DAARE/Board Buddies

Filtering Factors on the Transition to Electric Vehicles Through the Perspective of Diffusion of Innovation

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By
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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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Introduction

Anthropogenic global warming has been established as a problem with a multitude of disastrous effects (IPCC, 2018). To limit warming to 1.5^{o}C, emissions must be reduced significantly in all sectors (IPCC, 2018). The transportation sector is a major emitter; our routines of driving are responsible for 29% of the United States' greenhouse gas emissions in 2019 (EPA, n.d.). Over half of US' transportation emissions, equating to 15% of the US' GHG emissions, came from passenger vehicles, trucks, SUVs, and minivans (EPA, n.d.). Electric vehicles, EVs, have been shown through lifecycle assessments to be cleaner than gasoline powered vehicles. EVs must replace gas cars by 2035-2050 to keep temperatures in the 1.5^{o}C scenario (IPCC, 2018).

The technical topic is about a battery protection system, BPS, which prevent battery packs from getting damaged or catching on fire, as well as extending their life and maximizing their energy use. I aim to design a BPS meant for second hand li-ion batteries, and this would support the transition to EVs by supporting the reuse of cells. It may be possible to reduce the cost of EVs by using second-life cells, and this would make these cars available to more people.

The STS Topic about adoption of EVs is important for understanding the socio-technical relationship between humans and EVs. I hope to show the barriers that must be overcome for the electrification of passenger vehicles.

The design of a BPS is related to the adoption of EVs because it affects the owner's experience. Cost is one effect. If a BPS can work with second hand cells, this could lower the cost of EVs while making them more sustainable.

Technical Topic

To clean up the grid and electrify transportation, an enormous number of li-ion batteries are required. The task is a matter of scale, and the mass of raw materials and ore required for such a task is on the same scale. To minimize the damage that mining will have on the environment and nearby residents, reuse and recycling are areas that need innovation (CNBC, 2021). One way to remove burden on the battery supply is to reuse batteries from retired EVs and electronics. This will become especially important in the next decade as the number of EVs reaching end of life will increase 80-fold (Kumagal, 2021).

The problem with reusing batteries is safety. Second use batteries may come in batches with varying degrees of usage, and it may be difficult to collect information on the how much the battery was used in the past. Mismatched groups of cells are not ideal for creating a battery pack because some cells may over heat more than others. This is a fire hazard, so battery protection systems must be suited to deal with mismatched cells. Also, mismatching will limit the maximum power output, rendering the pack less efficient.

The scope of this technical research is to develop a battery protection system for secondhand li-ion battery packs. Research will cover how a battery degrades over its use,

proper battery pack design precautions, and the applications where secondhand batteries would be useful. Resources will include academic publications, automobile company reports, and the University of Virginia Solar Car Team. This will build off of the BPS design created by UVA alumni Dipesh Manandhar, Nripesh Manandhar, and William Zhang.

Second use batteries may be more useful in stationary storage, instead of in electric vehicles (Reinhardt et al., 2019). Stationary battery packs for storage need to be cheaper, and second life batteries can make that happen; Reinhardt et al. (2019) says it is a sustainable business model. Stationary storage is less demanding than EV usage. EV batteries end their first life at 70-80% of their original capacity, but this is enough for stationary storage (Reinhardt et al., 2019). The BMS designed in this project will have to work with cells that are at 70-80% capacity. Designing an entire BPS would not fit in this timeframe, so only a part of it will be designed, or the entire BPS will be designed conceptually. For example, there are over 13 strategies when it comes to measuring state of charge (Qays et al., 2020). I could work on tailoring one of the strategies to work better with second hand cells, or I could simply state which process is best suited. Regardless, the goal is to provide improvements that BPSs can incorporate as the EVs become a regular part of life.

STS Topic

Driver emissions make up 15% of the US' emissions, so we must switch to EVs. This must occur as fast as possible; however, there are technical and social barriers to

overcome. Technical barriers are considering mileage, availability of charging stations, and the price tag. This research will not focus on the technical reasons and instead explore cultural reasons that slow down the mass adoption of EVs.

EVs are being adopted at different rates based on country. Statistics from 2016 to 2020 show that the market share of EVs in Europe and China have increased exponentially, 60% and 36%, respectively (DeSilver, 2021). Meanwhile, the US has stayed relatively linear with an increase of 17% (DeSilver, 2021). In 2020, 10% of Europe, 5.7% of China, and 2% the US's vehicles were electric (DeSilver, 2021). Sales in the US have decreased recently, and DeSilver (2021) justifies it with the poor popularity of plug-in hybrids and lack of federal tax credits. This just shows how the US is behind on EV adoption. Although the US is doing poorly, California has been an EV success story by having abundant charging stations, incentives like rebates, and regulations on car manufacturers (DeSilver, 2021).

The public image of EVs is important in understanding what divides people. A majority of people claim they are not familiar with EVs, according to Pew Research Center who surveyed 13,749 adults ages 18 to 24 (Spencer & Funk, 2021). EV marketing departments may need to focus on clarifying the technology to more people. On another tangent, people that knew EVs were divided in their opinions. 30% of people claimed to be familiar with EVs, and of that group, 53% were in favor of them, while 39% were not. This could be interpreted as though people claim to know EVs, and there is misinformation being spread. It would also mean that the reality of EVs is divisive. Further research must be done in the demographics of these consumers. The Pew Research Center's survey did not collect data on the persons age, which may be a major factor.

Understanding the socio-technical relationship of EVs and humans is valuable for the adoption of EVs, car companies, and consumers. Companies can engineer cars that fit the needs of all people, and consumers are given more appealing options. The theoretical framework will be based on the sociology of innovation diffusion and actor network theory. Resources will include surveys, marketing material from EV companies, news articles, academic papers, statistics on EV sales and demographics, government policies, and cultural norms.

Some literature reviews have been conducted that found extensive lists of factors affecting EV adoption, and they used actor network theory as well. ANT is used to organize a list of factors affect EV adoption. One of the factors was personal innovativeness or, "Being willing to try new things (He et al., 2018)." Perceived risk was another factor, including, "Uncertainty over maintenance and repair infrastructure (Kumar & Alok, 2020)." Multiple studies found policy has a significant effect (Hardman, 2019; Ling, 2022). These lists will be useful when analyzing marketing material and news articles, because I can say which factor this source is appealing to. Kumar and Alok (2020) listed topics that need more study, and what has been extensively studied, so I will focus on the less studied areas.

Conclusion

The technical portion will modify an existing BPS to be more suited for use with secondhand batteries. As more EVs retire starting this decade, it's sustainable to plan a reuse for their batteries. The STS portion will explain the barriers slowing the adoption of

EVs and suggest strategies that relevant actors can take to increase acceptance. This may include actions for car companies to market or engineer their cars differently, for governments to pass legislation, or news media to correct misinformation. People that don't support EVs are sometimes written off using justifications regarding technical reasons such as range; by exploring the underlying systems in how people view EVs, people may be able to address the real issues, and make more progress on increasing EV adoption.

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