

Pollution from Container Ships
in the Port of Seattle:
Can Voluntary Shore Power
Use
Clear the Air?

William Orr

A Capstone project presented in partial fulfillment of the
Requirements for the degree of
Master of Arts in Policy Studies

Purpose of the Study

International trade is dominated by the maritime shipping industry. Transportation of goods and raw materials is a key component of the United Nations Sustainable Development Goals. The World Bank Group reported in 2003 that the maritime industry handles over 80% of all trade from developing nations. The economic value of these goods is over \$1.5 trillion globally. Global maritime shipping impacts over 13 million jobs directly and indirectly. ⁽¹⁾ According to the US. Department of Transportation, the United States economy used maritime shipping for 53% of imports and 38% of exports. The west coast ports of the United States account for over 48% of the container shipping into the United States. ⁽²⁾ In contrast to the positive economic impact of transporting goods across large distances at an economical scale, the maritime industry has a negative externality of producing a large amount of greenhouse gases. Most of the large ships at sea burn the lowest grade of diesel fuel to power their engines. This fuel is known as bunker fuel, and while it helps reduce operating costs to keep shipping rates lower, it also produces a higher volume of negative exhaust emissions around the world. Marine vessel emissions account for 14% of Nitrous Oxide (NO_x), 2.2% of global human-caused Carbon Dioxide (CO₂), and 5% of Sulphur Oxide (So_x) worldwide. In the United States, marine vessel pollution accounts for 7% of all NO_x and 6% of Particulate Matter (PM). ⁽³⁾

In Seattle, Washington, marine vessel air pollution most impacts the population in close proximity to the Port of Seattle, which includes residents of Pioneer Square, with a residential population of 14,431 and an occupational population of 72,060. The population of this area and the census tracts that directly border and include the Port of Seattle facility and the Duwamish River total 55,963 residents in the year 2013 census. ⁽⁴⁾ This number does not include the populations surrounding the cruise industry terminals, the downtown core, Capitol Hill, Beacon Hill, or West Seattle neighborhoods. Downtown tourism venues directly impacted by container ship pollution from the Port include visitors to Safeco Field, home of the Seattle Mariners Major League Baseball team, which had a 2016 attendance of 2.2 million plus. Century Link Field, home to the National Football League team Seahawks and Major League Soccer Club Sounders, had 2016 season

attendance over 1.2 million fans. ⁽⁵⁾ The cruise ship industry brought an additional 959,845 visitors in 2016. With the explosive residential and employment growth in Seattle, the current residential, employment, and tourism population will only increase.

The Port of Seattle Marine Division is currently undertaking a refurbishment of Terminal 5, in part to accommodate the newest and largest ocean going cargo ships referred to as the Super Containers. This Super Container ships not only carry more containers per ship, they also possess more fuel efficient engines, and more sophisticated on-board navigation equipment. The navigation equipment is tied in with global positioning satellites that monitor currents, wave size, and wind speed and direction to aid in engine efficiencies, with air pollution reductions associated with these efficiencies. All new Super Container ships are manufactured with the infrastructure and capability of connecting to shore power. ⁽⁶⁾ Shore power is defined as a ship at berth being connected to an electrical power system provided by the port of call. The main and auxiliary engines are shut down, and the on board systems for the ship are powered by electricity. Utilizing shore power eliminates the air pollution and noise associated with the ships engines and generators.

Two of the top ten ports in the world, Shanghai and Los Angeles, have entered into a voluntary agreement that all container ships would utilize shore power. ⁽⁶⁾ This voluntary agreement is perceived as a proactive policy prior to any industry or government regulation. The current policy for the Port of Seattle is for ships at a terminal is to use shore power on a voluntary basis. The reasoning for voluntary use of shore power is to not lose shipping business to other ports in the case where ships are either unable to use shore power, or if the cost of using shore power exceeds that of burning fuel while at terminal. Citizen groups have been pressuring the port to mandate shore power for all container ships in port, to reduce emissions from the use of diesel power while offloading and loading. ⁽⁷⁾ The Port of Seattle has in fact been working at decreasing emissions in the port, but their focus has been on shore side equipment and the supporting trucking industry. ⁽⁸⁾

To better understand what might be possible for the Port of Seattle, I use both the Ports of Shanghai and Los Angeles as a comparative foundation for this study, since Los Angeles and Seattle are both located on

the west coast of the United States, and the major percentage of cargo trade in Seattle and Los Angeles is with China and other Asian ports. This study will discuss the trade-off between the environmental emission reduction and the social benefits and potential negative economic loss for local stakeholders should shore power use by container ships become mandated at the Port of Seattle.

