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

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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

Every year in the United States, nearly 200,000 people die as a result due to emissions produced from industry, cars, trains, ships, as well as other industrial operations. The emissions generated from the burning of fossil fuels accounts for around 100,000 of these deaths (Milman, 2016). To put this into perspective, around 160,000 people die in the United States each year from the following: unintentional injuries, motor vehicles, and poisonous substances combined (Weatherspoon, 2023). While motor vehicle deaths are widely talked about when mentioning deaths in the United States, it seems as if emission-related deaths never are. To say the impact of industry-related operations on the surrounding communities is detrimental would be an understatement. As a result of the unintended consequences that arise due to industrial operations, many enterprises have begun to entertain the idea of converting to fully clean energy.

One organization in particular, the Port of Virginia, recently announced its decision to "fulfill all of its operational electricity needs from clean energy resources" by the year 2024, with the intent to become carbon-neutral by the year 2040 (Donnelly, 2022). As the port currently processes "over 4,000,000 containers" on a yearly basis and currently possesses the "#1 position in rail volume on the East Coast," the change is not going to go unnoticed ("Capabilities," 2022). Additionally, the port helps "create more than 400,000 jobs and generates $92 billion in total economic impact" throughout the state of Virginia, with nearly "10 percent of the state's resident workforce" linked to port activity. In all, these jobs create "$17.5 billion in annual compensation and $1.4 billion in state and local taxes" ("Investor Spotlight: The Port of Virginia," 2021). Surely, the switch to electrification will have profound effects on the surrounding community, as a goal of the newly adopted sustainability approach from the port is to become a "better neighbor." What is left to be unknown, however, is whether these profound effects will be in a positive or negative manner. Due to the potential advantages and disadvantages that port electrification brings on the local community, I evaluate the socio-economic impact of the port's commitment of electrification on the greater Norfolk community in this paper. I discuss stakeholder impacts, detailing the potential positive and negative consequences that the electrification process will

have on each respective group of interest. Using Actor Network Theory, I evaluate the relationships among the stakeholders, taking into consideration the influence of each stakeholder on the electrification process.

Port of Virginia Overview

The Port of Virginia comprises six main terminals, spanning over 1,800 acres: Norfolk International Terminal (NIT), Virginia International Gateway (VIG), Portsmouth Marine Terminal (PMT), Newport News Marine Terminal (NNMT), Virginia Inland Port (VIP), and Richmond Marine Terminal (RMT). As four of the six terminals are located in the Norfolk metropolitan area, I focus my research on this sole location. The machinery involved with the electrification process include utility trucks – semi-tractors used to transport containers within a cargo yard, ship to shore cranes – used for unloading containers from the ships, and rubber tire gantry/rail mounted gantry cranes – used for loading and unloading containers from the stacks ("Cargo Handling Equipment at Ports," 2023). The largest of the terminals, NIT, is at the forefront of the electrification process. Currently diesel powered with 49 utility trucks, 14 ship to shore cranes, 5 rubber tire gantry cranes, and 48 rail mounted gantry cranes, the electrification process is one that will not be a seamless transition ("Norfolk International Terminals (NIT)," 2023).

With around 350 employees, the economic impact of the Port of Virginia on the surrounding communities goes well beyond the number of people it employs. The port generates significant revenue for local businesses, creates spin-off jobs in industries such as transportation and logistics, and contributes to the overall economic growth of the region. A recent economic study concluded that "over 397,000 jobs in Virginia have ties to the port" ("Careers," 2023). The port is a key hub for international trade, handling a wide range of cargo from all over the world.

Actor-Network Theory Application

The Actor-Network theory (ANT) is an appropriate method to analyze the implications of port electrification on the surrounding communities. ANT is used to explore how both human and non-human actors interact on an ever-changing basis. According to Darryl Cressman of Simon Fraser University, at its core, ANT "approaches science and technology in the making," while once there, "ANT sets out to follow the actors," as they attempt to "interpret the process of network construction" Furthermore, Cressman argues that these networks normally consist of engineers and scientists, attempting to open the "black box" among technologies, knowledge, money, and people. There is nothing else in ANT besides associations, which detail how networks come to be larger and more influential than others. It should not be argued whether one actor is more powerful than another, but rather whether one association is stronger than the rest (Cressman, 2009).

