Battery Powered Electric Vehicles: How Various Stakeholders are Affecting the United States Automotive Industry

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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

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The Competition for the Future of

Battery-Electric Vehicles in the United States

Climate change is causing extremes of weather, compromising human health, and damaging ecosystems; it will also cause destructive sea level rise (EPA, 2022). Globally, 31 gigatons of greenhouse gas (GHG) emissions are produced each year; the United States alone accounts for 6.34 billion tons (CDP; EPA 2023b). According to the United States Environmental Protection Agency (EPA), 29 percent of US GHG emissions come from the transportation sector (EPA, 2023a). Energy companies, automakers, trade associations, advocacies and NGOs agree that battery-electric vehicles (BEVs) can be beneficial, but they disagree about their optimal place in a feasible low-carbon future. The extent to which BEVs can displace internal combustion engine (ICE) vehicles depends upon the reserves of battery minerals that are recoverable and consistent with human rights and environmental sustainability. While proponents of BEVs in the US characterize them as essential to a successful energy transition, many skeptics warn that they risk diverting attention from a greater underlying necessity: a future of much less driving. Without less driving, they argue, the environmental and human costs of a future of BEVs would introduce new kinds of unsustainability.

Review of Research

Researchers have measured the economic and environmental implications of a transition to BEVs. Erickson (2019), Pistoia (2018) and Ambrose & O'Dea (2021) review and forecast the economic and environmental costs of batteries, fuels and GHG emissions associated with both gasoline and battery-powered vehicles. Researchers at the American Economic Review show that the costs associated with BEVs are entirely dependent on the state (Holland et al., 2016).

Those most affected by this debate are the automakers, energy companies, and miners. Authors like Ambrose & O'Dea (2021) believe that EV's benefits outweigh their unsustainable production methods. Laezman (2023) reveals that the cobalt mining industry produces various dangerous pollutants; and Ahmad (2020) confirms this finding by revealing the direct environmental effects of cobalt mining. Though the efficiencies of batteries are expected to increase, Jevons (1865) found that efficiency gains in resource applications can accelerate total resource consumption.

Researchers Erickson and Brase (2019) prove that the cost of owning BEVs in the future will decrease significantly, making these vehicles more accessible. The decreasing cost, however, does not indicate whether or not these vehicles serve as a feasible solution to the climate crisis. Some Researchers (Gupta et al., 2023; Woodhouse & Mohsin 2023) believe that the real solution lies in increasing the use of public transit. Gupta and his fellow researchers (2023) share that the costs associated with each American purchasing an EV is too high for the average citizen to take on upfront. Woodhouse & Mohsin (2023) believe that the US has focused too much on technological advancements to solve the climate crisis when we should be working on cultural adaptations as well.

Consumer interest and fears associated with purchasing a BEV also limit the potential environmental effects. Thompson (2018) mentions the fears associated with BEVs, which could mean a slower adoption rate. The individualistic culture of driving in the US also inhibits the current usage and expansion of public transit. As the population continues to grow, the transportation infrastructure must adapt to reflect our current environmental goals.

Lithium and Cobalt Mining is Not a Sustainable Method to Producing Batteries

The primary resources involved in producing BEVs, including lithium and cobalt, require intense mining in foreign countries. A coalition in support of EV's is the Zero Emissions Transportation Association, ZETA, advocates for job creation, cleaner environment, and cost savings by transitioning to EV's. The Executive Director of ZETA, Albert Gore, claims that "ratifying the U.S.-Chile Tax Treaty… is an important step in making the supply chain for clean technologies more resilient and more secure" (ZETA). Gore supports the expansion of business in the "Lithium Triangle," of Chile, Argentina, and Bolivia in order to further the mission towards EV's. ZETA advocates for 100 percent EV sales; their second commitment is "enacting policies that drive EV adoption, create hundreds of thousands of jobs, secure American global EV manufacturing leadership, drastically improve public health, and significantly reduce carbon pollution." (ZETA). Similarly, car companies like BMW, Ford, GM, Honda, Nissan, Subaru, and Vollkswagen have all committed to EV's making up at least 40 percent of their sales by 2030 (Rubio-Licht and Roach 2022). Both ZETA and the car manufacturers' stances are clear: advocate for EV production in order to avert the climate crisis.

