

Measuring Airport Similarity to Create a Towering Decision Aid
Technical Report

Electric Vehicles' Engines and their Impact on the Global Warming
STS Research Paper

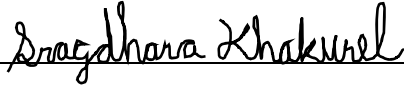
A Thesis Prospectus Submitted to the
Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia
In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering


Sragdhara Khakurel

4th Year, 2nd Semester

Technical Project Team Members: Austin Anderson, Toby Hansford, Mason Jordan, Chris
Marshall, Michael Quinn, Katherine Taylor, and Amy Xie

On my honor as a University Student, I have neither given nor received aid on this
assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signature  Date 4/20/2020
Sragdhara Khakurel

Approved  Date 05/01/2020
Cody Fleming, Department of Engineering Systems and Environment

Peer Reviews and Comments

I have to give a lot of credit to Steven Morrison with the idea and concept of my thesis. We would often discuss in class what topics we found interesting. There were many times that I said that I wanted to work on a topic that somehow included in the environment. At the same time, I had done so many papers and research on global warming that I wasn't really interested in the topic anymore. Steven suggested that I look deeper and find a more specific aspect that I had not done research in. From this conversation, I had done some thinking and thought that my topic would be on nuclear impacts on the environment or electric vehicles. After discussing with Steven, I was able to choose which topic I wanted to work on. Steven was also the one who suggested looking at multiple aspects of electric vehicles. My original plan was to look at many aspects of the car, but this changed when I realized how much material I had just for the electric battery.

I would also like to thank Professor Gorman. I had discussed with Professor Gorman about my STS framework. He was the one who gave me the suggestion to use Actor Network Theory (ANT). This fits perfectly into my paper, but for some reason, I just hadn't thought of it. Professor Gorman has also suggested Life-Cycle Analysis as a potential STS framework, but I felt that ANT fit better. While reading the first draft of this paper, Professor Gorman noted a couple of times where I had made claims without providing any evidence to back it up. In this new version, I made sure to have evidence to back up these claims.

Finally, I would also like to thank Sajal Rohatgi. Sajal and I talked a lot about my topic. I bounced off my ideas with him, especially when I was first structuring and writing the paper. Sajal also proofread the final version of my paper.

Electric Cars Overview

There are many advantages and disadvantages to the very popular Tesla's electric cars. These cars have technologically advanced features that will, according to the company, eventually accumulate in becoming a fully autonomous car. Furthermore, these electric cars are also known for being better for the environment than traditional gasoline-powered cars. Because of this, many environmentalists are very proud of the electric vehicle and encourage many who are worried about the environment to go purchase it. A downside to these vehicles is that they are expensive, especially when adding the technologically advanced features. Tesla is not the only company making self-driving cars and electric vehicles. There are many different companies making electric vehicles and many different types of electric vehicles as well.

There are four main types of electric vehicles. The first are hybrids. Hybrids “combine both traditional gasoline engines with an electric motor”¹⁹. In these cars, the batteries are charged when the car breaks by “converting the kinetic energy to electricity”¹. Toyota Prius is a popular example of Hybrid. The second type of model is plug-in hybrids electric vehicles. These are very similar to the hybrid model, except that the battery can also be charged¹. The third type is fuel cell electric vehicles. Fuel cell electric vehicles are a little different in that they store hydrogen instead of using batteries. “The hydrogen combines with oxygen to create electricity” which powers an electric motor¹. Just like filling up on gas, this car will fill up on hydrogen. This paper will not be looking at either hybrids, plug-in hybrids electric vehicles, or fuel cell electric vehicles. Instead, the paper will focus on battery electric vehicles. Battery electric

¹⁹ Goldman, J. (2014, Feb. 14). Comparing Electric Vehicles: Hybrid vs. BEV vs. PHEV vs. FCEV

vehicles have an electric motor and a battery. These cars need to be charged and can go up to “200 miles on a single charge”¹. One example of battery electric vehicles are Tesla’s cars. This paper will focus on battery electric vehicles since they are more popular in the market than fuel cell electric vehicles and are fully electric unlike hybrids and plug-in hybrids electric vehicles¹.

