University of Virginia Human Powered Vehicle Team

2021 ASME HPVC E-Fest Design Report

(Technical Paper)

Examination of California's Recent Efforts to Move Toward Clean Vehicles

(STS Paper)

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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

My capstone team is designing and building a human powered vehicle which will be entered in the Human Powered Vehicle Challenge (HPVC) and judged based on a list of criteria. Because of the Coronavirus, the competition will not precede as it has in past years, so we will not race our completed vehicle. Instead, we will still build the vehicle, but the report itself will be what is judged. We will be building this vehicle from scratch which means picking our own design and materials and doing all of the welding and testing ourselves.

The portion of my technical project that I find the most ethically intriguing is the renewable energy aspect. As a team, part of our goal is to understand the societal impacts of human powered vehicles and the environmental necessity of moving toward forms of renewable energy in the transportation sector. Transportation has one of the highest carbon footprints of any sector in the country, and light-duty vehicles (like cars) account for a majority of that. I therefore wanted to pick a case study concerning a government that is making strides toward renewable energy in the transportation sector.

My STS research focuses on the California state government and their role in guiding the implementation of renewable energy in the transportation sector. Specifically, my focus is on their recent legislation and how they have reached this point. The goal is to understand how they got where they are and to be able to make predictions about how successful their policies will be and in what ways they will impact the transportation sector as a whole.

Technical Topic

The team goals for this project are to reduce single occupancy transportation in combustion vehicles by designing a more practical human-powered replacement; learn about the design, qualification, and fabrication process; and understand the societal impact of using human powered vehicles as commuter vehicles in an urban environment. There are no specific partnerships involved in this project. However, it is affiliated with the American Society of Mechanical Engineers (ASME) in the sense that the Human Powered Vehicle Challenge (HPVC) is run by ASME. Further, our funds to build the vehicle will come from the Experimental Learning Fund (ELF) and the University of Virginia (UVA) Parent's Fund.

The construction of this vehicle requires many resources some of which we will have to purchase and some of which we can find on last year's vehicle because their competition was interrupted by the Coronavirus. Without going into too much detail, the vehicle will require steel rods to create the frame, wheels, a seat, material for a fairing, pedals, a steering wheel, a shifting mechanism, and small items such as screws, cables, chains, and springs. The project will also require use of UVA's Lacy Hall to build and weld, and each of the team members will have to be trained in these areas.

The team has decided that our metrics for success involve successful creation of a human powered vehicle that meets or exceeds the standards that the competition has laid out for us and that we have created for ourselves. Our quantitative specifications include a max speed greater than 25 km/h, a weight of less than 170 lbs., a turning radius of less than 8 meters, a braking distance of 25 km/h to 0 km/h in 6 meters, and can fit driver's heights ranging from 66 in to 76 in (ASME, 2020). Our qualitative specifications include being comfortable for long duration rides and performing efficiently without frequent failure.

The design of the vehicle was created by the team using information from previous reports submitted to the competition and articles published on specific vehicle subsystems. For example, one article provided us information on which type of steering and seated position was the most effective for the metrics of success we had set out (Beauchamp, 2016). Another article provided us information on one of the more contested topics of which wheel position to use: tadpole vs delta trike (Stefanovich, 2019). Most of the metrics for success that we are working with were given to us by the HPVC in their rules document which is our primary guidance document (ASME, 2020). We also have had access to previous reports submitted to the HPVC such as the design report from last year's UVA team which has already influenced our vehicle frame and different teams around the world which we can use to compare and see which designs worked the best (Schmidt & Khanan, 2020) (Zhong et al., 2017).

Within the team we have collaborated on coming up with the initial CAD design for our vehicle. We then split up into sub groups, such as steering and biomechanics, so that each group could focus on one part of the design. I am working on the Finite Element Analysis (FEA) subgroup. We completed FEA on the vehicle and worked on making modifications to the design and materials used so that the vehicle can withstand the required safety loads. Further, I have responsibilities in building the vehicle and learning welding basics in case more hands are needed in the assembly. I also have a responsibility to my team to learn about different areas of the vehicle in order to be able to contribute to other subgroups so that two people are not making all of the decisions in one area.