Review of literature:

Rarely is a research question such as this one a simple yes or no answer. If the answer was a simple yes, the Port of Seattle would have implemented mandatory shore power use at the same time the Port of Los Angeles and Port of Shanghai publicly announced their agreement. The review of literature in this study is to provide an overview for understanding the complexities of the maritime industry, greenhouse gas emissions by container ships and in the marine ports around the world, and alternative solutions.

What motivation is there for container shipping lines to reduce the greenhouse gas emissions of their ships? Outside of government regulation, there are three reasons for shipping companies to improve their environmental performance: social license to operate, corporate conscience, or to improve competitive advantage. ⁽⁹⁾

In a targeted survey of 17 port officials and shipping companies, one of the questions asked was to rank the most important variables that influence a shipper's decision to call on a port. In rank order, shippers' choices were most strongly influenced by geographical location, intermodal logistics, and cargo handling facilities. The term intermodal logistics refers to the system of moving freight containers between ships, rail cars, and trucks, without the need to handle the freight itself. The process speeds up transportation times, reduces handling costs, reduces inventory damage, and increases the security of the freight itself. The conclusion of the study was that to reduce greenhouse gases, ports and shipping companies both are most strongly constrained by overall costs and the time needed to unload and load a ship. For these decisions, the environment is considered a cost center in which only regulations or coincidence of environmental benefits and cost or time savings would create a preference to environmental actions on the part of shippers or port managers. Consequently, a port with Environmental Management Systems in place are only of value to a

shipping company if those systems add to efficiencies, creating faster service, and/or providing a competitive advantage. ⁽⁹⁾

Ship operators who do wish to participate in shore power programs while in port, by whatever motivation mechanism, are confronted with challenges that go beyond the cost of adding shore power systems during ship construction or retro-fitting an older ship. The global industry's lack of standards between ships and shore hardware limits where the ship can utilize shore power. Any ship calling on multiple ports needs to carry multiple connection systems that require more cost, more crew time, and impacts the turnaround time for the vessel. The ability of ports to deliver adequate power distribution to accommodate the service load requirements of a vessel varies from port to port. ⁽¹⁰⁾

The role of the ports themselves plays a much larger role in the shore power question, and the maritime industry goals to reduce greenhouse gas emissions globally. Shore power is only as clean as the production of the electricity. In a study by David Gibbs et al, as of 2014, in the United Kingdom, container ships were idling in port, burning bunker fuel in their main and auxiliary motors. The public policy demands in the UK were heavily focused on shore power to improve air quality, particularly in heavily populated ports such as London. In contrast to many renewable sources of clean electricity in the UK, many of the ports rely on the burning of fossil fuels to generate their electricity. Here is a quote from The United Kingdom House of Commons Environmental Audit Committee (2009; 33) "The provision of electricity to ships in berth is not a priority for climate change policy. Until grid electricity is decarbonized, it would have little impact on carbon emissions, unless ports installed new renewable energy generating infrastructure; while this would be welcome, there might be considerable practical and economic obstacles in doing so, especially at existing facilities". ⁽¹¹⁾ At the time, the United Kingdom did not have reduced low-sulphur fuel requirements for ships hoteling or berthed in port, and the study referenced the fuel switching and speed control success in the Port of Los Angeles. Fuel switching and vessel speed controls will be discussed later in my study.

This study also highlights the complexity of the subject. The container ship emissions in the UK were aggregated into the total port traffic emissions including passenger and freight, domestic and international.

Unlike the shore side greening efforts in the United States, the prevailing opinion in the UK is the port operation emissions are a minor share of the total, less than 2%, making the container ships look like an obvious target for emission reduction policies. This stands in stark contrast to Gothenburg Sweden, where the shore side emissions are estimated by their own port authority to be at approximately 70%. This huge discrepancy is easily explained. In Gothenburg, all ships are shore powered by clean and renewable wind generated electricity, not bunker fuel idling ship engines. ⁽¹¹⁾ Clearly, emissions mitigation plans need to review emission sources in a port as a whole.