Global Warming Overview

“No challenge poses a greater threat... than climate change,” President Obama declared in his 2015 state of the union address. The US remains the second-largest emitter of carbon dioxide in the world, following China, which increases temperatures by trapping heat²⁰. The past 18 years have been the hottest on record²¹. Due to the expected addition of 1.2 billion people in the world, energy consumption is expected to increase²². Currently, fossil fuels-oil, gas, and coal- power most of the world. However, the world will run out of oil by 2052, gas by 2060, and coal by 2088²³. As the amount of these nonrenewable energies decreases, the value of them will increase. The barrel of oil, which currently costs \$55, is expected to cost over \$200 in 2040²⁴.

The scientific consensus is that climate change is real and is extremely likely that it is caused by humans emitting greenhouse gases²⁵. Temperature anomalies have increased

¹ Goldman, J. (2014, Feb. 14). Comparing Electric Vehicles: Hybrid vs. BEV vs. PHEV vs. FCEV

²⁰ Park, M. (2015, Jan. 21). Obama: No Greater Threat to Future than Climate Change.

²¹ NASA. (2019). Global Temperature.

²² National Intelligence Council. (2012). Global Trends 2030: Alternative Worlds

²³ Ecotricity. (n.d.). The End of Fossil Fuels.

²⁴ U.S. Energy Information Administration. (2019). Annual Energy Outlook 2019

²⁵ Earth Science Communications Team at NASA’s Jet Propulsion Laboratory. (n.d.). Scientific Consensus: Earth’s Climate is Warming.

dramatically, nearly 1 degree Celsius, since 1880⁷. Multiple countries, academies, and scientific associations agree that global warming is occurring⁷. Without clean energy technologies, fossil fuels will continue to be used, resulting in the environment to become even more damaged. The effects of global warming include but are not limited to ocean levels rising, more droughts, stronger hurricanes, ocean acidification, and a loss of biodiversity²⁶. The environment might not recover if it ever gets to this stage. Humans inherently need a healthy environment to survive; continuing on this path is deadly for all living beings including us.

Climate change is already affecting the United States and the World, so there is no better time to take action. The United States must reduce its greenhouse gas emission levels. Since “cars and trucks account for nearly one-fifth of all US emissions”, one of the easiest ways to reduce carbon dioxide emissions is to have green cars²⁷.

Prospectus Main Focus

The question that my future research paper will explore is, can electric vehicles help solve global warming? Are they part of the solution that will help the United States and the World curb its carbon dioxide emissions? This issue will be explored by using an Actor Network Theory framework.

²⁶ Earth Science Communications Team at NASA’s Jet Propulsion Laboratory. (n.d.). The Consequences of Climate Change.

²⁷ Union of Concerned Scientists (2014, July. 18). Car Emissions and Global Warming.

Actor Network Theory

Actor Network Theory is best defined as a theory that “examines the mechanics of power through the construction and maintenance of networks (both human and non-human)”²⁸. The network is essentially a combined set of relationships between people, animals, objects, and the environment. These networks usually define the current state today.

The network of cars and the environment today includes many different actors. The actors are: the environment, animals living in nature, car companies, oil companies, gas companies, shipping companies, any company that has to ship items, electric companies, renewable energy companies, different governmental bodies (local, federal, and international), laws, political organizations, non-profit organizations, car users, and every day average people. Though this list is very extensive, there might be some organizations that are not on this list that are still part of the network. This current network is not good for the environment, as discussed in the Global Warming overview above. There are many actors who are currently benefitting greatly from the harm being done to the environment, but many people believe that enough is enough. Humans need to cut back on the amount of carbon dioxide that they are outputting so that the Earth can be healthy again. For electric vehicles to be truly successful in helping to cut carbon dioxide emissions there needs to be a complete change in the network. Just changing one or two relationships is not enough. The network needs cooperation from most if not all of the network for these cars to be completely ecofriendly.

