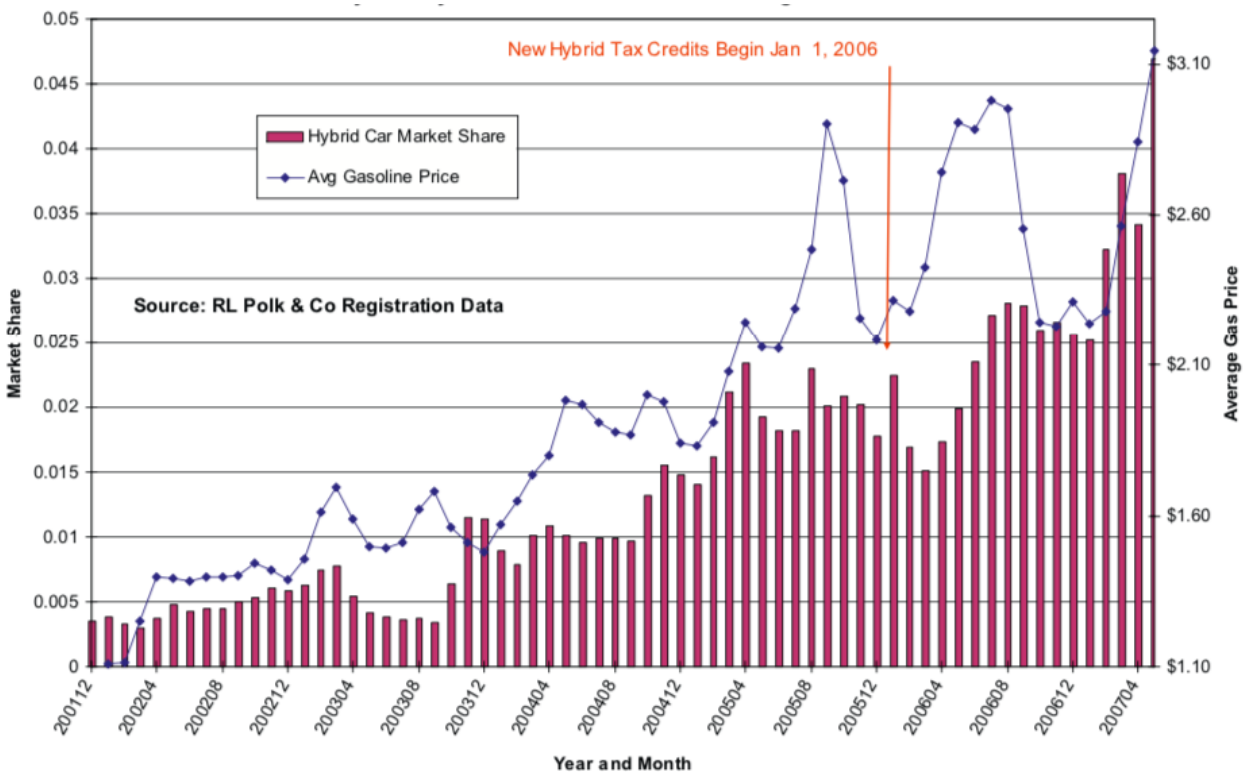


Figure 5. HEV Market Share Trends Before 2008

Coincidentally, he also makes the statement that this seems to occur based on cost perception rather than a detailed benefit-cost or lifecycle cost analysis. Much like I had suggested previously, consumers make the initial shift in purchasing behavior based on the perceived cost savings from external factors like gasoline prices, but when it comes to the final purchasing decision, they can get scared off by the higher than expected upfront costs, especially for PEV's.

Diamond also found in his analysis that there was a weak correlation between monetary incentives and state market share for HEVs from 2006-2008. He proposed two explanations. First, he suggests that car dealerships are actually factoring state and government incentives into their pricing structure. If we acknowledge this possibility, this means that the tax incentives would be effectively working as a subsidy for car manufacturers to produce and sell more

HEVs/PEVs than an incentive for consumers to change their purchasing habits. Of course, this is a theory that can be carried over to today's issue with PEVs, but it is difficult to confirm without insider knowledge on the cost of production and non incentivized MSRPs for individual vehicles. The second explanation given was that many of the state and federal incentives for HEVs provided their value to consumers over a long period of time. Consistent with the notion of consumers preferring a lower upfront purchase price in California and especially Norway, Diamond suggests the same. This explanation has supporting evidence now from Norway's example in addition to HEV incentives in the U.S. where Diamond found that sales tax or up-front excise tax waivers were more influential in convincing consumers to purchase HEVs over a decade ago. (Diamond, 2008, p. 982)