Shore power and the source of electric power generation, and container ship emissions are not the only source of total port emissions. Mitigation plans, voluntary or regulatory need to review emission sources in a port as a whole. While total port emissions vary from port to port, the U.S. Department of Commerce port base model has trucks producing 40% of all emissions, cargo and handling equipment 23%, railroads in and around ports 4%, and the remaining 33% of emissions are generated by all marine vessel traffic. ⁽²⁾

Much of the effort to reduce emissions in the Port of Los Angeles comes from enormous efforts to reduce air pollution in the area, with extensive regulatory effort devoted to monitoring air quality in the region. A comprehensive study of green truck regulations and the goods movement corridors of the Port of Los Angeles/Long Beach has been widely cited as a standard for emerging best practices. The emission data was gathered next to the roadways and freeways used heavily to transport containers, utilizing the Southern California Air Quality Management District (SCQMD) air monitoring stations. ⁽¹²⁾

One of the major strengths of this study lies in the fact that California itself has vast amounts of historical data, and extensive air monitoring sites. The research team had a sizeable control area that the shipping industry does not impact. The researchers were able to access before and after policy implementation data as well as pre 2008 economic downturn. Shipping volume and pollution was rapidly increasing prior to 2008, took a dramatic downturn in the economic recession, followed by steady increases of shipping volume. The study was able to control for the disruption in overall volume to determine the policy

intervention in "Green Trucks", port queuing, and port side equipment replacement, and the difference was statistically significant. ⁽¹²⁾

In Seattle, a comprehensive air quality study was conducted finishing in 2007, using the Washington State Department of Ecology Air Monitoring sites surrounding the Port of Seattle. It was an exhaustive study measuring for airborne soil, diesel emissions, wood smoke, aged sea salt, metal processing and oil combustion. The team also measured wind speed and direction in their study. The results of their study clearly pointed towards the Port of Seattle and some influence of ship emissions. The findings could not specifically identify the emission sources such as shore side equipment, ships, drayage trucking, or rail. ⁽¹³⁾

The next area of literature research was to study the emissions of container ships themselves. Container ships emit 92% of their greenhouse gas emissions while under power at sea. Shipping companies which operate on very tight margin, log fuel as their number one expense, comprising up to 70% of their operating budget.

Once again, we find a study from Southern California that is cross referenced in numerous articles published around the subject of the maritime industry and the goal of reducing greenhouse gases. This study is the most exhaustive research I found. Utilizing the vessel, the "Magrethe Maersk" was used as an intercept vessel off the coast of the Port of Los Angeles, by flying a NOAA WP-3D aircraft directly through the exhaust plume of the ship to measure emission changes as a result of fuel switching and speed reductions.

Fuel switching from bunker fuel to Marine Diesel Oil (MDO) in the coastal region resulted in the reduction of particulate organic matter by 70%, black carbon reduction of 41%, and a 90% reduction of SO_x. Current federal regulations in the United States now require all vessels make this fuel switch from bunker fuel to MDO inside of 45km of all coastal waters. ⁽¹⁴⁾

Prior to this study, container ships would operate under full power towards the Port of Los Angeles to reduce overall time at sea, and the studied ship "Margarethe" would normally travel at 25 knots in to the port. The speed of the vessel was reduced to 12 knots at the same location of regulated waters. The results of the VSR testing was an additional 56% reduction in particulate matters. The combination of fuel switching

and speed control at the 45km regulated water line resulted in the overall reduction of greenhouse gases by 96%. The additional benefits of speed control have led to a voluntary VSR program to incentivize ship operators by offering discounted berthing rates at the Port of Los Angeles and Long Beach. ⁽¹⁴⁾

Are there alternatives to bunker fuel and low Sulphur diesel? Alternative Fuels such as Liquefied Natural Gas and Hydrogen are being researched as a fuel source for marine vessels. While these fuel sources promise dramatic reductions in greenhouse gas emissions, and lower fuel cost to the operators, the physical and engineering of the fuel cells and engines appear to only work for short haul vessels, and the configurations are not suitable for ocean going container ships. ⁽¹⁵⁾

Battery cell technologies are being used and studied as an Alternative Marine Power (AMP). While the ship is at sea under main engine power, the battery fuel cell is being charged. When in port, there is no need for connections, no hardware issues, and the cells power the ships berthing functions. This emerging technology has a promising future, but currently has its own limitations. The size and weight of battery cells in the hull of a container ship is still problematic. A ships fuel efficiency increases as the fuel is spent, but the battery weight remains constant. The production of batteries, as well as the disposal of spent battery cells, still poses an environmental impact trade off that is unclear. ⁽¹⁶⁾

Terminologies:

AMP: Alternative Marine Power

IMO: International Maritime Organization

VSR: Vessel Speed Reduction

MGO: Marine Gas Oil .5% sulfur content

MDO: Marine Diesel Oil 1.5% sulfur

EMS: Environmental Management System

Alternatively, battery cell barges, to be used in port, show a promising start. While a container ship, or any other type of vessel, is hoteling in harbor or at berth, the barge rafts next to the container ship and supplies the necessary electricity to power the vessel of any type. ⁽¹⁶⁾

What is still unknown is how the container shipping industry impacts the Port of Seattle economically, what are the current practices in the Port of Seattle are to reduce greenhouse gas emissions, and how the use of shore power by the container shipping industry could improve Seattle air quality by reducing greenhouse gas emissions, and allow the port to remain profitable and continue to grow. These findings could prove to be of interest to other ports.