¹⁰ Rodger, K., S. A., & Newsome, D. (2009, October 16). WILDLIFE TOURISM, SCIENCE AND ACTOR NETWORK THEORY

One of the main issues with electric cars is that they still have to use electricity. In the United States, most of the electricity created is made by burning fossil fuels. Though electrical vehicles are not directly burning fossil fuels into the air like traditional vehicles are, they are still contributing to global warming by using electricity that harms the environment. One aspect I would like to explore in my research paper is whether electric vehicles when using electricity made by fossil fuels release less carbon dioxide than just regular cars. Regardless, to create ecofriendly cars, we have to have clean energy. Having clean energy is very complicated and involves a multitude of actors. Many people won't be happy with these changes and they will push back on them. The network and actors would have to adjust and change. To create completely green cars, we need to change the current network. I will be analyzing how this network will have to change so that we have electric vehicles that are ecofriendly. I will look at what actors will push back and which actors will be pushing the change.

Conclusion and Next Steps

To actually conduct my research, I need to find out how many kilowatts an electric vehicle can store, how far an electric vehicle can drive on a fully charged battery, and how much carbon dioxide is released per kilowatt of electricity used. From this, I will know how much carbon dioxide an electric vehicle releases for a certain amount of distance driven. I would then compare this to how much fossil fuel a typical car releases for a certain amount of distance driven. This comparison would allow me to see if electric vehicles are actually better than regular cars when they both use fossil fuels as sources of energy. The next part of my analysis

would be seeing exactly how the current network of cars the environment can change so that we have a network with ecofriendly cars. There are many different ways that the network can change. At the end of my research paper, I will understand exactly what needs to be done.

I also hope to look at many different aspects of electric vehicles as well. Looking at just the engine and how that saves the environment is not enough. A full life-cycle analysis of the electric vehicle needs to be conducted. Research can be done on how electric vehicle production affects global warming. Are these cars being made sustainably? Analysis can also be conducted on how these vehicles are being transported. Is the transportation of these vehicles sustainable? Further examination can be done on the effect of renewable energy. How much do these green sources energy reduce the carbon dioxide emissions of the electric vehicle?

There are also many other parts of the environment that my research paper will not be able to explore. My research focuses on just global warming, but there are many ways that electric vehicles construction can harm the environment. Electric vehicles need many raw materials to make their batteries. Mining for these raw materials often hurts the surrounding environment. How are Tesla and other electric vehicle companies getting these resources? Furthermore, these resources are often being mined in foreign countries. How can the United States ensure that these countries are mining their resources properly and safely? Electric battery disposal is another concerning issue. After some time, the electric battery becomes toxic. How can the United States ensure that these batteries are being removed of properly? Is there a way that we can recycle the battery materials? Are there parts of the electric vehicle that can be reused- making the car more sustainable?

Sources

- 25) Goldman, J. (2014, Feb. 14). Comparing Electric Vehicles: Hybrid vs. BEV vs. PHEV vs. FCEV. *Union of Concerned Scientists*. Retrieved from: <https://blog.ucsusa.org/josh-goldman/comparing-electric-vehicles-hybrid-vs-bev-vs-phev-vs-fcev-411>
- 26) Park, M. (2015, Jan. 21). Obama: No Greater Threat to Future than Climate Change. *CNN*. Retrieved from: <https://www.cnn.com/2015/01/21/us/climate-change-us-obama/index.html>
- 27) NASA. (2019). Global Temperature. Retrieved from: <https://climate.nasa.gov/vital-signs/global-temperature/>
- 28) National Intelligence Council. (2012). Global Trends 2030: Alternative Worlds [PDF File]. Retrieved from: https://www.dni.gov/files/documents/GlobalTrends_2030.pdf
- 29) Ecotricity. (n.d.). The End of Fossil Fuels. Retrieved from: <https://www.ecotricity.co.uk/our-green-energy/energy-independence/the-end-of-fossil-fuels>
- 30) U.S. Energy Information Administration. (2019). Annual Energy Outlook 2019 [PDF File]. Retrieved from: <https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf>
- 31) Earth Science Communications Team at NASA's Jet Propulsion Laboratory. (n.d.). Scientific Consensus: Earth's Climate is Warming. Retrieved from: <https://climate.nasa.gov/scientific-consensus/>
- 32) Earth Science Communications Team at NASA's Jet Propulsion Laboratory. (n.d.). The Consequences of Climate Change. Retrieved from: <https://climate.nasa.gov/effects/>

