

Gridlock of Perspectives: The Competition for the Future of Electric Vehicles

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Quang Lam

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisors

Joshua Earle, Department of Engineering and Society

Peter Norton, Department of Engineering and Society

STS Research Paper

How are drivers, automakers, advocacies, and regulators competing to influence EV adoption within the United States?

Introduction

Internal combustion engine (ICE) transportation accounted for 29 percent of U.S. greenhouse gas emissions during 2019 (EPA, 2021). Electric vehicles (EVs) have no tailpipe emissions, but they are only as green as the power source that charges their battery (Biello, 2016). Combustion of fossil fuels accounts for the most electric power generation in the U.S. An EV emits fewer greenhouse gasses (GHGs) than a comparable combustion-engine vehicle. Emissions attributable to vehicle manufacture, however, are significantly higher for EVs. Depending upon the vehicle, the power grid, and the operating conditions, reducing EV emissions below ICE vehicles may take years (Bieker, 2021). Despite this, EVs are necessary and essential to preventing further global warming of the Earth.

Multiple car manufacturers have spent millions of dollars on lobbyists to slow the electrification of cars in the US over several decades (Hillstrom, 2021). Toyota alone has spent \$3.4 million to slow the nation's EV transition in 2021 and is part of a major group of car manufacturers trying to slow down Congress' \$1.2 trillion infrastructure bill. This bill includes \$7.5 billion for building EV charging stations. Not all car manufacturers are completely opposing the infrastructure bill; car manufacturers Ford, General Motors, and the Volkswagen Group have all pledged electrification goals. With the recent success and rise of electric vehicle manufacturers like Tesla, many manufacturers have veered direction and have invested billions

of dollars in EV development. The Volkswagen Group has invested 73 billion euros over five years just to improve EV sales, research, and development (Volkswagen Newsroom, 2020). These car manufacturers are major participants and influence how many EVs are ultimately on the road.

State governments and their respective organizations affect the public's decision-making on what car to purchase. This is evident with California's tax deductibles and the California Air Resources Board (CARB) with their efforts to phase out combustion-engine vehicles. This paper will continue to explore the effect both the federal and state governments have and the correlation between these government incentives and the number of EVs being chosen at a dealership.

In addition to governments both within the United States and beyond, oil companies are actively battling infrastructure bills (Bade, 2019). As other states begin to follow California's zero-emission vehicle regulation plans, oil companies may begin to worry about their future with EVs beginning their popularity. Despite the threat of EVs penetrating their market, Exxon Mobil Chairman Darren Woods says, "We respect and support society's ambition to achieve net-zero emissions by 2050, and continue to advocate for policies that promote cost-effective market-based solutions". Exxon Mobil has lobbied against pieces of the budget bill, spending a total of \$2.7 million on lobbyists this year.

Methods

The first method for this STS paper is to gather data on each of the participants. These include car manufacturers, policymakers at the state and national level, and oil companies. These are quantifiable and usually budgets or analyses in order to be able to compare and find correlations behind other quantifiable data in regards to separate participants. An example that will be

analyzed later is the different lobbying budgets by big automakers like GM and Toyota in addition to their admitted investments in future EV development. Further data that will be researched are the expected government-allocated funds for EV charging stations and the electrical infrastructure within the United States and countries in the European Union. These budgets can be used to judge how reactive automakers are to this sudden change in trajectory for vehicles being offered to the public. As both the United States and European Union begin to adopt EVs, the trend of the investments in both lobbying and development is integral to watching how automakers are tackling EVs.

In addition to analyzing budgets on lobbying and infrastructure bills, an in-depth analysis of where EVs are more popular will be done as well. Comparing where EVs are being purchased the most and local legislation can judge the effectiveness of the aforementioned bills and regulations. Ultimately, the global temperatures and climate change evidence will also be analyzed to understand the significance of EVs. Although only 29 percent of the United States' GHGs, looking for figures of air quality, temperatures, and climate reports helped further understanding of EVs' impact.