Methodology

To understand the global state of the maritime shipping industry, the global economic and environmental impact of container shipping, I conducted a literature and archived studies-based method of academic and industry sources. Exploring the motivations and impacts of enacting policies that require shore power, I used the Port of Los Angeles/Long Beach as a comparative case study. This port was the first US port to mandate shore power. Further, the state of California, with its more stringent air quality regulations, also provides access to additional case studies and data relevant to my study.

To evaluate the impact of shipping traffic on local air quality, and the potential improvement in air quality, I analyzed air quality data publicly available from the Washington State Department of Ecology in relation to the vessel traffic report at the port. My air quality study was conducted over a twenty-nine-day period beginning on April 3, 2018, and ending on May 1, 2018. I utilized the Washington State Department of Ecology air monitoring sites at 10th and Weller, Duwamish, and Beacon Hill. These sites were also used in the ambient fine particles study from 2008.

Not all sites had the same variables to measure, but Beacon Hill has the most complete monitoring site, even though it is the furthest from the port. Measurements were obtained hourly for: Nitrous Oxide: NO_x, Nitrous Dioxide: NO₂, Sulphur Dioxide: SO₂, Wind Speed, and Wind Direction. The Northwest Port Alliance Vessel Schedule was used to document the hourly detail of container ships at berth, loading and unloading. The shipping schedule and atmospheric monitoring data were combined onto an excel spreadsheet. I could not identify any statistical relationship between the number of container ships at berth and any increase or decrease to air quality.

Results and Discussion

Global industry results

The International Maritime Organization, known in the industry as the IMO, is a specialized agency of the United Nations responsible for the regulation of shipping. Environmental concerns are one of the areas the IMO is chartered to develop and maintain a global regulatory framework. Since the 1967 grounding of

The *Torrey Canyon* in the English Channel, and the increased quantities of oil tanker shipping of crude oil, the organization has been primarily focused on oil pollution at sea and in coastal areas. Secondly, water pollution and the transfer of invasive species through ballast water release have also been major environmental concerns. As a result of the Paris Climate Agreement, the IMO is currently in its initial data-gathering phase to reduce greenhouse gas emissions as a result of maritime activities. The IMO study and subsequent actions are due by the year 2020. The IMO has set ongoing greenhouse gas reduction targets, but any policy implementations and/or recommendations that include shore power will be after the study is complete. There are over 2000 ports around the world, and the IMO has 173 member states which complicates their mission in terms of compliance and enforcement. ⁽¹⁷⁾

Another global constraint for the container shipping industry is the ability of ports to deliver adequate power distribution to accommodate the service load requirements of a vessel varies from port to port and ship to ship. Adequate power, coupled with a lack of clear IMO standards for hardware systems to connect a vessel to a port's electricity delivery systems, ship operators and port operators are confronted with a disincentive to participate in shore power due to the expense of buying multiple connection hardware systems, and the increased time and labor cost required to switch depending on the port of call. Beyond inconsistent standards, the economic cost of making a vessel capable of using shore power is a substantial barrier. The cost to retrofit older ships is prohibitive for most vessel operators with figures ranging from \$1.5 to \$5 million to retrofit a container ship. ⁽³⁾ Some of the older vessels are not shore power upgradeable.

Shore Side Electricity must also be clean, and the world's ports vary widely in both carbon emissions and pollution emitted in the generation of electricity used at the port. The industry and port authorities face the range of extremes from Gothenburg, Sweden having 100% green renewable wind generated electricity to the UK, where Scotland has renewable energy sources and some ports have dirty power sources, where idling container ships actually pollute less than if shore power was used.

With a lack of standards in the area of shore power for both ports and ships, the industry is also focused on a range of options for ship based Alternative Marine Power, including Liquefied Natural Gas

(LNG), Hydrogen, and battery power. These alternatives would provide emission reductions regardless of the Port of Call capability to deliver clean electricity. Prototype ships and engineering models using LNG and Hydrogen for fuel sources have similar outcomes. Both fuels are less polluting and less costly than bunker fuel and low sulphur diesel, but both fuel sources carry unique engineering requirements for mechanical space and for safe fuel storage. The current state of studies and results indicate these two fuel sources would only work in short haul vessels, not in trans-oceanic container ships. ⁽¹⁵⁾