33) Union of Concerned Scientists (2014, July. 18). Car Emissions and Global Warming. *Union of Concerned Scientists*. Retrieved from: <https://www.ucsusa.org/resources/car-emissions-global-warming>

34) Rodger, K., S. A., & Newsome, D. (2009, October 16). WILDLIFE TOURISM, SCIENCE AND ACTOR NETWORK THEORY. Retrieved from <https://www.sciencedirect.com/science/article/abs/pii/S0160738309000802?via%3Dihub>

Sources that I read for background reading but I had not cited them. These are sources for further reading and I may use these in my future research paper.

35) Woodford. C. (2019, May 4). Car Engines. Retrieved from: <https://www.explainthatstuff.com/carengines.html>

36) Clarke. S. (2017, Dec.). How Green are Electric Cars? *The Guardian*. Retrieved from: <https://www.theguardian.com/football/ng-interactive/2017/dec/25/how-green-are-electric-cars>

37) BU-1003: Electric Vehicle EV. (n.d.). Retrieved from: https://batteryuniversity.com/learn/article/electric_vehicle_ev

38) Carbon Fund. (n.d.). Calculation Methods. Retrieved from: <https://carbonfund.org/calculation-methods/>

39) Zdeněk, Č. & Pavel, M. (2011). Electric, Hybrid Electric and Combustion Engine Driven Cars and Their Impact on Environment. *IEEE*. Retrieved from: <https://ieeexplore.ieee.org/abstract/document/6020247>

- 40) Jesus, C. D. (2016, July 15). Tesla Changes One Word in its Mission Statement and it Already Says a Lot. *Futurism*. Retrieved from: <https://futurism.com/tesla-changes-one-word-in-its-mission-statement-and-it-already-says-a-lot>
- 41) Stewart, J. (2018, Mar. 15). Even More Evidence That Electric Cars could Save the Planet. *Wired*. Retrieved from: <https://www.wired.com/story/even-more-evidence-that-electric-cars-could-save-the-planet/>
- 42) Daniels, L. & Klock-McCook E. J. (2018. July 18). Another Study Argues Electric Cars are Bad for the Environment, It's Demonstrably False. *Green Tech Media*. Retrieved from: <https://www.greentechmedia.com/articles/read/electric-cars-are-not-bad-for-the-environment#gs.a2bfaq>
- 43) Energuide. (n.d.). Are Electric Vehicles really Environmentally Friendly? Retrieved from: <https://www.energuide.be/en/questions-answers/are-electric-vehicles-really-environmentally-friendly/197/>
- 44) Biello D. (2016, May 11). Electric Vehicles are not Necessarily Clean. *Scientific American*. Retrieved from: <https://www.scientificamerican.com/article/electric-cars-are-not-necessarily-clean/>
- 45) Fischer, H., & Keating, D. (2017, Apr 8). How Eco-Friendly are Electric Cars? *DW*. Retrieved from: <https://www.dw.com/en/how-eco-friendly-are-electric-cars/a-19441437>
- 46) Perujo A. (2010, Aug.). The introduction of electric vehicles in the private fleet: Potential impact on the electric supply system and on the environment. A case study for the Province of Milan, Italy. *Science Direct*. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0301421510002831>