Reasons For Not Incentivizing PEV Purchases

Norway's incentivization is widely seen to have been the most effective method of encouraging the use of more environmentally friendly road technology. They stand as a case in point that countries around the world have the tools at their disposal to reduce their carbon footprint through PEV adoption. However, some of these incentives can have a significant downside to them as well. With every tax credit or rebate the government is losing sources of revenue. In Norway, the loss of the Value Added Tax and Purchase Tax are already massive losses on the government's bottom line. Then you also throw in the loss of tolls and parking fees. These incentives, while greatly helping the consumer in terms of monetary benefits, are rather counter-intuitive. By not paying tolls or parking fees the owners of electric vehicles are surely contributing to possible future infrastructure problems. Much of the revenue from toll roads is put back into the nation or state's infrastructure projects which would of course benefit

the consumer through better and newer roads. Additionally, incentives such as the toll exemption and HOV/bus lane usage realistically have a built-in time restriction. With each person that buys an electric car, usage of the HOV/bus lanes will increase. Leading to longer commutes for these individual drivers and the rest of the public. Consequently, the more consumers you incentivize, the less of a benefit each one will receive. (Aasness & Odeck, 2015)

What Should the U.S. Do?

This is the overarching question that must be answered. However, I should preface this paper's conclusion by saying that I am in no position to make specific policy recommendations. I will simply use the research analyzed in this paper to propose general ideas that the U.S. should consider as they look to incentivize PEV purchases.

The problem presented is that CO2 emissions are far above acceptable levels, and solutions must be found to bring them to a more environmentally healthy place. Considering the statistics of how much passenger vehicles contribute to this problem, along with their likelihood of future contribution if the current market were to continue, PEV adoption presents itself as a logical solution to the given problem. Although, if this is the solution the U.S. wishes to pursue, the country as a whole, is not doing nearly enough.

California is ahead of the curve, offering a wide variety of incentives and even providing incentives to assist consumers in the purchasing of residential charging stations. Monetary savings for Californians are far ahead of other states, making it easy to see why they have the highest percentage of EV ownership in the country. Yet, even California's current rate of adoption, if spread country wide, would not result in the desired levels of greenhouse gas

reduction. As technology develops and base prices for electric vehicles continue to drop, they will inherently become more viable options to the average American consumer. Furthermore, if gas prices continue to rise, the indirect incentives will begin to drive more and more consumers towards PEVs. However, I firmly believe that a proactive approach is to be preferred.

Possible Solutions

There are many different routes that the U.S. can take, all of which would preferably be done at the federal level to the extent possible. First, the U.S. can make significant investments into infrastructure for PEVs. This could come in the form of direct purchasing or building of charging stations along highways and city centers, grants to state and city governments that are to be used for this purpose, or it could come in the form of significant tax breaks for businesses that install them on their property to allow employees to charge their vehicles while at work. The second prospective suggestion is to implement everyday cost exemptions like the toll exemption or even California's rate reduction for energy cost when using electricity to charge electric vehicles. Although, as we discussed earlier, the government must recognize and plan accordingly knowing that these incentives have significant drawbacks to both the consumer and the government. Lastly, the U.S. government could significantly increase the number or the value of tax credits, rebates, or exemptions that it provides for purchasers of electric vehicles. If they plan to go this route, I strongly recommend, based on research from throughout this analysis, the development of policies and incentives that will affect the up-front purchase cost so that consumers will receive an immediate cost benefit.

I think that based on all of the evidence uncovered, it is clear that proactive changes need to be made in the U.S. and even in California if we are to see the level of greenhouse gas reduction the country desires. Consumer habits are often slow to change, and to convince the nation to sacrifice things such as the ease of the gas pump is going to take significant incentivization. Ideally, all of these suggestions would be implemented in progressive stages. The first stage being the investment into charging station infrastructure which will help to keep current EV users on board. Then I would suggest the use of tax incentives. Preferably, these would affect the immediate purchase cost of EVs, which leaves our lower Value Added Tax or Sales tax to be meddled with. Lastly, and only if we are not seeing enough results after 5-10 years, I would suggest adopting a policy such as road toll exemption. Policies such as these can be destructive to both parties, but it was nonetheless clear that it was an important factor for many Norwegians who ultimately made the decision to switch to PEVs. If thoroughly considered and implemented at the federal level, there is little reason why these proposed incentivization changes would fail to entice a larger number of consumers to shift their purchasing decisions. Car manufacturers in the U.S. and abroad have already begun making the pivot towards an electrification of road travel. Now, it is up to the consumer.

Bibliography

Aasness Marie Aarestrup, and James Odeck. "The increase of electric vehicle usage in Norway Incentives and adverse effects." European Transportation Resources Review 7, no. 34 (2015).

Average Miles Driven per Year in the U.S. (2022) - the Zebra. https://www.thezebra.com/resources/driving/average-miles-driven-per-year/.

Bakker, Sjoerd, and Jan Jacob Trip. "Policy options to support the adoption of electric vehicles in the urban environment." Transportation Research Part D 25 (2013): 18-23.

Berardelli, J. (2021, April 2). *NASA measures direct evidence humans are causing climate change*. CBS News. Retrieved November 15, 2021, from https://www.cbsnews.com/news/climate-change-human-cause-nasa-study-carbon-emissions/.