Research

Of Toyota, Volkswagen, General Motors, and Tesla, General Motors had the largest budget with \$2.39 million (OpenSecrets, 2022) spent in 2021. Toyota spent the second-most over the past five years with \$6.42 million. Volkswagens spent \$1.22 million and Tesla spent \$640,000. These budget numbers coincide more to the size

of each of the car manufacturers as opposed to the intention of changing policies.

When looking at the budget trends over the past five years, each of the car manufacturers mentioned had significantly increased their lobbying budgets for 2021 except for Tesla. This is most likely due to the upcoming infrastructure bill; Tesla didn't raise its lobbying budget because of government funds to continue building EV charging stations throughout the United States.

Secondly, data gathered on Congress' upcoming infrastructure bill were focused on EV charging stations and the budget set aside for providing an upgraded power infrastructure delivering clean energy. Under the Biden administration, the White House has pushed the agenda to direct the United States towards a zero-emissions future. The United States market share of plug-in EV sales is only one-third the size of the Chinese EV market (The White House, 2021). The White House has promoted an agenda focused on investing \$7.5 billion to build a national network of EV chargers. This network of EV chargers will consist of 500,000 EV chargers aimed to accelerate the adoption of EVs, reduce emissions, and create jobs. The bill also focuses on a \$65 billion investment promoting clean energy transmission and grid. The bill focuses on the deployment of cutting-edge clean energy technologies, possibly further pushing for the use of EVs over ICE cars that rely on gas stations.

There were a total of 81,000 public EV charging stations available in 2018. Between 2016, 2017, and 2018, there were only 20% and 21% increases, respectively. As of 2022, there are 120,000 charging ports; the bill expects to expand this network with 500,000 additional ports.

There were 6.4 million EVs sold globally, with 487,560 units sold within the United States during 2021 (GreenCars, 2021). More notably, there was an 89% increase in sales from 2020 to 2021 in the United States. During 2020, Tesla sold the most EVs (16% share) with the Volkswagen Group (9% share) and SAIC (13% share) as the three dominant EV manufacturers globally. The SAIC is a Chinese state-owned automaker that allows China to rapidly convert towards EVs.

In addition to lobbying automakers, oil groups and trade associations like the American Fuel and Petrochemical Manufacturers, a group of gasoline makers, are lobbying against EV reform. Oil groups are opposing tax credits for EVs which 26 states currently have. Additionally, they support the proposed rollback of Obama-era fuel efficiency standards (Bade, 2019). Their arguments are focused on the lack of affordable Teslas and the use of taxpayer money on the creation of additional EV stations that the average citizen won't use. This lobbying has been effective; regulators scaled back a bill in Maryland to only allow 5000 chargers to be built over the next few years.

Analysis

Apart from Tesla, there was a significant increase in lobbying budgets across major car manufacturers. Car manufacturers like Toyota lobbied against or for pieces of the infrastructure bill. With an expected 500,000 EV charging points along with a very strong emphasis on clean energy, the infrastructure bill will be a major driver in more EV sales across the United States. This opposition, like from Toyota lobbyists, is largely due to the investment required to further develop EV technology. These investments take capital but also lose the companies opportunity cost

over the time it takes to develop. Tesla and other upcoming EV manufacturers like Lucid and Rivian have invested in their EV technology from their conception. To catch up to these EV manufacturers, Toyota and other automakers are attempting to slow down the infrastructure bill. With slowing down the infrastructure bill, these car manufacturers are able to slow possible government-incentivized demand from the public to develop and produce EVs that may rival current EV competition.

The infrastructure bill is a clear shift in public opinion in regards to EVs as well. EV sales increased 89% between 2020 and 2021 showing a growing market share of EVs when compared to ICE vehicles. The expanded charging stations are also known to promote the adoption of EVs (Illman & Kluge, 2020), which fortifies the choice architecture the United States is attempting to construct. The investments by both the government and automakers are paving a way for future EV adoption and ultimately less global GHG emissions.

