A Duty Ethics Analysis of the Implementation of Shore Power from Power Grid Electricity

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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

Ocean going vessels including cruise, container, and refrigeration can require significant power while docked at berth and waiting for the loading / unloading processes to finish. Currently, most vessels utilize diesel auxiliary engines to generate this power, and emissions from these vessels can be significant contributors to air pollution. According to the United States Environmental Protection Agency, exposure to air pollution associated with such emissions can contribute to significant health problems including premature mortality, increased hospital admissions for heart and lung disease, increased cancer risk, and increased respiratory symptoms (EPA, 2017).

Shore power technology refers to the process by which ocean-going vessels can "plug in" to the local electricity grid or other power sources and turn off their auxiliary diesel engines while docked at berth. Through this process, shore power (also known as cold ironing) virtually eliminates diesel emissions and other air pollutants that would otherwise arise from running the vessel's on-board auxiliary engines. However, most implementations of shore power today allow vessels to plug in directly to the local power grid, where electricity is not generated carbon-free. In 2019, power plants that burned coal, natural gas, and petroleum fuels were the source of about 62% of total U.S. electricity generation (EIA, 2019). If we continue to provide shore power through current means of power grid electricity generation, we will never be able to reach a truly emission-free and sustainable future.

I believe that examining the implementation of shore power through the lens of duty ethics will provide a means of pointing out the counterproductivity in the current system, and help provide a roadmap for a future emission-free port landscape. Specifically, I will demonstrate why the current means of shore power implementation through power grid

electricity is inconsistent with Immanuel Kant's categorical imperative and explain how shore power implementation violates the doctrines of duty ethics. I will employ Kant's theory of ethics to aid my analysis.

BACKGROUND

The ports of Los Angeles and Long Beach have led the movement to require cleaner performance from port operations and have been influential in shore power's global visibility and widespread adoption. Initial deployment for container ships in Los Angeles initially involved the use of a barge to deliver the power, however the future standard relies on permanent shore-side power that vessels can plug in to while docked. Currently, ports in California are a few of the only ports in the world that have constructed the required infrastructure to make shore power possible, but other ports in the U.S. and Europe have expressed interest and formed future plans for its implementation.

LITERATURE REVIEW

A wealth of research exists on the topic of shore power. Papers of this sort typically focus on the economic feasibility of implementing shore power technology, both for ship operators and terminal operators. Further, these papers usually delve into projected emissions reductions as a result of shore power implementation. However, most papers of this sort focus on shore power by means of electricity from the local power grid, which as stated before is not necessarily obtained emissions-free.

In *Prospects of cold ironing as an emissions reduction option*, Zis details the current status of shore power technology worldwide and analyzes its prospects for further

implementation. He discusses the challenges that may hinder global shore power adoption, including both the lack of a standard of compatibility between the ship and the grid as well as high installation costs for ship and terminal operators. He goes on to provide a modeling framework that allows for shore power's economic evaluation for all stakeholders, and finds that shore power "may be a viable emissions reduction option for the maritime sector" (Zis, 2019). His analysis, however, makes use of power grid electricity as the source of shore power but fails to consider the negative environmental impacts which result from power grid electricity generation.

In *Integration of cold ironing and renewable sources in the Barcelona smart port*, Rolán, Manteca, Oktar, and Siano build upon the notion that shore power technology is necessary to reduce emissions from berthed ships. But, unlike Zis's paper, this study takes into account the negative environmental impacts which result from power grid electricity generation, and instead proposes a shore power system "based on renewable energies, focusing the attention on the use of wind turbines and photovoltaic panels to satisfy the ship' power demand" (Rolán et al., 2019) Through Matlab-Simulink simulations, the study concludes that such a shore power system based on renewable energies appears to be a plausible solution for the port of Barcelona. This study attempts to shed some light into the problem that is at the heart of this paper; shore power technology will never be fully emissions efficient if we continue to provide shore power through electricity from the power grid, for this electricity from the power grid is not generated emissions-free.

While both papers praise shore power for its potential to reduce emissions from ships at berth, only the latter attempts to propose a truly emission-free solution. Furthermore, there is a paucity of research that attempts to propose such a solution; the majority of the current body of

research into this topic proposes solutions involving electricity from the power grid. This paper will use a duty ethics framework to explain why a shore power solution involving electricity from the power grid cannot be a viable solution at the present moment, for we are still reliant on fossil fuels to generate electricity for the power grid.