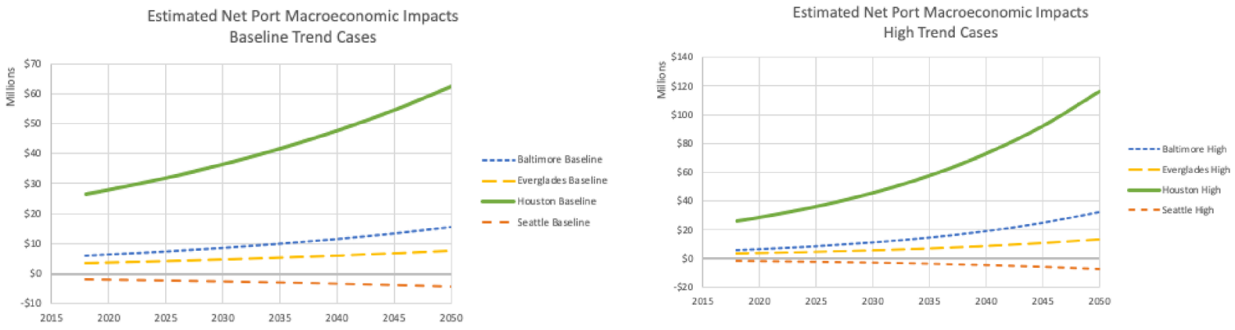
I use Actor-Network theory in the matter of electrification at the Port of Virginia to map out the interactions among key stakeholders and decision makers and analyze the impact on the surrounding communities. ANT is appropriate to use due to the human (surrounding citizens, management, port workers, government) and non-human (machinery, environmental impact, economic impact) actors within the network. The major actors in this case are those who are directly making the decisions (management, government) and the machinery with which they associate (diesel equipment changing to electric equipment). More broad actors are the humans in which are being affected, but not necessarily having a say in the changes (port workers, surrounding citizens), as well as the non-human actors that are changing as a result of the electrification process (economic impact, environmental impact). Using the ideas presented by Cressman, the strongest associations within the Actor-Network theory in this scenario are seen by the associations among the port management, government, diesel and electric machinery. These associations are stronger than the others because of the drastic movements in the network that come from the shift of diesel machinery to electric machinery. As Actor-Network theory is often described as an ever-changing network of actors, the largest change in associations are among the actors listed. While the associations among local citizens and port workers with the economic and environmental impacts also

drastically change, this does not necessarily take into account the decisions being made to drive this impact. Because these actors are more casual, in a sense, while the other actors are more assertive, the decision-making actors are more powerful in the end.

Stakeholder Impacts

Norfolk Community: Economic

The Port of Virginia's decision to switch to fully electric operations will arguably have the largest impact on the citizens of the local communities. As the port currently generates "$17.5 Billion in annual compensation and $1.4 Billion in state and local taxes," the Hampton Roads region accounts for more than ⅓ of the impact ("Investor Spotlight: The Port of Virginia," 2021). As seen with numerous ports who have already adopted electrification infrastructure, the economic activity in the surrounding counties are expected to multiply by 3.5x-5x from the years 2020-2050. In addition, "larger ports, with more activity,



show greater net change in economic output." As shown in the two figures above, the estimated net port macroeconomic impacts are projected to be much greater over time in high trend cases as opposed to baseline trend cases. With baseline trend cases being defined as no electrification outlook over time, and high trend cases being defined as a 100% conversion to electric operations, the switch to electrification nearly doubles the economic outlook in each port studied (Schenk, 2020). As the Port of Virginia is currently the 10th biggest port in all of North America, in addition to the fact that it will only get busier with "multinationals like Amazon and Navien setting up operations in the state," the economic impact on the greater community will undoubtedly be immense ("10 Largest Ports in North America," 2023).

Additional opportunities for local economic growth are brought upon by electricity sales. Ports in particular are especially viable to "obtain incremental electricity sales while contributing to emissions reductions and economic development in the communities they serve (DiBella, 2016). Beyond that, the electrification process of the port can attract new businesses and investors who prioritize sustainability and environmental responsibility, further expanding the economic impact on the region.

When looking at the economic impact on the local community through the lens of actor-network theory, the major relationships suggest that it is a very weak actor. As Cressman suggests, associations determine the strength of the actor, not the strength of the actor itself. As such, the primary relationships of the environmental impact are with other weak actors (port workers, local citizens). While certainly not an afterthought, the primary goal of the electrification initiative considers the overall environmental aspect of the change; electrification is not necessarily being put into practice for a major economic overhaul. Therefore, the economic impact is very weak in regards to the actor-network theory, as the relationships are lower on the power of influence, in addition to the fact that the economic impact is simply a result of other actors making changes..