Research shows the direct influence of EV adoption and electronic reliance on transportation. With an 80% drop in demand with net-zero emissions by 2050, oil companies must make an industrial change or simply fail to survive. Despite this, BP still expects oil demand to peak during the mid-to-late 2020s (Cohen, 2020). Other oil companies like ExxonMobil are now investing like automakers into greener alternatives or applications of their products. On their energy and innovation page, ExxonMobil states the use of lubricants, specialty greases, and e-motor fluids produced by them are integral in future EVs. 79% of ExxonMobil's revenue is their downstream products; most notably, their gasoline and their engine oil. This reliance on downstream products is extremely important in popular modern-day transportation including ICE cars. During 2020 and the COVID pandemic, the only profit ExxonMobil made was from their chemical-making segment which was only 13% of their overall

revenue during 2020. Despite other factors during the COVID pandemic, the stay-at-home quarantine heavily reduced the overall use of GHG-emitting ICE engines and transportation but still did not lead to a significant decrease in GHG emissions. With EVs and electronically powered transportation not requiring either gasoline or engine oil (ExxonMobil's downstream products), this results in potential turmoil and political pressure exerted by oil companies.

ExxonMobil follows the trend of future investment to survive within a world of EVs. They have planned to invest 3 billion dollars through 2025 on lower-emission energy solutions. As of right now, carbon capture and storage (CSS) technology will be needed to achieve net-zero emissions. CSS captures carbon dioxide from industrial activity and injects it into geological formations for permanent storage. This future investment in net-zero emissions follows the trend of every major participants' actions. Although there was prior opposition in order to preserve the profitability of their products, both oil companies and automakers alike must invest in future technologies to stay relevant in their respective markets.

Discussion

With the trajectory of the development and promotion of EVs, the general public within the United States are beginning to see clear incentives to drive EVs. This prompts the question of whether regulation is required in order to make this shift. It is evident that without both federal and state regulations and mandates, automakers would continue producing ICE vehicles in an effort to avoid costly investment into EV technology. However, government regulations are essential to the rise and success of other EV manufacturers like Tesla to help push larger automakers to acknowledge the market competition.

Despite Tesla's CEO Elon Musk stating that it was unnecessary for the infrastructure bill to focus on EV charging stations, Tesla has not lobbied against it. Musk has outwardly expressed concern for the elimination of automaker-specific tax credits (Morris, 2022). With no increase in Tesla's lobbying budget, this shows the manufacturer is not completely opposed to the developing government support of EVs.

Lastly, there is no conclusive research that shows an effect on climate change by EVs. This is based upon the fact that the majority of electricity is still producing GHGs. However, EVs are fundamentally emitting around 43% less GHGs than a standard ICE vehicle (Hausfather, 2019). There has not been enough time with EVs currently in the market in addition to the majority of ICE vehicles globally to exhibit a significant impact on global temperatures. In an overall effort to curb GHG emissions, the electrification of all road cars is not the silver bullet against global warming and climate change. Other techniques like Japan's unique reduction of energy on HVAC (Japan Today, 2020) and the redesign of both agriculture and city architecture are integral to reducing energy consumption that is produced with fossil fuels. Ultimately, EVs will still be a significant change to prevent irreversible climate change.

Conclusion

In order to avoid massive climate change effects, warming must be limited to only 1.5 degrees Celsius globally. These effects include rising sea levels, irreversible destabilization of ice sheets (Vox), and significant hits to global food production. EVs alone are not enough to keep the world from warming, as EVs are only as eco-friendly as their power sources. EVs can still have a significant impact on overall warming and can potentially lead to more non-GHG emitting alternatives. Popular ways to enhance city life have been the restructuring of streets for only

bikes and walking and the improvement of renewable energy sources like solar, wind, and hydroelectricity.