STS Topic

I am going to be looking at California and how their legislation related to climate change has influenced societal shifts toward more environmentally friendly technology. Specifically, I will begin with the 2020 executive order in California which mandates that the sale of light duty vehicles with internal combustion engines be eliminated by 2035. The goal will then be to connect this to an opening of a niche of innovation in clean transportation. To make this connection I will examine previous legislation in California and notice the correlations between the legislation and the societal and technological shifts as it pertains to transportation. I would like to look into how the state of California arrived at this specific executive order. The multi-level perspective theory will be used to help to analyze the interplay between the three levels of niches, socio-technical regimes, and socio-technical landscapes.

In September 2020, the governor of California issued an executive order which states that in 2035 the sale of new light duty vehicles with combustion engines will be banned. Light duty vehicles which were registered before 2035 will still be allowed and can be resold (John, 2020). The goal of the order is not to put financial hardship on the people in California by requiring them to replace their vehicles, but rather to inspire clean technological innovation for companies that wish to sell their vehicles in California. This executive order comes at a time when the air quality in California is a major issue as a result of the wild fires, and the governor makes a mention of not wanting the California air quality to give kids asthma (Hawkins, 2020). This order will contribute to California's goal of having zero economywide carbon emissions by 2045 (John, 2020).

I will also look at previous clean transportation legislation in California because California already has a fleet of 726,000 electric vehicles on the road, which is just under half of all the electric vehicles in the country (John, 2020). Therefore, even before this light duty legislation,

California was clearly doing something right to inspire niche innovation in clean transportation (California Energy Commission, 2020). Further, car companies such as Tesla, Ford, Volvo, BMW, Honda, and Volkswagen have already agreed to California's vehicle emission standards (John, 2020).

The multi-level perspective theory will be the main form of framing that I use to make my case concerning how legislation in California is impacting niche innovation. This theory relies on the interplay between the levels of niche innovation, socio-technical regimes, and the socio-technical landscape (Caletrio, Southerton, & Watson, 2015). The goal is that the different levels will influence each other to create sustained change on the macro scale.

California's environmental legislation fits the framework of this theory well because the main actors influence each other and match up well to the three levels. The niche innovation refers to inventions and technological advancements which can be a result of the socio-technical regimes and the socio-technical landscape. The socio-technical regime is the actors and networks which have a certain set of rules (Bilali, 2019). For this case study, the regime is the legislation being passed which will hopefully influence the niche innovations. The socio-technical landscape is defined more as the big events or the large-scale changes. The socio-technical landscape represents different things for this case study; it represents the increasing awareness of climate change which will then influence the socio-technical regime, and it represents ultimate large-scale changes such as a large-scale shift towards trains or green vehicles (Caletrio, Southerton, & Watson, 2015).

There are many different directions you could take when analyzing climate change using the multi-level framework. I am choosing to analyze the creation of niche innovations as a result of

the socio-technical regime and to some extent the socio-technical landscape. I hope to be able to draw the conclusion that the socio-technical regime is influencing niche innovation in a way that it will be able to be maintained long-term. Is the socio-technical regime influencing the fabric of society, and therefore simply guiding technology in a certain direction, or would all of the work done by the legislative mandates be immediately reversed if the mandates were repealed (Bilali, 2019)? I would also like to explore whether or not it is possible for the niche and regime level to continue improving at a fast-enough rate and remain consistent enough to actually make a difference on the macro-scale.

I believe that the most useful empirical evidence will be historical numbers of how legislation has directly influenced technology in California. The empirical evidence I expect to find should be advertised by the California government. However, it will be important to understand the bias incorporated in these figures because California will want to paint themselves in the best possible light. The essential actors in this case study will be the California legislation, the automobile companies, and the consumers. To bring in controversies to this discussion, it may be interesting to look at the pushback that the California government received from President Trump or the pushback they have received by some vehicle companies.

Next Steps

For the rest of the semester, I would like to identify a few more sources that fill in any gaps of my knowledge concerning the executive order and prior legislation that directly relates to the order I am focusing on. I would also like to gather any more information I can about the interplay of different levels in the multi-level perspective theory.

In the early spring, the goal is to obtain more information related to environmental progression in California and understand how previous legislation has effect that progress. I would also like to determine how California got to this point and if other states are moving along a similar track or if this really is an isolated case in the United States. I hope to have some empirical data early next semester to back up the claims that I want to make.

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