There has been an ongoing experiment with hydraulic docking systems to reach out to the ship and gently pull it to the berth, and eliminate the need for and the emissions produced by tug boats in port. This alternative may be of value in certain ports with conducive tide and currents, but this is neither a universal option, nor is the environmental value of this technology very high, given the small contribution of tug boat emissions to the overall emission burdens. ⁽¹⁵⁾

One alternative energy source that is showing promise is the use of battery cells on board ships and portside barges. The theory is a container ship would have enough battery power to run ship operations in port, and then recharge itself under main engine power back at sea. The current challenge is the amount of space and weight of the batteries in the ships' hull. A container ship at sea actually becomes cleaner relatively speaking as it consumes fuel, and the overall ship lightens. Batteries stored in the hull will not change weight, so operational efficiencies are reduced.⁽¹⁶⁾ The environmental impact of battery production and end of life disposal was not discussed in any of the studies I read.

A very promising use of battery power is in the form of battery barges in port. These barges would be rafted alongside any marine vessel hoteling or berthing in port, and this would become the power source. ⁽¹⁶⁾ However, the challenges of a lack of standards on connecting, and limitations on a ship by ship basis are similar to the challenges with shore power.

When discussing shore power and alternative marine fuel, it is important to understand the full life cycle of emissions from a container ship on round trip. The vast majority of total ship emissions (92 %) of take place while the ship is at sea, powered by burning bunker fuel. In areas such as the coastal region of the Port

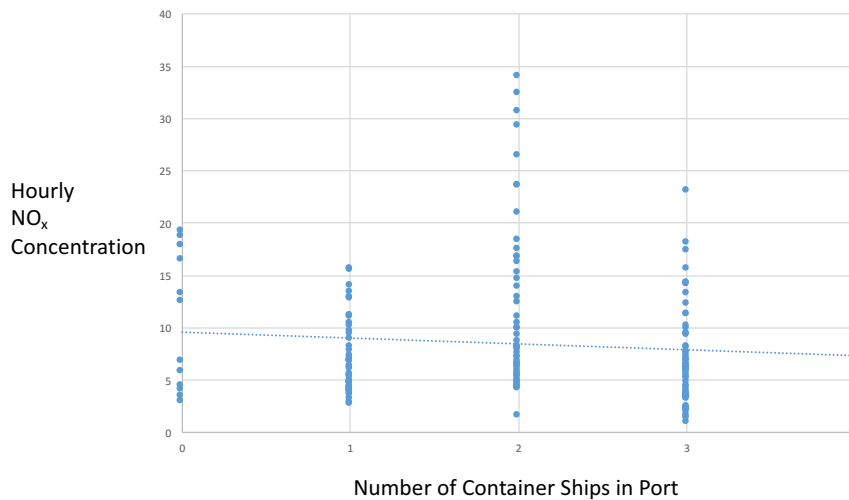
of Los Angeles, and the inner waters of Puget Sound leading to the Port of Seattle, vessel speed reduction programs eliminate 45% of the remaining 8% of emissions. The U.S. Federal mandatory fuel switching to low Sulphur diesel brings additional 42% reduction in emissions, leaving less than 3% of emission when the ship is hoteling or at berth. ⁽¹⁾

Container ships are not the sole source of greenhouse gas emission at ports; the ports themselves generate significant emissions. When looking at a port as a single entity, U.S. Department of Transportation lists the total emissions break down as follows: Trucks produce 40% of all emissions, cargo and handling equipment 23%, railroads in and around ports 4%, and 33% of emissions are generated by all marine vessel traffic. ⁽²⁾ The IMO, the marine industry, and port authorities all recognize these pollution generating sources.

The Port of Seattle has shown similar patterns to those found by the U.S. Department of Transportation studies. In the 2008 Seattle Community Green House Gas Inventory by sector, emission sources were quantified and allocated for the downtown Seattle area, including the Port of Seattle. Road transport was the number one category, accounting for 40% of emissions, with this statistic broken down to passenger vehicles at 22% and freight at 18%. Non road transport, which includes all marine vessels, aircraft, and portside equipment and activities accounted for 22% of the greenhouse gas emissions. Building energy, a category responsible for heating, electricity, operations, and construction was responsible for the remaining 21%. One emission source potential was not discussed in the 2008 Inventory is the potential role of Boeing Field and SeaTac airports. Departing and arriving aircraft fly over the studied area, and emissions from ground operations could have an impact on the area depending on wind direction and speed.