CONCEPTUAL FRAMEWORK

The decision to provide shore power from electricity from the power grid can be analyzed using a duty ethics framework. Developed predominantly by Immanuel Kant, duty ethics is an ethical theory that places emphasis on the rules that govern actions. According to Kant, moral laws or normative ethics cannot be based on happiness, for happiness is individual and subjective. Instead, Kant argued that duty was a better guide for ethics. In Kant's opinion, man himself should be able to determine what is morally correct through reasoning. Thus, we should place a moral norm upon ourselves and should obey it out of a sense of duty. Only then are we acting with "good will," and our actions are led by the moral norm.

According to duty ethics, "an action is morally right if it is in agreement with a moral rule (law, norm, or principle) that is applicable in itself, independent of the consequences of that action" (van de Poel & Royakkers, 2011). How then do we know what a moral rule is? According to Kant, there is one universal principle from which all moral rules can be derived. This universal principle is known as the categorical imperative, and the first formulation of the categorical imperative (the universality principle) is as follows: "Act only on that maxim which you can at the same time will that it should become a universal law" (van de Poel & Royakkers, 2011). Thus, any rule that can be made universal and followed by everyone that does not result in the breakdown of society can be viewed as a moral rule in the eyes of Kant. The second

formulation of the categorical imperative (the reciprocity principle) is as follows: “Act as to treat humanity, whether in your own person or in that of any other, in every case as an end, never as means only” (van de Poel & Royakkers, 2011). In other words, people should never treat others as merely stepping stones to accomplish an underlying motive or overarching goal; instead, people should make their motives clear and respect the rationality of others by treating others as if they are the end goal, not just a frivolous step in a larger goal.

In the following section, I will analyze the decision to provide shore power from electricity from the power grid through a duty ethics framework. In my analysis, I will demonstrate how this system is not consistent with both formulations of Kant’s categorical imperative, and ultimately how such a solution is not morally sound under a duty ethics lens.

ANALYSIS

The decision to provide shore power from electricity from the power grid violates both formulations of Kant’s categorical imperative, namely the universality and reciprocity principles, and therefore such a solution is not morally sound under a duty ethics lens. While shore power can certainly be a promising and effective solution in the future, the decision to provide shore power from electricity from the power grid is counterproductive and ultimately works against the desired goal of emissions reductions. The following paragraphs analyzes these violations of the categorical imperative in further detail.

Violation of the Universality Principle

In order to understand the ways in which shore power from power grid electricity violates the universality principle, it is necessary to provide additional information on an example implementation of such a system. I will look at ports in California for this part of the analysis.

Beginning in 2017, California mandated that at least half of all container ships run on shore power while docked at berth (Port of Long Beach, n.d.). At these California ports, ships receive this shore-side power by plugging directly into the California power grid. However, California's power grid is not entirely emissions-free. A 2018 analysis showed that natural gas, a fossil fuel, was by far the largest source of electricity generation, constituting around 30% of total electricity generation in California (Petek, 2020). So, while ships docking at California ports can shut off their auxiliary diesel engines and make use of the shore-side power (seemingly emission-free), emissions have been released into the environment as a byproduct of generating this electricity. The utilization of shore power from grid electricity only helps to reduce emissions around the port area, which it certainly does. The California Air Resources Board (CARB) estimated that shore power "would reduce localized emissions of particulate matter (PM) by 75% and oxides of nitrogen (NO_x) by 74% in 2020" (EPA, 2017).

Currently, roughly 70 percent of electricity consumed in California is generated in-state and the remaining 30 percent is generated out of state but imported into California through transmission lines (Petek, 2020). Imagine a moral norm of the form "you must utilize shore power to achieve emission-free operations while docked at berth." If this moral norm were to become a universal law, would society fall apart? Considering all ships docked at berth must plug in to the local power grid, this would put immense pressure and strain on the power grid, and maybe even force ports to suspend the utilization of shore power so there is enough electricity for heating, lighting, and other necessities. In August of 2020, California was forced to suspend shore power in the face of a heat wave that put incredible strain on the demand for electricity (Maritime Executive, 2020). If every ship docked at berth in the world was required to plug in to the local power grid, society would break down; there would be immense pressure to

produce more electricity and therefore release more pollutants into the environment, ultimately working against the very problem shore power was designed to solve. California might not be able to import the electricity it does today (30%) or generate the amount of electricity required in-state, and society would not be able to function properly.

