Thesis Project Portfolio

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

(Technical Report)

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

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Container ports face the decision of investment into a variety of emerging technologies, including electric vehicles, autonomous equipment, and hydrogen-based power. The technical project of this research presents a simulation-based optimization study of a port using simulation software to reduce carbon emissions and improve efficiency of operations of a maritime container port. Through capacity planning and electrification modeling, the port was provided with recommendations that will be used for 3-5 year-out planning focused on decreasing emissions and improving energy utilization. Research focused on reduction of operational emissions, existing simulations of ports, and emerging technologies including electric vehicles, liquid natural gas, hydrogen power. The methodology included modeling smaller sections of the port through simulation software. Use cases were extended to various forms of equipment and vehicles. Carbon emissions were also represented. These models allowed for the simulation of the effect of the changes in equipment and observation of resulting financial and time costs.

Recommendations for the number of chargers and the number of additional vehicles to be purchased were also discussed. Use cases also allowed for the identification of beneficial expansion into electric vehicles according to fuel times and maintenance requirements, with consideration of financial constraints. Preliminary results revealed positive potential, both environmentally and economically, in regard to the transition towards electrification of heavy-duty port machinery and away from diesel-powered equipment. The findings of this study highlight the prospect of using simulation-based optimization to improve the sustainability of operations of the maritime container port and to reduce their overall carbon footprint. The technical portion of the project focuses on the following machinery: Utility Tractor Rigs (UTRs), Rail Mounted Gantries (RMGs), Shuttle Carriers, and Top Picks. By simulating potential investments and strategic operation activities for these machinery, the Port of Virginia will be able to visualize the differences in production for each specific scenario.

The STS research paper aims to evaluate the overall societal impact of electrification at the Port of Virginia on the local community. A general overview of the Port of Virginia is defined, giving the

reader a sense of the contributions to the mass public by the port. In particular, the economic capabilities of the Port of Virginia are described. The port currently comprises six main terminals, so there is no shortage of cargo coming in and out of the port. As the port currently employs around 350 people, many of the jobs currently utilized by the Port of Virginia are subject to change as the electrification process evolves. The majority of the machinery used by employees is defined, as much of the machinery will be evolving during electrification. As the local economy, and much of the state, relies upon the port activity, the paper strives to evaluate how electrification will ultimately impact these aspects. By using Actor-Network theory and evaluating the strength of relationship between each actor involved in the electrification process, the major players in the operation are identified. The stakeholders are recognized throughout the paper, along with their main contributions towards the electrification process and their relationships with other stakeholders.

Additionally, the paper strives to project the economical and environmental implications on the local community done by the electrification process. The economic impact is described by the potential job outlook and economic activity in nearby communities, while the environmental impact is described by the changes in greenhouse gas emissions and their effects on local communities. Stakeholders involving these impacts are also thoroughly outlined throughout the piece. For example, the impact of electrification on the port workers are shown, ultimately contributing to the economic impact of electrification. In addition, government action is closely monitored in the paper, as much of the electrification process would not be possible if not for subsidies and grants provided by local, state, and federal government action. Ultimately, a general view is taken on how the electrification at the Port of Virginia will impact the overall health, both economically and environmentally, of the surrounding community.