The results of my air quality data analysis showed no relationship between measured pollutants and the number of container ships at berth. These results are reinforced by the 2008 study results. Utilizing the available air quality monitoring sites, while pointing towards the port and other vessels, I was unable to assess what portion of emissions are from container ships, and what emissions are from a multitude of other vessels in port, as well as other sources of pollution. ⁽¹³⁾

Data Sample from Beacon Hill Station April 13-20, 2018



This does not mean shore power emission reductions would be insignificant, it just proves the difficulty of quantifying those emissions. Separating the container ships emissions from all of the other vessels in port, let alone the other emission sources, would be extremely difficult, and require a different study. My limitations, and what could be included in future studies would be finding a way to isolate the container ship emissions from the rest of the port activities. The use of portable monitoring devices would have the ability to move closer to the vessels, compensate for wind speed and direction, select the desired emissions to measure, and accommodate any lag time that I was unable to obtain.

The next important step in this study is to identify what emission control programs are in place at the Port of Seattle. The first step is to identify the programs that directly impact the container ships. Secondly, what programs are in place on the shore to reduce greenhouse gases.

As demonstrated in the study using the "Margarethe", the two programs that directly affect vessel emissions are fuel switching and vessel speed reduction (VSR) programs. Both programs are already in place for the entire Puget Sound waterway leading to the Port of Seattle. With these two policies in place, the remaining 3% of a container ships emissions that could be minimized or eliminated are the ones associated with the berthing process involving tug boats, and using shore power at berth.

I have a personal observation that validates the difficulty of quantifying and separating the container ship emissions from all other vessels and activities. The Port of Seattle has a brisk bulk hauling grain business. At times there will be one ship loading at berth, and three ships hoteling in Elliot Bay. The loading process of these grain ships takes up to 4 days, unlike the container ships that turn around in 12-36 hours. The ships hoteling can be in the bay for up to 10 days depending on the ships arrival, waiting to load, and waiting for the grain terminal to be stocked. A quick back of the envelope analysis tells us that these ships hoteling, running on their generators are contributing far more emissions than a container ship on a per ship visit basis.

Given the constraints and relative costs and benefits of varying options, what on-shore programs does the Port of Seattle engage in? The Green Port Initiatives include the replacement of port owned and operated equipment. The Port of Seattle On Dock Rail has upgraded rail and other port located rail systems. Diesel burning rail engines have been replaced with cleaner LNG powered locomotives. The Port of Seattle On Dock Rail system has replaced 200,000 miles of truck trips on an annual basis. ⁽⁸⁾

The equipment owned and operated by the Port of Seattle are on a continual replacement cycle. The Port's annual budget has a line item for continued replacement of aging equipment with either electric battery power or LNG as its fuel source, eliminating diesel burning equipment. The cranes on the docks are not owned by the Port; the portside real estate is leased to private companies to operate. Working with the lessees, 80% of the cargo handling cranes have been upgraded to the highest environmental standards of the industry, and the new cranes at Terminal 5 will be of the highest standards. ⁽⁸⁾

Similar to the Green Trucks program in Los Angeles, the Port of Seattle has a similar implementation. As stated on the Northwest Ports Alliance Green Ports environmental stewardship web site:

"The 10-year-old Northwest Ports Clean Air Strategy established a goal that 100 percent of the drayage trucks serving container terminals would have cleaner diesel technology – a 2007 engine with diesel particulate filter or equivalent. In 2010, we achieved the first goal in the Northwest Ports Clean Air Strategy that all trucks be at least a model year 1994 or newer. Since that goal was set, we have invested more than \$15

million in matching grant funds to spur truck conversion and invest in gate infrastructure. More than 410 trucks were scrapped and replaced with new trucks through partnership with the Puget Sound Clean Air Agency." (8) There were no studies found on the effects of Green Trucks in the goods movement corridors surrounding the Port of Seattle; similar results to the goods movement corridors in California seem likely. The Northwest Shipping Alliance reports the combined effect of all their programs has been to reduce diesel particles by 80%, and overall greenhouse gas reduction of 15%. (8)

Economics:

What role does the Port of Seattle have in the local and regional economy? In 2015, The Washington State Department of Commerce reported the maritime industry was accounted for 22,300 jobs, and extends outward to 48,000 regional jobs. These jobs represent over \$1.5 billion in wages to the area. The overall economic value to the region is \$5.2 billion in revenue. (18)

The top three import items at the Port of Seattle are (1) defense related aircraft parts, (2) furniture, and (3) shoes. The valuation of all imports in 2015 is placed at \$15.226 billion. On the export side of the equation, the value of exported goods was \$6.1 billion. The top three categories are civilian aircraft parts, agriculture products, and articles of stone and mineral. (19)

Looking at the global interconnectedness of international maritime trade, the top three trading partners with the Port of Seattle are China, as the top trading partner, accounting for 47% of trade; Canada is the second largest partner with 11%; and South Korea is the third largest trading partner with 7.9% of the trade. Rounding out the rest of the top ten in order are Japan, Australia, Taiwan, Italy, Vietnam, Indonesia, and Hong Kong. (19)

Shore use policy: a comparison among ports

What are the similarities and differences between the Port of Los Angeles' voluntary and the Port of Seattle's use of shore power? The two ports share many programs in common for the reduction of greenhouse gases at the port and with container ships. There are many similarities in the economic position of both ports, but there are also some key differences.