The impacts of cobalt mining are detrimental to both the surrounding environments and the people who participate in it. The use of the batteries for EV's is not a true sustainable option. About 70 percent of cobalt – a necessary mineral for batteries – is located in the Democratic Republic of the Congo (DRC) (Tabuchi, 2021). Mining cobalt poses threats to both the natural and human environment (Tabuchi, 2021). Cobalt mining uses machinery that contributes to GHG emissions, releases excess nitrogen dust, and produces carcinogenic pollutants (Laezman, 2023). The artisanal and small-scale mining that cobalt mining requires violates human rights (Laezman, 2023). Similarly to cobalt, lithium mining requires excessive amounts of water that

cause water shortages, contaminate water, and hinder farmers ability to “grow crops and maintain live-stock” (Ahmad, 2020). PACT, a nonprofit supporting African mining companies, has expressed concerns about the environment and miners in the Congo (Tabuchi, 2021). DRC miners themselves such as: Alain Kasongo, Patrick Kazadi Mumba, and Rock Makina Mununga have also voiced concerns about the safety of mining. Kasongo, a 43-year-old miner, who suffered back pain from operating heavy machinery, said “it hurt so badly when I went home, I would lie awake at night” (Houreld, 2023). Mumba, a neurologist from Lubumbashi, saw an unusual rate of young people with spinal problems (Houreld, 2023). Miners work 12 hour shifts for 6 days in a row, many of them not reporting injury until surgery was necessary (Houreld, 2023). These employees, after being injured, are either given tasks they cannot complete or forced to find a new job. The new job then requires health exams which they can no longer pass (Houreld, 2023). Mununga, a former truck driver for Tenke Fungurume, said “I was in good health before my job,” but “now I can’t walk well, I can’t work, I can’t provide for my family” (Houreld, 2023). In 2016, Amnesty International released a report revealing the governments of these mining countries have failed to recognize and enforce their own labor standards (Amnesty International, 2021). The report reveals that child labor exists and “the government has yet to remove financial and other barriers that children face in accessing primary education” (Amnesty International, 2021). Amnesty urges the companies who recognize these human rights violations to not discontinue the relationship, but to “take action to remediate the harm suffered by the people affected’ (Amnesty International 2021). The victims of the unsafe conditions urge the proponents of BEV production to support them in making the production more sustainable.

Increasing Efficiencies of Batteries Does Not Equate to Less Cobalt and Lithium Needed

The concerns about the use of rare minerals has been deterred by various researchers. Some believe that increasing battery efficiency equates to less cobalt needed, thus less problems associated with the production of batteries. The Union of Concerned Scientists claim that by 2035, the battery industry hopes to reduce their cobalt use in kilograms per 100kWh from 28 percent, from 2018, to 10 percent (Ambrose and O'Dea, 2021). Recycling batteries, which "reduces the need for extracting, refining, and transporting new minerals," is another rationalization of the continued cobalt mining (Ambrose and O'Dea, 2021). These recycled batteries can be used in lower-power applications. Given that these minerals are finite resources, the longevity of relying on them must be considered. Based on various simulations summarized by Sverdrup (2016), we are expected to reach maximum extraction of lithium by the year 2060. The goal of replacing all ICE vehicles by 2050 will not be possible with the decline of supply available. This declining supply may be remediated by recycling, however, the dwindling supply of lithium also signals a price increase for consumers. (Sverdrup, 2016) These arguments assume that with increasing efficiency, less cobalt is used. Jevons paradox reveals that the technological progress of increased battery efficiency will result in falling costs and increasing demand for batteries and the necessary raw materials (Jevons, 1865). Producing more batteries mens that the need for cobalt and lithium mining will ultimately increase.

Cost of Ownership Limits the Pool of Potential Consumers

The cost and life-cycle of lithium batteries pose a challenge in making these EV's cost effective (Cheng et al., 2011). According to researchers Erickson and Brase (2019), there are two methods to reduce GHGs which should be used together: shifting to EV's or changing electricity

generation methods. Though there are cost concerns associated with making the transition from ICE vehicles to EVs, they state a number of reasons as to why these are avoidable: 1) The costs of batteries are projected to decline from $200/kWh to $70/kWh by 2025. 2) Maintenance costs for BEV's are lower than those of ICE vehicles because BEV's have fewer pieces involved in the drive-train. 3) BEV's save energy by converting potential and kinetic energy into electricity by regenerative braking. 4) Though total cost of ownership (TCO) varies across geographical locations, the discontinuity between TCO's is the cost of petroleum (Erickson and Brase, 2019). With a global goal of decreased petroleum production in the future due to climate concerns, the cost may increase; this will make the TCO of a BEV less than an ICE vehicle anywhere. Other researchers have stated that "if the electricity is generated from fossil fuels, the electric car remains competitive only if the electricity is generated onboard" (Pistoia et al., 2010). Both papers avert the warnings of cost and specify when the BEV's become advantages from a GHG perspective.

