Getting to a Fossil Fuel-Free Future
(Technical Paper)

Sustainability as a Paradigm Shift: Exploring How Cultural Differences Between the US and Denmark Influence Environmental Attitudes and Behaviors
(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

Introduction

If humans do not significantly alter their current habits, the Earth will continue to warm due to heat-trapping carbon dioxide emissions, causing irreversible climate change. This crisis has spurred technological innovation in the renewable energy sphere, including continued development in solar, wind, and battery storage, just to name a few. Many countries, states, and corporations are committing to clean energy goals. The state of Virginia recently passed legislation that will require the electrical grid to slowly transition to 100% carbon-free by 2050 (Exec. Order No. 43, 2019). The University of Virginia committed to similar goals of achieving 100% fossil fuel-free by 2050 (Kelly, 2020). Recent publication of a master plan to fully develop the University's Fontaine Research Park presents this location as an excellent case study on how to integrate and manage distributed energy resources, the topic of this research team's technical project (Fontaine Master Plan, 2018). Conducting this research now is critical to ensuring that the state and university meet their emission goals by 2050, given that transitioning entire energy systems to be more renewable is a slow and complex task.

While it is crucial that our electrical grid and infrastructure transitions to renewable and distributed energy resources, these technological solutions are not enough. The social behavior of people is just as critical of a component to prevent climate change (Heeren et al., 2016). There have been mixed responses from all over the globe regarding the urgency of addressing our climate issue, even in developed countries. Despite being one of the most technologically advanced countries in the world, the United States have been slow to transition to environmentally-friendly behaviors. In 2018, the number of cars per 1,000 inhabitants in the US was 838 versus 438 in Denmark ("List of countries", 2020). In order to combat the climate issue, it is imperative that every person in every country participate in eco-friendly behavior. This STS research paper will

analyze the cultural differences between the United States and Denmark to understand what encourages Danes to live more environmentally-conscious lives as opposed to their American counterparts.

Technical Topic

Virginia's Executive Order 43, signed on September 19, 2019, solidifies the state's commitment to reversing the current climate trajectory by requiring 30% of electricity production to be from renewables by 2030 and 100% of electricity to be carbon-free by 2050 (Exec. Order No. 43, 2019). Details of this mandate reveal that Dominion and Appalachian Power Company, Virginia's largest electricity providers, are required by law to gradually transition their electricity production from mostly natural gas to renewable energy sources. Burning fossil fuels in a power plant provides a constant, reliable source of energy. On the other hand, solar and wind depend greatly on the weather conditions, such as overcast skies or wind speeds. Transitioning our electrical grid to gradually rely more and more on a variable energy source such as solar and wind results in a more volatile electrical grid. A cleaner grid brings on the new challenge of better balancing the demand on our electrical grid to counteract the variability of renewable electricity generation.

The University of Virginia (UVA) committed to similar goals of achieving 100% carbon-neutrality by 2030, and 100% fossil-free by 2050 (Kelly, 2020). Fontaine Research Park, located near the US-29 Bypass and I-64 on Fontaine Avenue, was originally developed in the 1990s. Currently, Fontaine consists of eight outdated buildings and parking lots on a total space of 54 acres. UVA has developed a master plan, including near-term and long-term plans, to fully develop Fontaine for primarily outpatient care and research activities. (Fontaine Master Plan, 2018). Given

that UVA is still in the planning stage of this development, there is opportunity to integrate distributed energy resources and use Fontaine as a case-study to demonstrate how to build and manage a sustainable infrastructure system that supports the electrical grid and institutional emission goals.

The University's bus fleet consists of 40 buses, and serves more than 3 million passengers each year (University Transit Service, 2020). The University Transit System (UTS) anticipated changing locations for managing and storing their bus fleet, but those plans were abruptly halted due to the financial impact UTS experienced from the COVID-19 pandemic. As batteries for electric vehicles continue to improve, UTS has been looking into slowly switching out their diesel buses for electric ones. There is also opportunity to incorporate the University's bus fleet, a hopefully increasingly electric one, into the Fontaine development plans.

Based on conversations with stakeholders involved in the University's transition to zero emissions, including UTS and Facilities and Management, the identified distributed energy resources the team will research include thermal storage tanks, rooftop solar, and vehicle-to-grid support from an electric bus fleet. This project will not only look into emission savings and balancing peak electric demand, but also consider the economic incentive to incorporating and managing these resources. Analysis methods include modeling Fontaine's base-case scenario (if Fontaine Research Park were to be developed without any grid-supporting technologies), and comparing it to a system that includes the aforementioned technologies. Variables in the model will include cost-benefit analysis, variability of electricity supply over time due to increased dependence on renewables, the building's heating and cooling needs, rooftop solar potential, among many others. It is imperative that there is an economic incentive; otherwise, it will be difficult to convince the University to adopt these technologies. Ultimately, this research is to aid

UVA on how to best transition to a clean and fossil-free electrical grid, apply the knowledge gained to other university campuses and institutions in Virginia, and demonstrate UVA as a leader in the sustainability movement.

STS Topic

The first industrial revolution, sparked by the invention of the steam engine, increased production in all industries from textiles to transportation, transforming Europe and America from largely rural to urban societies (Industrial Revolution, n.d.). Consequently, the steam engine and expanding railway and steamboat networks all required burning coal. Then came the second industrial revolution during the late 19th century, characterized by the development of the automobile and Fordism. As a result, there was mass production and consumption of personal automobiles, and with it came the construction of vast highways across the United States. This rapid development exponentially increased coal and gas consumption.

