Driving Resistance: Investigating Social and Cultural Factors Slowing Electric Vehicle Adoption in the United States

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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

In 2008, the National Academy of Engineering identified 14 engineering challenges aimed at improving life in the 21st century and beyond. These challenges span across four categories: sustainability, health, security, and joy of living. Within the sustainability category one of the most critical challenges is making solar energy economical. Solar energy, a clean and renewable power source, stands out for its safety and minimal negative environmental impact, offering a promising solution to the world's energy needs. Over the past 16 years, technological advancements have allowed solar energy prices to significantly decrease, with another projected drop of nearly 54% between 2024 and 2031(Tabassum et al., 2021, p. 1). Despite being more competitively priced, solar energy still only accounts for 3% of the US energy portfolio. Still, optimism remains high in advancing toward a more sustainable future, signaled by large government funding such as the US Department of Transportation's $150 million fund toward sustainability projects in 2024 ("DOT Grants $150m for EV and RNG Projects at US Ports," 2024). The combination of improved economic feasibility and low market share of solar energy has created space and opportunities for innovation. My capstone team, which is designing a front-end suspension system for UVA's Solar Car team, is helping to advance one of the industries that can benefit most from solar: transportation.

With all this optimism surrounding alternative energy and sustainability, one might wonder: where are all the electric vehicles in the United States? In 2023, battery electric vehicles (BEVs) accounted for just 7% percent of light vehicle sales in the US with total EV sales (BEV, hybrid, and hybrid plug-in light vehicles) reaching only 16.3% of total vehicle sales

(*Electric Vehicles and Hybrids Surpass 16% of Total 2023 U.S. Light-Duty Vehicle Sales - U.S. Energy Information Administration (EIA)*, n.d.). Despite the first mass-produced American electric vehicle being introduced to the market over a quarter-century ago (GM's EV1), EVs made up less than two of every ten cars sold in the US in 2023. In contrast, countries like Norway saw EVs make up over 90% of the market share in 2023 (*Norwegian EV Market Surges to 91.5% Market Share, Setting a Sustainable Example | European Alternative Fuels Observatory*, n.d.). The limited growth of EVs in the US market raises the question about barriers like inadequate charging infrastructure or lingering customer concerns. While inadequate infrastructure is often cited as a barrier, the issue may run deeper. After all, if infrastructure was the primary barrier, the United States- a country that developed an entire space industry to send man to the moon- would surely have the capacity to overcome it if consumer demand were strong enough. Given the state of the technology available today, the limited growth in EV sales suggest a lack of consumer demand rather than purely a lack of infrastructure. This points to a need to investigate the underlying consumer mentality and attitudes toward electric vehicles.

Technical Topic

The motivation behind our team's project is to bring a high-performance suspension package to a high-performance race vehicle. UVA's Solar Car team competes in races including the American Solar Challenge, a cross-country endurance race, and the Formula Sun Grand Prix, a circuit style race, both of which being tests of endurance, reliability, and speed. As with conventional race cars such as Formula 1 and stock cars, performance is achieved by optimizing every component for weight. Optimization is especially important for the solar car, given that the motor outputs only 5 kilowatts (kW), compared to a conventional vehicle such as a Toyota

Corolla, which outputs roughly 125 kW of power. To put this in perspective it's about the difference required to power 5 microwaves versus 125 microwaves. With such a low power output, each component's impact on the vehicle's performance is relatively amplified, meaning every additional pound that doesn't directly contribute to efficiency or speed can significantly hinder the car's overall performance.

One of the most critical vehicle systems is the suspension system, which is designed to maintain optimal vehicle stability (Simionescu, 2017, p. 1375) and provide shock absorption the chassis. Typical suspension systems such as the MacPherson system consist of a shock and coil mounted directly to the wheel upright and contained within the wheel well. Although reliable, these systems are more generally suited for daily driver cars as they prioritize ride comfort over high-speed handling and weight savings. To resolve these issues, our team is designing and manufacturing a pushrod suspension system, which allows the strut assembly (shock and coil) to be reduced in size (Totu, 2021, p. 7) ultimately reducing weight, while simultaneously allowing for better handling by moving the weight suspension system towards the center of the car. The pushrod suspension system works by adding a lightweight pushrod and rocker arm into the suspension package. This setup allows the strut assembly to be repositioned away from the wheel, centralizing it with the chassis. The pushrod works by transferring the mechanical load from the wheels to the rocker arm. The rocker arm transforms the oblique displacement of the pushrod into a horizontal displacement that can be absorbed by strut. Furthermore, the arm ratio on the rocker, which is an L shaped bracket with the pushrod attached to one arm and the strut attached to the other arm, can be adjusted to amplify or attenuate the input from the pushrod onto the shock assembly. By designing the rocker to be easily customizable, it becomes convenient to adjust the vehicles ride quality with the simple swap of a single component. This improved

suspension package will bring greater performance to the solar car by reducing overall vehicle weight and improving controllability.