Bjerkan, Kristin Ystmark, Tom E. Norbech, and Marianne Elvsaas Nordtomme. "Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway." Transportation Research Part D 43 (2016): 169-180.

Cattaneo, L. (2018, June 7). *Plug-in electric vehicle policy*. Center for American Progress. Retrieved October 26, 2021, from https://www.americanprogress.org/issues/green/reports/2018/06/07/451722/plug electric-vehicle-policy/.

Diamond, David. “The Impact of Government Incentives for Hybrid-Electric Vehicles: Evidence from US States.” *Energy Policy*, Elsevier, 13 Dec. 2008, https://www.sciencedirect.com/science/article/pii/S0301421508005466.

Egbue, Ona, and Suzanna Long. “Barriers to Widespread Adoption of Electric Vehicles: An Analysis of Consumer Attitudes and Perceptions.” *Energy Policy*, Elsevier, 27 June 2012, https://www.sciencedirect.com/science/article/pii/S0301421512005162.

EV incentives. Electric For All. (2021, August 24). Retrieved November 15, 2021, from https://www.electricforall.org/rebates-incentives/.

Federal tax credits for electric and plug-in hybrid Cars. www.fueleconomy.gov - the official government source for fuel economy information. (n.d.). Retrieved November 15, 2021, from https://www.fueleconomy.gov/feg/taxevb.shtml.

Fuel Cell Motor Vehicle Tax Credit. Alternative Fuels Data Center: Fuel Cell Motor Vehicle Tax Credit. (n.d.). Retrieved November 15, 2021, from https://afdc.energy.gov/laws/350.

Gilbert, N. (2021, March 25). *The number of cars in the US in 2021/2022: Market share, distribution, and Trends*. Financesonline.com. Retrieved November 15, 2021, from https://financesonline.com/number-of-cars-in-the-us/.

Helveston, John Paul, Yimin Liu, Elea McDonnell Feit, Erica Fuchs, Erica Klampfl, and Jeremy J. Michalek. "Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the U.S. and China." Transportation Research Part A 73 (2015): 96-112.

How Do Gasoline Cars Work? *Alternative Fuels Data Center: How Do Gasoline Cars Work?*, https://afdc.energy.gov/vehicles/how-do-gasoline-cars-work.

How Do Gasoline & Electric Vehicles Compare? - Idaho National Laboratory. https://avt.inl.gov/sites/default/files/pdf/fsev/compare.pdf.

“How Long Do People Keep Their Cars?” *How Long Do People Keep Their Cars? - ISeeCars.com*, https://www.iseecars.com/how-long-people-keep-cars-study.

“How Much Does an Electric Car Cost? A Complete Overview.” *Compare Car Insurance Quotes*, 4 Jan. 2022, https://www.compare.com/electric-cars/guides/electric-car-cost.

Hybrid and plug-in electric vehicles. Alternative Fuels Data Center: Hybrid and Plug-In Electric Vehicles. (n.d.). Retrieved October 26, 2021, from https://afdc.energy.gov/vehicles/electric.html.

Javid, Roxana J., and Ali Nejat. "A comprehensive model of regional electric vehicle adoption and penetration." Transport Policy 54 (2017): 30-42

Jenn, Alan, Ines L. Azevedo, and Pedro Ferreira. "The impact of federal incentives on adoption of hybrid electric vehicles in the United States." Energy Economics 40 (2013): 936-942.

Jochem, P., Babrowski, S., Fichtner, W., 2015. Assessing CO2 emissions of electric vehicles in Germany in 2030. Transp. Res. Part A: Policy Pract. 78, 68–83. http://dx.doi.org/10.1016/j.tra.2015.05.007.

Kessler, Jeff. "Assessing low-carbon fuel technology innovation through a Technology Innovation System approach." PhD Dissertation, Davis, 2015.

Pournazeri, Sam. “Understanding Electric Vehicle Charging Infrastructure Costs and Variables.” *ICF*, ICF, 25 Jan. 2022, https://www.icf.com/insights/transportation/electric-vehicle-charging-infrastructure-costs?utm_medium=emp-social&utm_source=LinkedIn&utm_campaign=thehub.

Ritchie, Hannah. “Cars, Planes, Trains: Where Do CO2 Emissions from Transport Come from?” *Our World in Data*, 6 Oct. 2020, https://ourworldindata.org/co2-emissions-from-transport.

Monkman, Robb . “Understanding the Total Cost of Deploying Commercial EV Charging Stations.” *Charge Up USA*, Charge Up USA, 23 Feb. 2022, https://www.chargeup-usa.com/post/understanding-the-total-cost-of-deploying-commercial-ev-charging-stations.

Scott Hardman. *Reoccurring Incentives Literature Review*. https://phev.ucdavis.edu/wp-content/uploads/reoccurring-incentives-literature-review.pdf.

The history of the Electric Car. Energy.gov. (n.d.). Retrieved November 15, 2021, from https://www.energy.gov/articles/history-electric-car.