Undergraduate Thesis Prospectus

Personal Watercraft Propulsion System

(technical research project in Mechanical Engineering)

Sustainable Mobility: Are Electric Cars the Answer?

(STS research project)

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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General Research Problem

How can the impact of the transportation sector on climate be reduced?

Greenhouse gasses contribute to rising global temperatures, one of the causes of climate change (Ahuja et al, 1990). The EPA reports that the transportation sector was responsible for 29% of all greenhouse gas emissions in the U.S. in 2017, more than any other sector (EPA, 2019). The impacts extend into urban life. The impact of the sector on air quality and disease incidence has been documented, and links between particulate matter and cardiovascular disease have been found (Chan et al, 2011; Ostro, 2004). Sustainable transportation alternatives would reduce the sector's impact on climate.

Personal Watercraft Propulsion System

How can the efficiency of personal watercraft propulsion be improved while reducing their environmental impact?

Personal watercraft emit large quantities of greenhouse gasses, leak fuel and other chemicals into the surrounding environment, and create noise pollution (Davenport et al, 2006). Noise pollution from personal watercraft has caused birds to change their flight behavior and mating habits (Burger et al, 2000). The concentrations of methyl tert-butyl ether (MTBE), a fuel additive linked to cancer, increases by a factor of ten in bodies of water during the summer months due to personal watercraft leakage (Baehr et al, 2003). The gasoline engines used by these personal watercraft causes these hazards. The engines are relatively inefficient, as they operate at only 40% efficiency in ideal cases (Caton et al, 2010). While some argue for a ban of personal watercraft (NPCA, 2019), an alternative propulsion system, such as an electric motor system, could greatly reduce their environmental impacts.

This technical project will be completed by mechanical engineering students under the supervision of Professor Gavin Garner. The project goal is to design and build an electric propulsion system to be mounted on a personal watercraft. Understanding CFD modeling, machine design, and battery and electronics integration in marine applications are secondary goals. The design must incorporate mechatronic applications, so the solution must include a motor system. Existing propulsion systems include trolling motors, or underwater propeller systems that are propelled by either internal combustion or electric motors, and waterjet systems found on jet skis. Trolling motors are light and versatile, but do not provide significant thrust in most cases and are unable to operate in shallow waters. Waterjet systems are more maneuverable and may be more efficient (Carlton, 2007), but are more complex.

The system will be designed with the help of computer aided design and computational programs for performance prediction. The SolidWorks Flow Simulation package will be used to model the system and to quickly test various configurations. Focus will be placed on the pressure and velocity distributions, mass flow rate and exit velocity of water from the system. Prototypes will be built via 3D printing, and the final design may include both 3D-printed and metal components. A test rig will be developed to test prototypes. Experimental parameters of interest are thrust and exit flow profile. A successful product would be a propulsion system that can be mounted on a kayak, that is more maneuverable and powerful than common trolling motors, and that employs an electric powertrain.

Sustainable Mobility: Are Electric Cars the Answer?

How are proponents and critics of electric vehicles competing to advance their version of sustainable mobility?

The impact of the transportation sector on climate has necessitated the development of more sustainable transportation. Of the 29% of U.S. GHG emissions produced in the transportation sector, 82% are emitted by gasoline-powered cars and trucks (EPA, 2019). Vehicle emissions are hazardous to human health (Axon et al, 2013). Electric vehicles, which now account for about 1% of vehicles in the United States (Irles, 2019), may be a more sustainable alternative to gasoline-powered cars.

Many critics of electric cars favor internal combustion engine automobiles. An iron triangle between automotive and fossil fuel interest groups, Congress, and the Department of Energy may protect the status quo as developed by defense contractors, Congress, and the Department of Defense (Adams, 1981). Recent climate strikes may affect federal energy policy (Sengupta, 2019). To win popular support, interest groups may learn from the example of the tobacco companies which attempted to ally themselves with consumers to fight regulation in the 1990s (Givel and Glantz, 2001). Promoters of electric cars can learn from Chidambaram and Kwon (2000), who found that perceived ease of use and apprehensiveness greatly influenced consumers' decision to use cellphones (Chidambaram et al, 2000).

Proponents of electric vehicles include automakers that have invested in EV technology, such as Ford, Mercedes-Benz, Tesla, and Audi. Consistent with the technology acceptance model, they characterize electric vehicles as easy to use. Ford wants consumers to "forget what [they] think [they] know about electric vehicles" (Ford Motor Company, 2019), and Mercedes-Benz has an electric vehicle FAQ section for customers that reassures them that charging stations

are easy to use (Mercedes-Benz USA, LLC, 2019). Fighting the perception that electric vehicles' range is too short Tesla's and Audi's websites offer maps of trips their cars could complete in one charge (Audi, 2019; Tesla, 2019). These automakers market electric vehicles to consumers as easy-to-use and advantageous.

Electrify America, LLC, serves companies in the electric vehicle market. It is investing in infrastructure for electric or ZEVs in the U.S. and plans to "promote greater Zero-Emission Vehicle (ZEV) adoption" through "education and awareness of zero-emission vehicles" (Electrify America, 2019). By developing a streamlined charging process and through public relations, it promotes electric vehicles.

The Union of Concerned Scientists is an advocacy that supports adoption of electric vehicles by publicizing their environmental advantages over gasoline-powered vehicles. It opposes oil industry trade associations (Houston, 2019).

The Edison Electric Institute is an electric utility trade association that supports electric vehicles. The member utilities companies stand to benefit from the infrastructure development required to support electric vehicles. The association lobbies Congress to expand tax credits for electric vehicles that incentivize consumers (EEI, 2019). It argues that electric vehicles will be cheaper for the consumer and that charging infrastructure will stimulate economic growth (EEI, 2019).

The American Fuel and Petroleum Manufacturers oppose the growth of the electric vehicle market. The oil industry trade association lobbies Congress to oppose electric vehicle subsidies, emissions regulations and clean fuel mandates to maintain the status quo in the transportation sector. To gain public support, the organization aligns its positions with consumers' ideas and values, such as an "America first Energy policy" and the "right to know

the ethanol content of the fuel they are putting in their engines" (Sommers and Thompson, 2019). AFPM seeks to build an iron triangle between oil companies, Congress, and the Department of Energy (Adams, 1981).

The American Energy Alliance opposes electric vehicles. Like AFPM, the group is backed by large oil companies and opposes electric vehicle tax credits and clean fuel mandates. The group solicits popular support by vilifying the wealthy and large corporations. AEA argues that the subsidies, which are funded by tax revenue, represent "an extension of special privileges to wealthy individuals and corporations" (Stevens, 2019).

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