Obstacles to the Widespread Adoption of Electric Cars
(STS Topic)
ASME Human Powered Vehicle

(Technical Topic)

A Thesis Prospectus

In STS 4500

Presented to

The Faculty of the

School of Engineering and Applied Science

University of Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Systems & Information Engineering

By
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December 6, 2019

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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.

Signed: ____ Date: ________

Kevin Meyers

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Michael Gorman, Science, Technology and Society

Approved: ____ Date: __________

Natasha Smith, Mechanical Engineering

Feedback

Dr. Gorman suggested that I incorporate Actor Network Theory in addition to social construction. I thought that this was a very beneficial suggestion, particularly for discussion of infrastructure improvements, which was previously somewhat lacking in STS theory. I have incorporated actor network theory into this section, and plan to further expand on the network, potentially expanding it to include other steps in the adoption process, in my thesis.

STS Research Topic

Beginning with the introduction of the EV1 by General Motors in the late 1990s[1], as well as options from Ford and Toyota the electric car has been seen by many as a necessary solution to the significant environmental impact of the automotive industry. I plan to use the social construction of technology framework to highlight issues with a reliance on electric vehicles as a widespread solution to emissions and fuel consumption. Notably, while widespread electric vehicle adoption would lead to a significant reduction in both emissions and energy usage, approaching the problem solely from a top-down, fleetwide perspective fails to consider the role that the consumer plays in the development of a technology. Additionally, it is critical to consider the impact that widespread electric vehicle adoption would have in infrastructure requirements as we evaluate possible vehicle technologies. I was inspired to research this topic after leasing a Nissan Leaf in high school, personally experiencing many of the pros and cons of electric vehicle use.

From the early days of the automobile, a number of different social groups were instrumental in its development. The early automobile was primarily driven by urban users, with rural farmers viewing it with intense skepticism. Beginning with the availability of cheaper, more robust vehicles, like the Henry Ford's model T, however, the social group of farmers and other rural residents began to see benefits to the automobile. This led to the proliferation of high-ground-clearance cars with simple yet effective suspension technology geared towards rural life. Many farmers used rudimentary power take off methods to power a variety of equipment with their cars, from grain grinders to washing machines.[2]

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[1] Adler

[2] Kline & Pinch

In their social construction of technology framework, Bijker, Hughes, and Pinch argue that to understand the development of a technology we must understand the social groups that shaped it, as "a problem is defined as such only when there is a social group for which it constitutes a 'problem.'"[3] By examining the development of the automobile through this light, we can gain an understanding of what the relevant social groups may be in relation to the electric car.

Remarkably, the social construction of technology framework shares many similarities with Geoffrey Moore's model of the technology adoption life cycle, which is commonly taught in the context of marketing high-tech products. Moore argues that there are five segments of the market in the adoption of a new technology: innovators, early adopters, the early majority, the late majority, and laggards.[4] While there are, in most cases, a number of smaller social groups within each of these segments, they are categorized in this manner due to common overall attitudes towards new "discontinuous innovation". Moore's primary development is that there is a large "chasm" between the early adopter phase and the early majority phase, which represents a significant difference in the meaning of the technology to the two groups. Therefore, he focusses primarily on these two segments, with early adopters willing to go out of their way to be part of technological change, while the early majority primarily makes decisions rooted in practicality.

Applying this to the above discussion of the initial development of the automobile, the rural users can be primarily though of as members of the early majority and late majority, showing interest in the technology only when it clearly provided more utility than other options. For instance, Kline and Pinch note that a woman was able to do more work around the house

[3] Bijker, Hughes, & Pinch 23
[4] Moore

after getting a car, as it made her butter delivery route take significantly less time.[5] This is emblematic of rural use of the automobile, with many being adapted to have large cargo areas for the transportation of farmed goods.