In addition to the problem of electricity supply, the method by which power grid electricity is generated still poses a problem. Even if every port in the world built the required infrastructure to make shore power possible, most ports would allow ships to plug in directly to the local power grid. As displayed in Figure 1, in the U.S. in 2019, coal constituted 23% of total electricity generation while natural gas constituted 38% (EIA, 2019). Thus, over 60% of total electricity generated and provided to power grids in the U.S. was generated by burning fossil fuels and releasing harmful emissions into the atmosphere. Renewables made up just 17% of electricity generation. So, while ships could indeed shut off their auxiliary diesel engines and plug into shore-side power, the process would not truly be emission-free. Thus, the maxim "you must utilize shore power to achieve emission-free operations while docked at berth" cannot become a universal law, as society would ultimately not be able to achieve true emission-free operations by using power grid electricity for shore power.

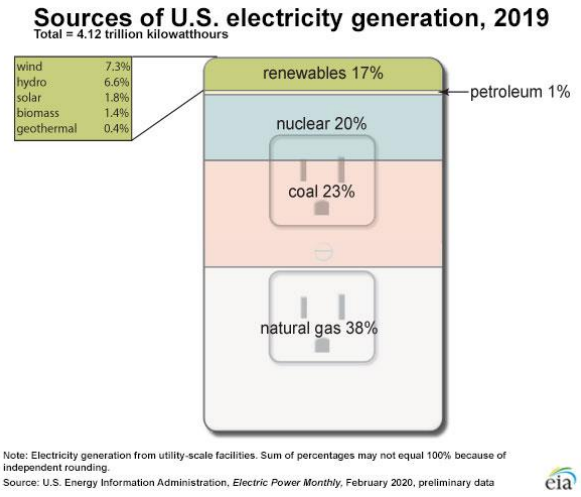

Figure 1: Sources of U.S. electricity generation, 2019

I have shown that the utilization of shore power from the electricity grid does indeed result in reduced emissions in the port area. Some proponents of shore power from power grid electricity praise the massive benefits that arise from these reduced emissions in the port area.

However, these proponents fail to consider that these emissions are not completely eliminated; instead, they are simply relocated to the areas where the power grid electricity is generated. So, while indeed the port area benefits from reduced emissions, another environment in close proximity to natural gas or coal power plants feels the full negative effects of ramped up electricity generation. According to a cost and benefit analysis for shore power at the Port of Shenzhen, "the life cycle emissions reduction from using shore power in place of marine fuel relies partly upon the generation mix of power stations that supply ports with electricity" (Wang et al., 2015). The study found that the generation mix in Hong Kong (near Shenzhen) was "dominated by coal, representing 53% of total electricity," while oil and renewable constituted only 2% of the generation mix (Wang et al., 2015). For the Port of Shenzhen, while shore power would indeed reduce emissions in the port atmosphere, there would still be emissions elsewhere due to the generation of the electricity used provide shore power. The study found that the "coal-fired power units have the highest share of emissions, accounting for 50% of total SO_2, 22% of NO_x, 14% of respirable suspended particles (RSP), and 50% of greenhouse gas (GHG) emissions" (Wang et al., 2015). Thus, shore power from power grid electricity is not a viable solution to solve the emissions problem in the transportation sector, for it does not solve the problem but simply moves it elsewhere and away from the port.

Violation of the Reciprocity Principle

At the present moment, the decision to provide shore power through power grid electricity is simply a means of achieving future emissions reductions, not an end. An ideal end would be one where ports provide shore-side power through renewable means – whether that be through wind turbines, an electrolyser and hydrogen fuel cell hybrid system, etc. – and ship

operators make the required infrastructure upgrades to their vessels to be able to make use of shore power.