As demand for EVs will inevitably rise, this begins another struggle for finite resources. These finite resources are the metals and materials used to create the popular lithium-ion batteries. Argentina and Congo (Frankel, 2016) are natural sources of the lithium and cobalt required within these batteries. As demand rises for EVs and rechargeable batteries, the race for more efficient batteries and the resources required for them creates present and future problems just as fossil fuels had.

References

- 3 major US Electric Vehicle Initiatives - which is most important?* CleanTechnica. (2022, January 8). Retrieved February 7, 2022, from <https://cleantechnica.com/2022/01/08/3-major-us-electric-vehicle-initiatives-which-is-most-important/>
- Anthony, S. (2021, April 19). CBS news poll - eye on Earth: What drives views on electric cars? CBS News. <https://www.cbsnews.com/news/electric-cars-2021-opinion-poll/>.
- Atiyeh, C. (2020, November 13). Automakers, looking for one clear (lower) standard, back trump on fuel-economy rollback. *Car and Driver*. <https://www.caranddriver.com/news/a29626084/automakers-support-trump-fuel-economy-rollback/>.
- Bade, G. (2019, September 16). The oil industry vs. The Electric Car. POLITICO. <https://www.politico.com/story/2019/09/16/oil-industry-electric-car-1729429>
- Bared, C. (2021, November 7). *Do electric vehicles have an impact on climate change?* University of Miami News and Events. Retrieved February 7, 2022, from <https://news.miami.edu/stories/2020/10/do-electric-vehicles-have-an-impact-on-climate-change.html>
- Beresford, C. (2021, April 30). GM is part of why U.S. isn't beating Norway in evs, despite Super Bowl bragging. *Car and Driver*. <https://www.caranddriver.com/news/a35434371/general-motors-super-bowl-electric-slow-adoption/>.
- Bieker, G. (2021, July). A Global Comparison of the Lifecycle Greenhouse Gas Emissions of Combustion-Engine and Electric Passenger Cars. International Council on Clean Transportation.
- Biello, D. (2016, May 11). Electric Cars Are Not Necessarily Clean. *Scientific American*. <https://www.scientificamerican.com/article/electric-cars-are-not-necessarily-clean/>
- California Air Resources Board. (2021, June 8). State and Federal electric vehicle incentives. Clean Vehicle Rebate Project. <https://cleanvehiclerebate.org/eng/ev/incentives/state-and-federal>
- Dearborn. (2021, May 19). Login. The Ford Electric Vehicle Strategy: What You Need to Know | Ford Media Center. <https://media.ford.com/content/fordmedia/fna/us/en/news/2021/05/19/the-ford-electric-vehicle-strategy--what-you-need-to-know.html>.
- EAA. (n.d.). About Us. Electric Auto Association.

<https://www.electrcauto.org/about-us-landing>

- EPA. (2020, July 27). Sources of Greenhouse Gas Emissions. United States Environmental Protection Agency.
<https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>
- Evers-Hillstrom, K. (2021, October 12). Democrats' Electric Vehicle Push Sparks intense lobbying fight. TheHill.
<https://thehill.com/policy/transportation/infrastructure/575990-democrats-electric-vehicle-push-sparks-intense-lobbying?rl=1>.
- Fairley, P. (2007, Nov). California to Rule on Fate of EVs [News]. IEEE Spectrum, vol. 44, no. 11, pp. 10-12. <https://ieeexplore.ieee.org/document/4378449>. Web of Science.
- Frankel, T. (2016, September 30). *This is where your smartphone battery begins*. The Washington Post. Retrieved February 7, 2022, from
<https://www.washingtonpost.com/graphics/business/batteries/congo-cobalt-mining-for-lithium-ion-battery/>
- Gavin, N. (2021, April 26). Governor Newsom announces California will phase out gasoline-powered cars & drastically reduce demand for fossil fuel in California's fight against climate change. Office of Governor.
<https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/>.
- General Motors. Committing to an all-electric future: General Motors. Committing to an All-Electric Future | General Motors. (n.d.).
<https://www.gm.com/commitments/electrification>.
- GreenCars. (2021, December 29). *How many electric vehicles sold in 2021?* GreenCars. Retrieved February 7, 2022, from
<https://www.greencars.com/post/how-many-electric-vehicles-sold-in-2021>
- Hausfather, Z. (2021, October 8). *Factcheck: How electric vehicles help to tackle climate change*. Carbon Brief. Retrieved February 7, 2022, from
<https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change>
- Illmann, U., & Kluge, J. (2020, July 27). Public charging infrastructure and the market diffusion of Electric Vehicles. *Transportation Research Part D: Transport and Environment*.
<https://www.sciencedirect.com/science/article/pii/S1361920920306003?via%3Dihub>. Web of Science.
- Japan Today. (n.d.). *Cool biz campaign begins across Japan*. Japan Today. Retrieved February 7, 2022, from
<https://japantoday.com/category/national/cool-biz-campaign-begins-across-japan>