Returning to the social constructivism of technology theory, the suitability of the electric car to serve as a direct replacement for internal combustion engine powered vehicles is dependent on the electric car having the same meaning to or solving the same problem for a given social group. Broadly speaking, I believe that the vehicle market can be divided into 3 primary groups: rural drivers, suburban drivers, and urban drivers. Rural drivers cover larger distances on a regular basis, frequently in sparsely populated areas, requiring a vehicle with comparatively high range or the ability to quickly and easily add more range. Additionally, many farmers require a truck or other large vehicle to navigate rough roads, carry large cargo volumes, and tow things on a regular basis.[6] These use cases, which mimic the initial benefits of rural automobile adoption, present significant challenges to the adoption of electric cars, suggesting that rural users are likely to be part of the late majority or laggard sectors. Urban users, by virtue of being located within close proximity to many of the places they may be going, have vehicle use patterns that match the capabilities of current electric cars. However, many urban residents live in high-density environments such as apartments or condominiums, which may require street parking or the use of a parking garage. Additionally, because they are less likely to own their own housing, they are reliant on landlords and cities to make the necessary infrastructure improvements to make charging a car every night feasible.[7] Suburban drivers present possibly an ideal use case for electric cars, with predictable commutes and garages to charge the car in at

[5] Kline & Pinch
[6] Gatti
[7] Nicholas, Hall, & Lutsey

night.[8] This is the case for many early adopters, many of whom have multiple car households, providing an alternative to finding charging stations on long road trips.

An interesting case of electric vehicle adoption occurred in Georgia in the early 2010s. After the state implemented a $5000 tax credit for the purchase or lease of a zero emission vehicle, it was discovered that by combining the state credit with the federal credit, one could lease a Nissan Leaf for a very low net cost, sometimes even free.[9] [10] As a result, Georgia became one of the national leaders in electric vehicle sales, with the metro-Atlanta area having more electric vehicles per capita than any other city.[11] This is an interesting case of the effect that government regulation can have on the technological adoption cycle, as many of the Georgia buyers could be considered part of the early majority, motivated strictly by a pragmatic approach. Provided that the tax credit could be realized, it was cheaper to own a leaf, even in many cases as an additional car, than to not own one. This is a key demonstration of how governments can use policy to affect market changes, helping a technology to “cross the chasm” to widespread adoption.

In order for electric cars to make inroads past the early adopters and into the early majority, governments and public utilities will need to address a number of significant infrastructure shortfalls. As it stands now, while many public locations feature electric vehicle chargers, most have only a few in each location. While this suits the current market share, with more electric vehicles sold every year, significant expansion will be necessary for charging at a destination to remain a possibility. In order to accommodate the 3 million plug-in vehicles

[8] Penn
[9] Joyner
[10] Drive a Nissan Leaf for FREE in Georgia
[11] Electric Vehicles and Georgia

expected by 2025, 88 out of the 100 largest metropolitan areas will need to more than double the number of chargers.[12] In addition to the expense of installing the chargers, the increased number of electric vehicles is likely to further stress the power grid. According to Southern California Edison, the utility responsible for much of Southern California including the Los Angeles area, more than 25% of the grid system will need improvements to accommodate increased load in the near future.

Actor network theory can be used to further analyze the infrastructure aspect of electric car use. In this application, the primary actors are automotive companies, electric vehicle owners/prospective owners, governments, utility companies, charger operators, and oil companies. As shown below, one key distinction between the current and normative network is the elimination of oil companies as key influencers of policy and car design. Since electric cars were born with the introduction of the EV1, oil companies have actively fought against electric cars through aggressive lobbying efforts.[13] Additionally, the establishment of a relationship between governments and electric vehicle charging operators is reflected in the normative network. This would likely take the form of subsidies for the installation of new chargers, particularly in sparsely populated areas where installation might not otherwise be economically viable.

