Capacity Planning and Investment into Electrification of Container Ports at the Port of Virginia

Evaluating the Societal Impact of Electrification at the Port of Virginia on the Greater Norfolk Community

A Thesis Prospectus

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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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Introduction

The Port of Virginia aims to become carbon neutral by the year 2040. Doing so requires a commitment to source all of their energy from clean energy, with the intention to become the first carbon neutral port on the east coast (Donnelly, 2022). This undertaking brings upon many questions, specifically when looking into how this change will affect the greater Norfolk area. As the port creates nearly 400,000 jobs for the state of Virginia, in addition to the fact that the port generates around $92 Billion in economic activity for the state, the process of switching to fully electrical operations will undoubtedly leave a mark on the community, for better or for worse (Investor Spotlight: The Port of Virginia, 2021).

The technical aspect of this project aims to build replica simulation models of numerous port processes through discrete event simulation methods. The ultimate objective is to replicate what the port will look like 3-5 years down the line. This allows for future forecasting on the optimal equipment to be used in operations, producing the greatest efficiency. Additionally, through the results of the simulations, my group will be building Power BI dashboards, visualizing the total electricity usage and charging outputs of the vehicles. Power BI is a tool that is used to interactively visualize data, thus allowing the viewer to look at specific areas within the data to key in on. The emissions saved will also be visualized through this dashboard, allowing for decisions to be made based on the tradeoffs provided.

The STS research portion of the project aims to evaluate the overall societal impact that the port electrification process will have on the greater Norfolk community. The goal of this research is to forecast the economic and environmental benefits/detriments that the process will bring. This research will complement the technical aspect of the project, which aims to optimize the operation processes of the port.

It is critical that these questions be answered to ensure the prosperity of the surrounding community of the Port of Virginia. Port operations, mostly located in coastal locations, are more susceptible to extreme weather conditions, specifically flooding. With electrification being the main goal, the risk of flooding on electrical substations and vessels could be detrimental to the surrounding community (Ports Primer: 7.1 Environmental Impacts, 2022). As such, the aim of this exploration will

first outline the technical aspect of the project, followed by the STS research portion, explaining the social groups impacted and the framework used to determine the societal impact of electrification at the Port of Virginia.

Capacity Planning and Investment into Electrification of Container Ports

In order for the Port of Virginia to satisfy their goal of sourcing all of their energy from clean energy by the year 2024, they cannot go into the process blindly. With six terminals and over 4,000,000 containers processed on a yearly basis, the switch over to fully electric vessels must be fully thought out beforehand to prove efficient, both operationally and financially (Capabilities, 2022). As such, using the simulation software, Simio, my group will be implementing numerous use cases, potentially showing what the port could look like years down the line with a fully electric fleet.

The initial step of the process involves designing the simulations. The ship to shore process contains numerous steps, each containing different types of vehicles and charging stations. As such, we will be simulating each step of the process separately, allowing for a dissected view of each part of the container transferals.

The next step of the process involves the acquisition of interarrival times between each point of the ship to shore expedition, as well as maintenance and fuel times for the possible vessels. We will collect data based on locations in which these vehicles are already being used, ultimately verifying the process to be accurately portrayed by the simulations. Once this data is collected and interarrival times have been found, the distributions can be implemented within the software to conduct experiments.

The goal of each simulation is to design the optimal fleet to achieve the greatest possible throughput rate within the given financial constraints. We will be proposing recommendations for the number of electrical charging spots and differing types of vehicles after numerous experiments have been conducted. With hydrogen and electric powered vehicles both in consideration for use, the simulations will provide insight on the optimal balance of vehicles based on fuel times and maintenance repair times. The final deliverable within this experiment will recommend a specific fleet utilized within the

simulations that achieved the greatest efficiency, meaning that the throughput rate was the highest, while charging and repair times were at a minimum.

Evaluating the Societal Impact of the Emergence of Electrification at Port of Virginia

While electrification is becoming an essential investment to reaching the goal of carbon neutrality, as shipping accounts for 3% of global greenhouse gas emissions, it is also pivotal to understand how this change will impact the surrounding communities ("Shift to port electrification a key component of meeting zero emission shipping target," 2021). As such, the STS research section of this project will be focused on the question: What is the Societal Impact of the Emergence of Electrification at the Port of Virginia?