Climate change is the long-term shift in global climate patterns caused by the rise in global temperatures due to human activity. Specifically, the burning of fossil-fuels releases carbon dioxide molecules into the atmosphere, trapping the heat from the Sun, and warming our Planet. The first scientific discoveries related to climate change occurred much earlier than one expects, with Fourier's theory that the Earth's atmosphere acted as a greenhouse by trapping the incoming sun ray's thermal energy in the 1820s or John Tydall's demonstration that coal gas was especially effective at absorbing energy in the 1860s ("Climate Change History", 2020). However, climate change as a social issue only surfaced around the 1960s, following over a century of irresponsible and excessive consumption patterns. Climate change has only very recently started to be taken seriously. Even in 2009, the reunion of 115 heads of government in Copenhagen to draft and sign

a climate accord proved unsuccessful ("Why did Copenhagen fail", 2009). Eventually, the Paris Climate Agreement was reached in 2016.

Every country has responded differently to the climate change crisis. When Donald Trump was elected President, one of the very first things he did was remove the United States from the Paris Climate Agreement. The other side of the Atlantic paints a different picture. Denmark in particular is praised as the European leader in sustainability, with Copenhagen consistently placing in the top of the world's greenest city rankings ("Have you been to the world's greenest city?", 2019). Specifically looking at the transportation sector, both countries exhibit very different behaviors. Copenhagen's world-renowned City Bike program has grown substantially in popularity since its introduction in the 1980s, and the city now reports that 62% of Copenhageners choose to commute by bicycle (Weihe, 2017). Cycling is now fully integrated into Danish culture and identity (Oosterhuis, 2016). Unfortunately, the same enthusiasm for cycling has not spread in the United States. Americans still remain attached to their automobiles, with 76% of commuters traveling by car and only 0.6% commuting by bicycle ("Who Drives to Work?", 2015). A common theme throughout literature review reveals that "in Denmark sustainability is the rule, while it is only an exception in the United States" (Sheppard, 2011, p.68).

This research paper will analyze climate change as both a scientific and social paradigm shift, comparing the United States and Denmark and how their cultural differences influence environmental behavior, especially in the transportation sector. A paradigm shift, conceptualized by Thomas Kuhn in his book *The Structure of Scientific Revolutions*, is a major change in the accepted set of theoretical assumptions that guides the direction of scientific work and defined scientific discipline (Kuhn, 1962). An example of a paradigm shift would be when the scientific community accepted the heliocentric theory that the Sun was the center of the universe over the

outdated geocentric theory that the Earth was the center of the universe. The paradigm shift theory, much to Kuhn's intention, explicitly describes *scientific* revolutions. There continues to be debates over the applicability of Kuhn's theory to the nonsciences, which then brings up the question of what is considered science. Oddly enough, the "paradigm theory has been most persistent in fields such as sociology, which Kuhn regarded as beyond the scientific pale" (Percival, p.29). Despite these past critiques, the transition from the irresponsible behaviors during the industrial revolution to current sustainable behaviors such as recycling and commuting by bicycle demonstrates that Kuhn's theory can be applied to the social dimensions of climate change. Through this research, the social factors that influence Denmark's strong environmentalism will be analyzed in order to better understand how America can shift their behaviors to better combat climate change.

Research Question and Methods

Research Question: How do cultural differences between the United States and Denmark influence environmental attitude and behavior, especially in the transportation sector?

The theory of paradigms and paradigm shifts will be applied to the issue of climate change as both a scientific and social paradigm shift. The scientific paradigm shift section will be a general discussion with no particular country's perspective, while the social paradigm shift analysis will compare the United States and Denmark. Background research will contextualize the two countries, including historical, political, and economical considerations. The analysis of climate change as a social paradigm shift will begin with a discussion and comparison of each countries' transportation sector, noting in particular the bicycling culture, infrastructure policy, and automobile culture. A general analysis of each country's cultural identity, starting with Denmark, will follow. The last section will compare and contrast Denmark's and the United States'

paradigms, and extract successful methods from Denmark to be applied in the United States to shift the American sustainability paradigm. Most sources for this research will consist of scholarly articles and reliable websites.

Conclusion

This paper includes an analysis of integrating distributed energy resources, mainly thermal energy storage tanks, rooftop solar, and an electric bus fleet, to UVA's Fontaine Research Park. The team will model a base-case scenario consisting of Fontaine's current development plans, and compare it to a model with the distributed energy resources. This analysis is two-fold: both for an emission reduction purpose as well as from an economic incentive perspective. The team hopes to demonstrate to the University the potential long-term emission and monetary savings by properly integrating the given technologies, and aid other campuses and institutions around Virginia with a clean energy transition.

The STS research will begin with a discussion of climate change as a scientific paradigm, but mostly tackle climate change as a social paradigm shift by comparing the United States and Denmark. A comparison of each country's transportation sector will be an introductory example to a more general analysis of the cultural differences on the paradigm that encompasses sustainable attitudes and behaviors. The anticipated outcome is to extract and synthesize reasons for a more successful sustainable paradigm in Denmark in hopes of applying them in the United States and hasten the American sustainability paradigm shift.

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