Norfolk Community: Environmental

Just as the economic outlook for the surrounding communities of the Port of Virginia appears to be optimistic, the environmental outlook does not appear to be much different. When the Ports of Baltimore, Everglades, Houston, and Seattle conducted studies, the switch from diesel to electric machinery significantly decreased the amount of Nitrogen Oxides (NOx) and greenhouse gasses (GHGs), while slightly increasing the amount of Sulfuric Oxide emissions (SOx) in nearby communities. Additionally, the greatest environmental benefits appear to come into effect when pertaining to ports with 100% electrification, leading to greater optimism for the Port of Virginia (Schenk, 2020).

The reduction of NOx is especially important to maintaining the surrounding environment of the Port of Virginia. NOx, in its purest sense, is formed mainly of two molecules, nitrogen oxide and nitrogen dioxide. As these oxides are mainly emitted through high temperature combustion events, such as car

engines, the switch from diesel to electric will undoubtedly play an integral role in the reduction of these emissions. Nitrogen Oxides prove extremely detrimental to environments in ways such as producing smog, contributions to acid rain, worsening harmful algal blooms, among others. When inhaled, Nitrogen Oxides can cause serious damage to lung tissue in addition to being linked to increased risk of heart disease and premature death (Beaudry, 2021). The overall reduction of Nitrogen Oxides will create a cleaner, much safer environment for the surrounding communities of the port, creating a better ecosystem for both citizens and animal life.

While electrification studies at similar ports have seen a great reduction in Nitrogen Oxides, a slight increase in Sulfuric Oxides also appear to be present. Sulfuric Oxides are detrimental when combined with water and air, forming acid rain, which can be extremely harmful to aquatic life. Similar to Nitrogen Oxides, Sulfuric Oxides also negatively affect the respiratory system, particularly lung functions ("Sulfur dioxide | Environment, land and water," 2017). Sulfuric Oxides and Nitrogen Oxides mostly have similar effects, both impacting pollution and the environment, as well as human and aquatic health. As the molecules act in a similar manner, it can be concluded that the overall impact on the local environment is a net benefit, as a large decrease in Nitrogen Oxides outweighs a small increase in Sulfuric Oxides.

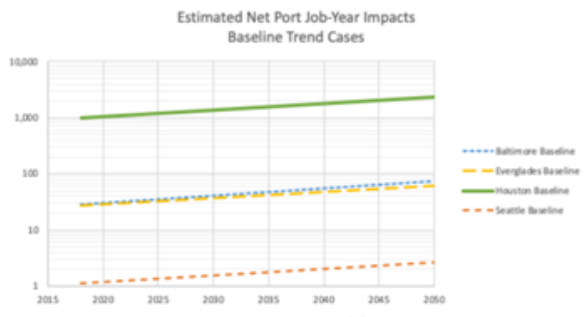
While the emission reductions seem promising, there are environmental worries involved with the electrification process. As the port operations are located in Norfolk, a coastal area, the community is more prone to natural disasters, specifically flooding. As grid electricity infrastructure must be installed for the electrification process, flooding poses a serious risk to the well-being of the local communities also using the power ("Ports Primer: 7.1 Environmental Impacts," 2022). While risk resilience plans will almost certainly be put in place, it is still a threat worth acknowledging.

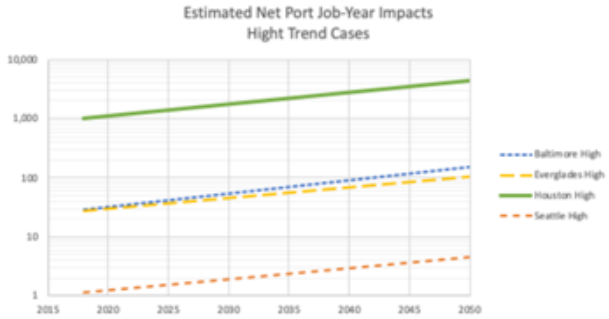
Through the actor-network theory, it can be seen that the environmental impact on the community is a weak player among the actors in the total network. Due to the fact that the environmental impact is simply a consequence, not a direct catalyst for change, the relationships between other actors and the environmental impact on the community are not nearly as strong as others, according to Cressman's approach. However, the environmental impact is definitively a stronger actor than that of the economic

impact when factoring in the relationships of other stronger actors, port management and governments. As the main premise for port electrification revolves around becoming carbon neutral and reducing overall emissions, the environmental impact's relationships with other actors can be said to play a stronger role than that of other impacts on the local community.

Port Workers: Job Outlook

The switch to electrification at the Port of Virginia brings numerous benefits and detriments to those actually on the jobsite. As many of the current processes used at the port will soon be obsolete, many port workers will be forced to learn new trades. As all processes are currently diesel powered, but will soon be fully electric, the traditional style of everyday operations will only see minor changes. However, with autonomous vehicles being tested in some ports around the world, the trajectory of the overall demand for port workers is in question. In the long run, as evaluated at the Ports of Baltimore, Everglades, Houston, and Seattle, employment is expected to increase from 3.7x to 4.8x from the years 2020 to 2050. Additionally, larger ports with greater activity tend to show a greater net change in employment. This is certainly a net positive for workers at the Port of Virginia because as previously stated, the Port of Virginia is one of the largest ports in all of North America.