Common Best Practices of the Port of Seattle and Port of Los Angeles

- Fuel Switching in coastal waters and in port.
- Vessel speed reduction controls entering coastal waters.
- Green Trucks initiatives.
- Green Port initiatives: Port Equipment replacement programs.
- Truck and drayage traffic controls reducing truck idle time and emissions.
- Ship to truck unloading and loading efficiency programs to reduce vessel time at berth.

As the studies have shown, the practice of fuel switching and vessel speed reductions yield the greatest reduction in the emission cycle of a container ship. The policy programs of Green Trucks, Green Ports, and traffic controls to reduce port emissions are used by both ports, and are very effective tools. The traffic controls and upgraded port equipment also serve the shippers in quick and efficient loading and unloading the containers, resulting in quicker turnaround times for the vessels. Both ports have similar efficiencies with their intermodal logistics and cargo handling facilities, although the scale is much larger in Los Angeles.

However, there are critical economic differences between the Port of Seattle and Port of Los Angeles that would lead the Port of Seattle's to have a voluntary, rather than mandatory shore power usage policy. Overall, these stem from fear of losing business should such a policy be mandatory in Seattle, while this fear is not an overriding factor in Los Angeles. One reason for this difference in policy is scale and competitive advantage. The Port of Los Angeles and Long Beach is the #1 port in the United States. In review, the number one criteria for shipping companies was location, to speed delivery of the cargo to the end market. The freight destination breakdown for the Port of Los Angeles is 80% of the containers have an in-market destination. The market destination for this freight is not just Southern California, but also includes Arizona and Southern Nevada. (20)

When analyzing the freight distribution in the Port of Seattle, we find a very different distribution pattern. Only one-third of the inbound container destination is the Seattle and Northwest areas. The port is

used to offload utilizing the intermodal logistics of Seattle, and then 66% of the freight is sent off elsewhere in the United States. ⁽²⁰⁾

This large percentage of incoming containers to Seattle not being in-market, but destined for other locations in the U.S., suggests the Port of Seattle is vulnerable to losing this business to other ports. During the West Coast Port's slowdown of 2016, with a potential strike and complete shutdown looming, the shipping companies' response was not to slow the amount of containers to match the slow down, but to divert their ships through the Panama Canal to the Gulf and East Coast Ports, further reducing west coast shipping. From the survey of Port Authorities and shipping companies referenced earlier in this paper: Container carriers have the scale, and they seek fewer and less costly ports. The competition between Los Angeles/ Long Beach, Oakland, Portland, Seattle/Tacoma, and Vancouver B.C. is intense. A quote from a Port Authority: "*We are pawns in this game, the shippers call the shots.*"⁽²¹⁾

While the Port of Seattle does not have the scale of Los Angeles, it does offer some competitive advantages in west coast container shipping. First, the trip to the Port of Seattle is one day shorter than the California ports, reducing a container ships round trip by two full days. This trip duration advantage gives the shipping company the opportunity to make more money, by reducing fuel and labor costs. The Port of Seattle and Tacoma are also the #1 gateway for refrigerated exports. The infrastructure is used primarily for the agriculture exports of the Northwest farming industries.

These first two competitive advantages are straight up business decisions based on cost & benefit, logistics and timing differentials between ports. There is one more advantage for the Port of Seattle. In a very large survey of 1200 shipping companies, the Port of Seattle was ranked #1. The key factors cited were fast and efficient terminal operations, good port facilities for their ship crews and land personnel, and the port personnel were recognized for their strong relationship building and their willingness to work together and problem solve. ⁽²²⁾

How does this all fit with the Port of Seattle's fear of losing business? Close to 100% of exports and 33% of imports are all in-market goods. It would be a reasonable projection to say these imports and exports

would not be affected by enforcing mandatory shore power. What is unknown, and may never be known, is what could happen to the remaining 66% of import containers that move out of the area to the rest of the country. That quantity of freight could in fact be diverted to other ports at the will of the shipping companies.