STS Topic

While our team's work directly impacts the performance of a solar car, it also reflects a larger trend within the automotive industry and furthermore the transportation industry as a whole- electrification. The US Environmental Transportation Agency reports that the transportation sector accounts for 15% of global greenhouse emissions (US EPA, 2016), which is on the magnitude of millions of barrels of oil burned and released into the atmosphere every day in the US alone. These greenhouse gas emissions directly worsen climate change impacts. The transportation sector's significant contribution to human-driven climate change has driven engineers to design replacements for conventional combustion engines, which run on carbon-emitting fuels, with more sustainable energy units such as electricity, hydrogen fuel, and biofuels. EVs are one of the most popular forms of sustainable transportation, growing by nearly 9% in global sales between 2021 and 2022 (Dar et al., 2024, p. 1). EVs popularity rise can be attributed to consumer attitudes towards environmental responsibility (Ham et al., 2022, p. 377). Decreasing prices and an expanding electric infrastructure has allowed the EV market to grow (Mohammadi et al., 2023). However, despite these optimistic trends, the US's EV adoption rate is lagging compared to other regions of the world, falling 18.5% behind China and 6.8% behind Europe in new EV sales in the 3rd quarter of 2023 (Rattner, 2023). The relatively low rate of EV adoption in the US can be attributed to a complex interplay of factors, including vast geographic diversity and political influences, each shaping public acceptance and deployment of EVs in unique ways. Understanding these issues through the Social Construction of Technology (SCOT)

framework, which is a framework that explores how technology is defined by social groups, allows us to see how societal factors and stakeholder interests influence and ultimately hinder widespread EV adoption in the US. Moreover, Technological Momentum (TM), a framework that explains the power of technological inflexibility, describes how technologies such as conventional combustion vehicles, once widely adopted and integrated into society, become difficult to change or replace.

One of the unique characteristics of the US is its vast geography which encompasses everything from cold urban centers to arid desert rural landscapes. Given these geographic differences, EV adoption in the US should be examined at the regional level to capture the unique factors and challenges present in each area. For example, regions with significant climate variation, such as extreme heat or cold, which can negatively affect vehicle battery life, are generally slower to adopt EVs (Cervini et al., 2024, p. 9). This relative reluctance to adopt EVs in these regions can be explained by range anxiety (RA), which is the fear that an electric vehicle may run out of battery power before reaching a charging station. However, current EV technology can handle the needs of average drivers in the US (Pearre et al., 2011). Research suggest that RA is a consequence of consumers' hesitant response to using new technology, even when it performs comparably to traditional options (Rainieri et al., 2023, p. 68). From a SCOT perspective, for most Americans, cars are considered an essential tool, as they serve as the primary mode of transportation for work, errands, and maintaining independence across both urban and rural areas. The strong societal attachment to conventional combustion cars has also contributed to the technology gaining significant momentum in our society, making it difficult to pivot away from the combustion cars. This entrenched role of cars in American society helps explain why people can be hesitant to accept any technology that challenges the status quo, even

if it offers much of the same benefits. This resistance is reinforced by the established systems and infrastructure built around conventional vehicles, such as gas stations, which collectively create barriers to adopting alternative technologies (Hirsh & Sovacool, 2006, p. 6).

Beyond utility, cars serve as extensions of personal identity for many Americans. Personal vehicles, specifically EVs, are used to communicate social status, environmentalist attitudes, and even political party preferences (Ashmore et al., 2018, p. 570). Studies show that personal identities are so strongly intertwined with personal vehicles, auto retailers have a higher likelihood of selling EVs if they are framed as an aspect of the consumers environmentalist self-identity rather than a tool to address climate change (White & Sintov, 2017). Furthermore, in the currently divisive political environment EVs are often used as a metric to determine ones political affiliation, with Democrats being seen as more likely to purchase EVs than Republicans (Sintov et al., 2020). The use of personal vehicles as symbols for personal identity, especially when used for political self-identity, can impede widescale EV adoption.

SCOT, which is a theory that explores how society shapes technological development, can be employed to help better explain the factors that are inhibiting EV adoption in the US. Central to the SCOT theory is the concept of interpretive flexibility, which means that "technologies are open to more than one interpretation by different relevant social groups" (*Social Construction of Technology - an Overview | ScienceDirect Topics*, n.d., p. 109). In the US, cars are seen as more than just a way to get to from point A to point B quickly. They are also seen as tools that promote independence, a characteristic trait of many Americans, and a method of expressing self-identity, which is shown to be a leading motivator for personal vehicle selection. The added social interpretations that personal vehicles possess in the US, combined with the hard-to-stop technological momentum of conventional combustion cars, has generally

hindered widespread EV adoption in the US. Fortunately, automakers can tap into the societal values of vehicle owners that align with environmental goals to produce vehicles that are attractive to a wider range of consumers.

Conclusion

Although the recent integration of EVs into the US offers reason for optimism, relatively low EV adoption rates measured against comparable countries suggest there is much more work to be done. The US presents a compelling case study where unique societal factors, such as viewing cars as essential to personal independence, and as symbols of social and political status, can be examined through the lens of SCOT. Our capstone team aims to help bring forward some of the more technical solutions that make electric vehicles more attractive to consumers. Simultaneously, the STS investigation deepens insight into the societal factors that affect EV adoption can be used to help automakers meet the demands of the US consumer market and ultimately help mitigate negative impacts of climate change. By combining technical innovation with widespread EV adoption, Americans can usher in a new era of sustainability.

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