The port's impact on the local community is immense, with Hampton Roads taking account for approximately ⅓ of the $17.5 Billion generated in annual state-wide compensation and $1.4 Billion in statewide taxes (Investor Spotlight: The Port of Virginia, 2021). While the shift to electrification is deemed necessary for the long-run health of the environment, it is also important to understand how this switch will ultimately impact the workers, most of which reside in the nearby communities. As shown by many other industries, the switch to fully electric resources reduces the demand for human capital, ultimately leading to structural unemployment and therefore a loss of income for many workers. However, the implementation of electrification could bring about new jobs for the community, leading to new skills and capabilities learnt by the local workforce. Additionally, the switch to fully electric introduces the opportunity for the port to obtain incremental electricity sales, supporting the local economy (DiBella, 2016). While the impact on the local economy is essential, it is also important to investigate the impact of electrification on the surrounding environment. It is no secret that this change hopes to benefit the environment with the goal of becoming carbon neutral. However, it will be interesting to ponder whether or not there are any detrimental effects to the environment as a result of the switch to fully-electric machinery.

I will be using the Actor-Network theory to model the electrification process, further enhancing the ability to understand the relationship between the Port of Virginia and the outside community. The Actor-Network theory suggests that technology exists with a set of social "actors" within its network, which are always evolving. With the main technology being the newly installed electric vehicles/vessels, the Actor-Network theory will be applied to show how this main technology impacts the relationship among all of the stakeholders. It will be utilized to further understand the impact of the new technology on the outside community, and how this technology will evolve to ultimately benefit and/or harm the full network. I will be creating a diagram, outlining all of the potential stakeholders within this implementation, with networks of relationships shown among them to detail how they interact with one another.

The timeline for the STS and research portions of the project are as follows: I will be completing the STS prospectus by November, 2022 and the rest of the research paper throughout the duration of Spring, 2023. My group will be completing the technical portion of the project throughout the Fall of 2022 and Spring of 2023. We will be simulating various use cases throughout the fall, while completing the data analysis in Power BI in the Spring.

Key Texts

A key resource that I believe will be beneficial in my research comes from a study called *Macroeconomic and Environmental Impacts of Port Electrification: Four Port Case Studies* written by Ellen Schenk. This study details the work of four ports located in Baltimore, the Everglades, Houston, and Seattle. Different scenarios are outlined at each port, covering the macroeconomic and environmental impacts on the county and state in which the port operates under 0% electrification, 50% electrification, and 100% electrification. The models utilized within this study will be accommodating to my research, as I begin to discover the environmental and economic impacts of the Port of Virginia on local communities. The study argues that the investment in port electrification can lead to greater economic performance through modernizing ports, achieving greater throughput efficiency, and advancing integrated supply

chains (Schenk, 2020). Other referenced journals within this study will also be beneficial to me as I begin my research.

Additionally, the paper *Port Electrification Benefits the Local Economy and Environment While Providing New Electric Load for Utilities* written by Bob DiBella will be an asset to my research (DiBella, 2016). The study argues that upgrading existing port technology and converting into clean-powered technology will benefit the local economy and environment of areas that choose to do so. The study details the potential benefits in both areas, while outlining a strategy for ports to do so. This will be beneficial to my research in that the potential technologies available for use are displayed with emission reduction impacts. I will be able to leverage this paper to define an argument for the societal impact of the surrounding areas of the Port of Virginia based on the research done.

The research from *An Assessment of Macroeconomic Impacts of Medium- and Heavy-Duty Electric Transportation Technologies in the United States* will also be helpful to me as I begin my research (Winebrake, 2018). The purpose of this journal is to evaluate the overall impact on the economy, through savings and new jobs created, based on the switch to shore electrification. With the implementation of new technologies, new models are outlined to generate the impact on the economy. This will be extremely helpful, as I will be able to use the models provided to show the impact on the local communities' economy based on differing technology evolutions. Fuel cost and emission savings are also detailed in the study, which I will be able to model to the Port of Virginia to also cover the environmental impact of electrification.

Similarly, the study *Electrification at Ports: A Port of Houston, Texas Electrification Case Study and Options for Electric Cranes* will aid me in my research as I look into different electrification strategies and how those will impact the total costs generated (van de Walle, 2013). This paper also details the emissions saved by each investment into clean energy, which I will be able to use to estimate the total emissions saved at the Port of Virginia. Different methods within electrification are outlined in this journal, furthering my technical project analysis, as we hope to optimize the vehicle fleet to improve

efficiency while reducing emissions. Overall, this paper will help me in my STS and technical research monumentally.

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