The reciprocity principle states that each human must have respect for the rationality of another and that we must not misguide the rationality of another. From the perspective of a port, such an investment in shore power technology may lead to reduced emissions in the port area, cleaner air quality, and an improved perception from the public. However, if there are not enough ships with the necessary infrastructure upgrades to make use of the shore-side power, the benefits of installing shore power from the port's view will be limited. From the perspective of a ship operator, retrofitting the ship with the required technology will improve his/her public perception as we shift to a more sustainable future, but cost will inevitably be a factor. According to EPA's 2017 report, Shore Power Technology Assessment at U.S. Ports, shipping lines are less likely to use shore power rather than diesel fuel due to "high up-front vessel commissioning costs associated with shore power, the cost of purchasing the electricity while in port, and lower cost options available such as Advanced Maritime Emission Control (AMEC) systems that scrub exhaust gases and do not require power retrofits" (EPA, 2017). In addition, a report by the European Sea Ports Organization (ESPO) noted taxation on electricity as a barrier for shipping lines to retrofit their vessels. Currently, ships that plug into shore power at ports in the EU must pay taxes on electricity, whereas electricity produced from typical diesel engines is tax-exempt (Sukharenko, 2019).

Even with these economic constraints, both the ports and the ship operators have incentives to retrofit their respective technologies to make shore power a reality. However, a violation of the reciprocity principle comes to light and creates a chicken / egg problem. Ports do not respect the rationality of ship operators (who would also benefit from shore power), and will

not invest in shore power upgrades until there are enough ships capable of utilizing the technology. Similarly, ship operators do not respect the rationality of ports (who would also benefit from shore power), and will not retrofit until there are enough ports capable of providing shore power.

While California ports have installed the required infrastructure to make shore power possible, they still find that many ships have not retrofitted their ships to make use of the shore power upgrade. To aid this dilemma, the state of California has enacted legislation to ensure that shore power is utilized. The Shore Power Regulation is a California law administered by the CARB that imposes regulations on vessels docking at California ports. From 2014-2016, 50% of any shipping line's vessel visits to each California port must shut down their auxiliary engines and plug into shore power (The Port of Long Beach, 2014). This number was increased to 70% between 2017-2019 and 80% past 2020. This law serves as a method of enforcing collaboration between ports and ship operators by law, but requires government intervention that might not be so easy to obtain for ports in other areas. Through the lens of duty ethics, this law forces ports and ship operators to obey the reciprocity principle, however other ports across the world may not be able to receive aid from such a law due to a lack of political motivation by the government.

If both ports and ship operators followed the reciprocity principle by respecting each other's rationality in decision making and realized the massive potential for a mutual benefit, both could collaboratively retrofit their respective technologies and avoid this dilemma altogether, without need for government intervention. However, the notion of implementing shore power using electricity from the power grid provides grounds for a violation of the

reciprocity principle, and as a result it is difficult to promote its implementation and collaboration between ports and ship owners.

Autonomy Without Action

According to Kant, man himself should be able to determine what is morally correct through reasoning. While individually both ports and ship operators can see the potential benefits of shore power, there lacks action on both ends to accelerate shore power adoption. Grid power serves as the biggest infrastructure challenge for implementing shore power at ports due to its volatility, both in price and in quantity. I demonstrated earlier that a shore power solution utilizing electricity from the power grid will be difficult if not impossible to implement worldwide; both ports and ship owners know that sustainability and emissions reductions are morally correct, but will not act due to the reasons I laid out earlier in this paper (autonomy without action). It is not shore power in itself that violates Kant's duty ethics; it is shore power provided by power grid electricity which breeds the violations. A shore power solution utilizing electricity from a renewable source will result in autonomy with action; both ports and ship owners will feel a moral duty to retrofit and make use of the technology.

CONCLUSION

Although the idea of shore power is revolutionary and serves as a stepping stone towards future emissions reductions in ports, the decision to provide shore power from local power grid electricity is not consistent with duty ethics. Using a duty ethics framework, I demonstrated how a shore power solution utilizing electricity from the local power grid violates both formulations of Kant's categorical imperative, namely the universality and reciprocity principles, and how such a solution leads to stagnation by both ports and ship operators.

As we move into an era characterized by an emphasis on sustainability, it is imperative that we propose sustainable solutions that will allow for quick and smooth adoption. I do envision an emissions-free future, and I thoroughly believe shore power will play a crucial role in such a landscape. As we continue to progress towards that future, we must not forget that the engineers are the ones who will ultimately get us there, and as engineers we have a duty to respect the rationality of our peers when designing solutions for a better world.

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