- Johnston, M. (2021, September 8). *How ExxonMobil makes money: Downstream business generates most revenue*. Investopedia. Retrieved February 7, 2022, from <https://www.investopedia.com/how-exxonmobil-makes-money-5116766>
- Kane, M. (2021, February 20). U.S. all-electric car market share hit all-time high in 2020. *InsideEVs*. <https://insideevs.com/news/489525/us-electric-car-market-share-record-2020/>.
- Kane, M. (2021, February 6). *World's top 5 EV automotive groups ranked by sales: Q1-Q4 2020*. InsideEVs. Retrieved February 7, 2022, from <https://insideevs.com/news/486325/world-top-ev-automotive-groups-2020/>
- Musk, E. (2013, November 18). The Mission of Tesla. Electric Cars, Solar Panels & Clean Energy Storage. <https://www.tesla.com/blog/mission-tesla>.
- Newsom, G. (2020, September 23). Governor Newsom Announces California will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change. Office of Governor Gavin Newsom. <https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/>
- Plumer, B. (2014, April 22). *Two degrees: The world set a simple goal for climate change. we're likely to miss it*. Vox. Retrieved February 7, 2022, from <https://www.vox.com/2014/4/22/5551004/two-degrees>
- Ray, S. (2021, December 10). *'delete it': Elon Musk once again opposes Biden's proposed subsidies for electric vehicles built by union workers*. Forbes. Retrieved February 7, 2022, from <https://www.forbes.com/sites/siladityaray/2021/12/07/delete-it-elon-musk-once-again-opposes-bidens-proposed-subsidies-for-electric-vehicles-built-by-union-workers/?sh=723341bc778b>
- Salvanto, A. (2021, April 19). CBS News poll - eye on earth: What drives views on electric cars? CBS News. <https://www.cbsnews.com/news/electric-cars-2021-opinion-poll/>.
- Schwartz, B., & Pramuk, J. (2021, September 30). Exxon Mobil has been lobbying against parts of Democrats' big social and climate spending bill. CNBC. <https://www.cnbc.com/2021/09/29/exxon-mobil-has-been-lobbying-against-parts-of-biden-reconciliation-bill.html>.
- The United States Government. (2021, December 2). *President Biden's Bipartisan Infrastructure Law*. The White House. Retrieved February 7, 2022, from <https://www.whitehouse.gov/bipartisan-infrastructure-law/#electricvehicle>
- Volkswagen Newsroom. (n.d.). Volkswagen Group raises investments in future technologies to EUR 73 billion. Volkswagen Newsroom.

<https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-group-raises-investments-in-future-technologies-to-eur-73-billion-6607>.

Wesseling, J. H., Farla, J. C. M., Sperling, D., & Hekkert, M. P. (2014, July 23). Car manufacturers' changing political strategies on the Zev Mandate. *Transportation Research Part D: Transport and Environment*.
<https://www.sciencedirect.com/science/article/pii/S1361920914000716>. Google Journals.