The transition to allow BEVs to positively impact the environment requires a massive overhaul of the current public personal vehicle fleet. Participants that claim to support the energy transition include various nongovernmental organizations. The Electric Vehicle Association (EVA), a non profit organization supporting the transition to EV's promotes the cost savings of EVs (Gerke, 2023). Conversely, there are various researchers and professional organizations that counteract the work of the EVA by claiming the long term benefits don't outweigh the initial spend. The Institute of Electrical and Electronics Engineers (IEEE) shared via Spectrum, a publication of theirs, that the amount of vehicles needing to be replaced by EV's is too high to be feasible (Charette, 2023). Lastly, MIT and Argonne National Lab researchers concluded that the

battery technology is too expensive to sustain replacing gas, and the public won't make sacrifices continuing towards net zero (Temple, 2020).

The Transportation Fairness Alliance is an alliance supporting a "competitive and equitable transportation sector" funded by FTI Consulting and the American Petroleum Institute (TFA, 2021). They're concerned that BEVs will cost the owner more, claiming that the "electric vehicle drivers contribute to road construction and maintenance costs, and… pay more than drivers of gas-power vehicles" (TFA 2021). The alliance hopes to dissuade vehicle owners from purchasing the BEVs due to the high TCO. One of the members of the American Petroleum Institute, ExxonMobil, spearheaded a campaign against the electrification of automobiles. The Mobil 1 team, a motor oil sold by ExxonMobil, ad shows individuals attempting to move about their daily life while carrying cables with them. Mobil 1 stated that the commercial "makes visible the invisible threads that keep us all overconnected." The commercial aims to convince its viewers that EVs negatively impact their daily life. The commercial alludes to the American Dream of freedom, with the slogan: "Disconnecting. Feels a lot like breaking free. For the love of driving." (Mihalascu 2023).

President Biden has a goal to make 50 percent of new cars sold be BEVs by 2030 (Gupta et al., 2023). This requires BEV production to increase by 15 times its current rate (Gupta et al., 2023). This goal is in response to the idea that BEVs will solve the climate crisis, however the consumer attitude is not in favor of this transition. In 2019, "74 percent of drivers said their most recent vehicle purchase was a used car", and in fact one third of all drivers in the US had never bought a brand new car in their lifetime (Davies, 2019). The 50 percent of all new cars sold attributed to BEVs will not significantly impact the environment. The turbulent economic state of the world since the 2020 pandemic makes the costs associated with transitioning to a BEV less

attractive to new buyers. The average BEV owner earns more than $100,000 a year, however only 8.7 percent of Americans had a six figure income in 2021 (Gupta et al., 2023; Illia, 2023). The amount of sales needed for BEVs to make a measurable difference poses an economic problem for the average American. Infact, about half of the consumers that had bought BEVs in 2021, purchased an ICE vehicle after (Thompson, 2023). The S&P attributes the 30 percent decrease in consumer consideration for BEVs to the cost, lack of infrastructure, and lack of range (Thompson, 2023). In order to increase the infrastructure and range of BEVs, there must be consumer interest in purchasing the vehicles, which is cyclically dependent on the infrastructure already existing prior to purchase (Hagem et al., 2023). BEVs lack the pricing structure and availability to the average consumer to have a significant environmental impact. The government must continue funding the initial investment for BEVs to become attractive to consumers (Hagem et al., 2023). The fraction of US citizens that are financially able to make the transition is very little, thus there must be another method to reduce GHGs in the transportation sector.

In the US today, subsidizing the BEVs has been utilized to reduce the cost to consumers, however, it is not enough. Some vehicles qualify for a $3700-$7,500 federal tax credit (USDE). This does not offset the average initial cost increase of $18,000 for a BEV (Gupta et al., 2023). With a difference ranging from $10,500-$14,3000 average cost increase to purchase a BEV, some states offer incentives to combat this (USDE). The difference in cost associated with physically driving the vehicles varies substantially from state to state (Holland et al., 2016). Because of the variability in cost of the vehicles themselves and raw materials such as petrol, local pollution must be considered in addition to the generalized global environmental benefits. For example, BEVs in metropolitan areas have benefits of about $0.01 per mile. However, when

driven in rural areas, they cost about 1.7 cents per mile more than a typical ICE vehicle (Holland et al., 2016). BEVs are an expensive solution that only a fraction of the population can afford.