As shown in the figures above, the estimated net port job-year impact is significantly higher for high trend cases, as opposed to baseline trend cases. As the Port of Virginia can be seen to be a high trend case, since

the transformation is to be fully electric rather than partially electric, the job outlook is considerably high (Schenk, 2020).

While the job outlook seems comparably high when factoring in the outlooks of the ports shown in the figures above, this does not take into account the future autonomous-driving element. The Port of Virginia has recently expressed interest in autonomous utility tractors entering the terminal operations. While this integration will most likely not take place for years to come, it's still important to suppress extreme optimistic job outlooks, as technologies are only going to become more advanced in the coming years, potentially making manual labor jobs obsolete. While in theory, the job outlook for those at the port seems to be trending in a positive direction, it's important to take this in stride, as we do not know what future technologies may hold.

Factoring in actor-network theory, the relationship among the port workers and other actors are not as strong as the decision-making actors (government and management), mostly due to the fact that the workers are not directly shifting the network. While the workers are undoubtedly affected, arguably the most, the strongest actors in actor-network theory are those who impact relationships the greatest. So while the workers themselves are directly impacted, they are not impacting relationships to the degree of other actors (management, government). However, the port workers are unionized through the 1248 ILA Union, so while the workers may not be able to make direct changes, drastic changes by management could cause drastic ramifications by the unionized workers ("International Longshoremen's Association"). The greatest shift in port worker relationships can be seen in their relationship with the machinery. As electrification progresses, the relationship between the workers and diesel equipment essentially becomes non-existent, while a new relationship emerges between electric equipment and the workers.

Government Action

Just as involved as the local community is in the electrification at the Port of Virginia, the local and state governments also hold high stakes in the impact on the process. With the goal of prioritizing "public health in every way possible," Ralph Northam, Governor of Virginia, pledged $14 Million to the

Port of Virginia for the purpose of replacing diesel equipment with electric equipment. The aim of this grant is to "eliminate more than 3,000 tons of diesel pollution, more than 71,000 tons of greenhouse gasses, and more than 6 million gallons of diesel fuel" (Eason, 2020). While government action has enabled reductions of emissions for the local communities, the Port of Virginia additionally received funding from the federal government to "widen and deepen the commercial shipping channels and Norfolk Harbor," bringing more positive news to the community (Crawford, 2022). The agreement will allow the port to safely accommodate the two way traffic of ultra-large container vessels, putting the port in a unique position to attract, and thus handle, more business. As mentioned before, ports that are able to handle more traffic volume are more susceptible to economic growth, both in the local communities and employee outlook at the port, moving forward.

As the port generates $1.4 Billion in state and local taxes, with ⅓ of the impact in the Hampton Roads area, the influx of ships coming in and out of the port will only increase the tax revenue in the surrounding communities ("Investor Spotlight: The Port of Virginia," 2021). There is no doubt that both the federal and state governments have made electrification at the Port of Virginia a priority, ultimately benefiting the surrounding areas in the long run.

Through the actor-network theory, it can be seen that the government plays a major role in the development of the electrification process at the port. Because of the potential impact that the government plays, mostly through subsidies and grants given to the port, the relationship among the government, port management, and the machinery plays a major role in the economic and environmental impacts of the port on the local communities. The government, in terms of the actor-network theory, is the obligatory passage point, or a catalyst, for the rest of the relationships, as much of this process would not be available if not for government contributions.

Conclusion

In conclusion, the Port of Virginia's decision to switch to fully electric operations will have a significant impact on the surrounding community. Using Actor-Network Theory, this essay evaluated the socio-economic impact of the port's commitment to electrification on the greater Norfolk community. The stakeholders' impacts were discussed, detailing the potential positive and negative consequences that the electrification process will have on each respective group of interest. The strongest associations within the Actor-Network theory in this scenario were found to be among the government, port management, diesel and electric machinery. While the change to electric machinery will have a significant positive impact on the environment, it could also have negative impacts on the local economy, specifically on the workers in the diesel machinery industry. The switch to electrification will require a significant investment, but if successful, it could be a model for other ports and industries to follow. Ultimately, the positive or negative impact of the port's electrification on the community remains to be seen and will depend on how the transition is managed and the extent to which stakeholders are involved in the decision-making process.

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