[12] Nicholas, Hall, & Lutsey

[13] Sony Pictures Classics

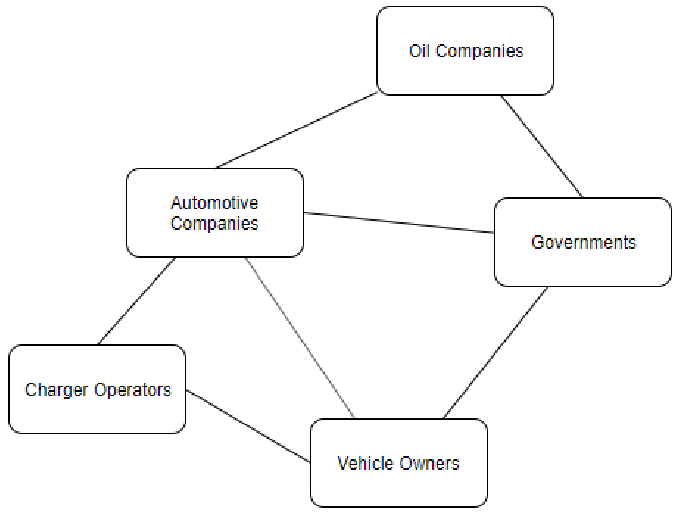

Figure 1 Current Network

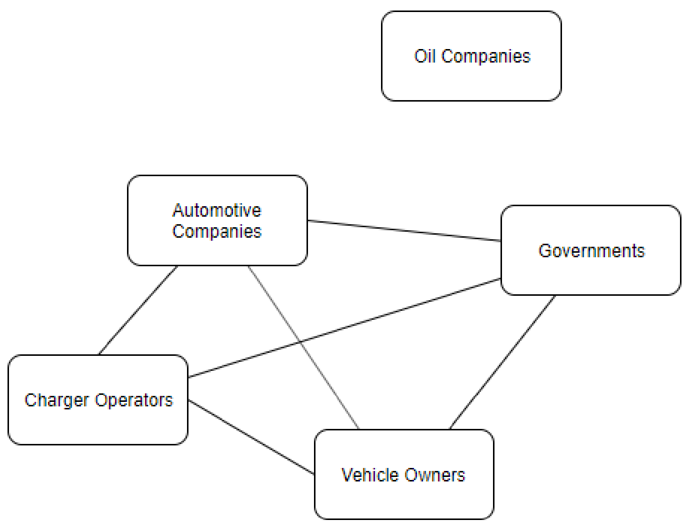

Figure 2 Normative Network

In my thesis, I plan to further apply the social construction of technology framework, as well as successes and failures of similar discontinuous innovations, to electric vehicles. In doing so, I hope to highlight areas where electric cars may face challenges as well as areas of opportunity in their adoption. In addition, I plan to further develop the actor network describing charging infrastructure to further describe the various actors' motivations.

Technical Topic

The goal of our technical project is to design and build a human powered vehicle, primarily to compete in the ASME sponsored Human Powered Vehicle Challenge competition. This is particularly applicable as may people seek to reduce their carbon footprint by finding alternative means of transportation. In an effort to build a comfortable vehicle that requires relatively little training to operate, we will be building a recumbent trike style vehicle with one rear and two front wheels. Because the vehicle must accommodate both male and female riders, we will provide significant adjustability in pedal position as well as potentially adjustable steering handles. In order to allow drivers to easily switch during the endurance event, this will be done via a quick-release type mechanism and will not require the chain to b a different length, which is a common issue in commercial recumbent vehicles. While we considered providing adjustment in the seat mounting rather than the pedals, we determined that pedal adjustment would be a simpler design due to the forces on the seat back during a ride. Additionally, the vehicle must be designed with a robust driver restraint and rollover protection system to meet the competition's safety regulations. This will be evaluated using the finite element analysis capabilities included with Solidworks. In our steering system, we will be incorporating an Ackerman steering geometry to correct for the different turning radii of the inner and outer wheel. We will also be using an inclined kingpin (the axis of rotation of the hub when steering) to reduce scrub by positioning the effective center of rotation close to the center of the tire. We will determine the geometry for these by using Solidworks to create a movable sketch of its behavior in a turn. For the drivetrain, we are evaluating possible groupsets, but our primary options are either a three-by or one-by system which refers to the number of gears on the crank.

This will be primarily determined by our budget, as we would prefer the more expensive one-by system. We plan to implement a partial fairing on the front of the vehicle, which would hopefully reduce its drag coefficient. This would be evaluated primarily through the use of computational fluid dynamics with the CAD model. As an overall goal, we hope to keep the vehicle's weight below 55 pounds, and hope to build a vehicle that is reliable enough to finish each of the events at the competition.

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