Public Transportation Beats EVs in reducing GHG Emissions

In rural areas, public transportation may seem like a less viable option. However, transit agencies can work together to interlink bus systems and rail systems (Gupta et al., 2023). Using buses to interlink existing rail systems would require less funding than implementing new infrastructure (Gupta et al., 2023). Cities like Tokyo have figured out how to make public transit thrive: high parking costs and a vast rail network lead to low levels of car ownership (Altieri, Silva & Terabe, 2020). An impedance to making public transit environmentally advantageous is that park-and-ride services do not encourage sustainable ridership (Truong & Marshall, 2014). The parking lots that allow more people to access public transportation negate some of the positive environmental benefits: it unintentionally forces drivers to make long trips to reach the facilities (Truong & Marshall, 2014). About 46 percent of these passengers drove less than two miles to reach the facility, thus leaving a large opportunity for the trip to become more sustainable by walking or biking (Truong & Marshall, 2014). Another alternative method of transportation to consider are car-share applications such as zip-car, where you only use the car on a need basis. According to Jung, J., & Koo, Y. (2018), the GHG emissions resulting from shifting to car-sharing systems "outweigh the GHG reduction due to unpurchased vehicles".

The US has valued individual comfort over environmental concern in the transportation sector by the ubiquitous usage of personal vehicles. Around 76 percent of commuters in the US use their personal vehicle to get to work (Richter, 2022). The other modes of transportation such as public transit or biking, lack the supporting infrastructure to be a reliable method of

transportation. States have used about four fifths of their transportation budgets on expanding highway and road systems since the 1980s (Plumer & Popovich, 2021). Therefore, using public transportation in a city dominated by infrastructure designed for personally owned vehicles, puts the passenger at a disadvantage for work opportunities, attending school, or living options. According to Mohamed Mezghani, secretary general of the International Association of Public Transport, in order to effectively reduce carbon emissions "US cities don't need electric cars, they need less cars" (Woodhouse & Mohsin, 2023). This is substantiated by the study from the National Academies of Sciences, Engineering, and Medicine: the energy saved by passengers choosing public transit over personal transportation was 63M tons of CO_2 in 2018 (Woodhouse & Mohsin, 2023). In a study analyzing the environmental effects of park-and-ride services such as trains, 88 percent of drivers claimed that they would have made the drive alone if public transportation was not available (Truong & Marshall, 2014). Had those passengers driven their personal vehicles, there would be an excess of GHG emissions. Another aspect to consider is the usage of other energy sources to power the public transportation system. In Canada, a transit bus that uses compressed natural gas (CNG) exerts a "60 percent less global warming effect than diesel" (Pourahmadiyan, Ahmadi, & Kjeang, 2021).

While BEV's may generally represent a change that benefits the environment, the solution to the climate crisis relies on the usage of other transportation methods: biking, walking, and public transportation. The American Public Transportation Association (APTA) states that public transportations yields quantifiable economic benefits. The industry employs more than 430,000 people, and every $1 billion invested creates about 50,000 new jobs (APTA, 2023). Currently "45 percent of Americans have no access to public transportation" (APTA, 2023). There is a huge opportunity for the building of public transportation infrastructure to have

economic benefits on America. Gupta and his fellow researchers (2023) believe that transit systems can take advantage of the existing road infrastructure, and may use renewable energy to operate to offset the GHG it inevitably produces (Gupta et al., 2023). Additionally, the researchers demonstrate the success of a better transit system by introducing the Transjakarta system. It has reduced the amount of CO_2 equivalent to removing 20-40k personal vehicles off the road (Gupta et al., 2023). The APTA (2023) also claims that using public transportation is "10 times safer per mile than traveling by automobile." From a greenhouse gas perspective, there is 55 percent less GHG emissions associated with public transportation than driving a personal vehicle (McGraw et al., 2021). To show the immense opportunity for growth in this sector, in 2018 "public transportation avoided 148 billion miles of personal vehicle travel" (McGraw et al., 2021). This only accounted for 5 percent of total vehicle miles in the US. Public transportation may serve as a economically and environmentally viable alternative to BEV's in creating a solution to the climate crisis. The amount of lives that can be impacted by increased public transportation is greater than the single life affected by a personal BEV.

Conclusion

The solution to the climate crisis requires a multifaceted approach that must represent the intersection of technological advancements and cultural shifts. Many people are eager for the opportunity to explore BEVs because of its apparent decrease in GHG emissions compared to ICE vehicles. This decision ignores the other environmental and societal impacts of BEV production that are detrimental to our society. The adaptation of the BEV in the US represents an ignorance of how our internal decisions negatively affect the countries we rely on, such as those in the Lithium Triangle. The countries most affected by our adaptation of the BEV will face

GHG emission and human rights concerns. This is a result of the US viewing the climate crisis as an internal problem instead of a global one. It is a common understanding that BEVs represent a zero emission future; however, it is important that the public is aware of the costs, both environmentally and economically, that BEVs pose to consumers and producers. There should be more research into how cities can adapt to become more people-centric instead of car-centric. How can the 15 minute city be a reality? What are the environmental impacts of such a concept? The cultural shift from individualism to collectivism involved in a 15 minute city means more investment into public transportation or building cities that are better adapted for people not personal vehicles.

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