(20)

Conclusion:

The Port of Seattle is following a path of best practices as identified in my research. Fuel Switching and vessel speed reduction has reduced container ship emissions down to, according to my estimates, below 3% while the ships are berthed in the Port of Seattle. This does not mean it is an insignificant amount of pollution, or unworthy of policy change, but the Port of Seattle's fear of potentially losing business by mandating shore power seems real. The emphasis from the Port of Seattle on shore side activities such as Green Trucks, replacement of port owned equipment, and on dock rail, have been proven to be very effective in improving overall air quality, not just localized at the port but regionally as well. Constant logistics improvements to reduce truck idle time, clean and green equipment on shore ensure efficient loading and unloading, and reduced vessel time at berth. Shorter time at berth reduces emissions and is a prime feature for retaining and attracting additional business.

Recommendations

My first recommendation to the Port of Seattle would be to continue with the current voluntary shore power program and not jeopardize losing business that could have devastating effects to our local economy. Federal, State, and Local government could force a mandate, but the Port should remain steady, but look for a source of funds to incentivize capable ships to use shore power. As the shipping industry grows, and more Super Container ships that are shore power capable, make their way into the market place, marketing and attracting these ships to the Port of Seattle would be a worthwhile strategy. It is clear the Port of Los Angeles has not suffered any business loss.

My second recommendation is to continue looking for improvements in the current Green Port and Green Trucks programs. Both programs are within the control of the port, are already in place, and are producing desired results.

My last recommendation is to hold off on any policy changes that impact the shipping companies until after the IMO releases their 2020 plan. Until the global maritime industry policy changes are known, the shipping industry has proven they will look for work-around solutions by calling on other ports.

Implications for the future and green-house gas emissions in The Port of Seattle.

The industry studies have proven that container ship emissions have been greatly reduced in port. What is unclear and unknown are the other marine vessels in Port. In particular, the other bulk carriers operating in the Duwamish River berths, and from my personal observations, the grain haulers. The grain ships hotel at idle for long periods of time, up to 7-10 days, with up to 3 ships hoteling while one ship is loading, or waiting for grain silos to be filled. Emerging technologies offer up potential for further emission reductions. Battery cell barges, to be used in port, show a promising start. While a grain ship is hoteling in harbor or at berth, the barge rafts next to the vessel and supplies the necessary electricity to power the ships in port functions. Additional battery technologies and applications are happening in the trucking industry. With the mandate of the European Union to eliminate diesel as a fuel in all vehicles, electric trucks are making the way into the market place. Here in the United States, Tesla has announced electric trucks are under development. Both FedEx and UPS have placed futures orders to add these new trucks to their delivery fleets. I can already envision an all-electric fleet of drayage trucks at the Port of Seattle, moving the containers out of the city to a long haul distribution center.

Citations:

(1) Diane Bailey, Gina Solomon *Ports: Clearing the Air* Environmental Impact Assessment Review 2004

(2) United States Department of Transportation

- (3) M. Morsy El Gohary; Ibrahim Sadek Seddiek *Utilization of alternative marine fuels for gas turbine plant onboard ships* Published: International Journal of Naval Architecture and Ocean Engineering Volume 5, Issue 1, March 2013
- (4) U.S. Census Bureau 2013
- (5) Seattle Downtown Association
- (6) Linder, Alison J. *Linking Participation, program design and outcomes, voluntary air quality programs at the Ports of Los Angeles and Long Beach* University of Southern California August 2010
- (7) West Seattle Blog May 23, 2016
- (8) North West Seaport Alliance Web Site: nwseaportalliance.org
- (9) Adams, Michelle; Quinonez, Pablo; Pallis, Athanasios; Wakeman, Thomas
Environmental Issues in Port Competitiveness
Atlantic Gateway Research Initiative Working Paper 7 Dalehouse University June 3, 2014
- (10) Khersonsky, Yuri; Islam, Moni; Peterson, Kevin IEEE Transactions on Industry Applications (Volume 43, Issue: 3, May-June 2007).
- (11) David Gibbs, Patrick Rigot-Muller, John Mangan, Chandra Lalwani
The role of sea ports in end-to-end maritime transport chain emissions
Energy Policy 64 (2014)
- (12) Jason G. Su, Ying-Ying Meng, Melissa Pickett, Edmund Seto, Beate Ritz, and Michael Jerrett
Identification of Effects of Regulatory Actions on Air Quality in Goods Movement Corridors in California
Environmental Science and Technology 2016
- (13) Eugend Kim, Philip K. Hopke *Source Characterization of Ambient Fine Particles at Multiple Sites in the Seattle Area* Center for Air Resource Engineering and Science, Clarkson University March 20, 2008
- (14) Daniel A. Lack, et al. *Impact of Fuel Quality Regulation and Speed Reductions on Shipping Emissions: Implications for Climate and Air Quality* Published in Environmental Science & Technology September 12, 2011.

(15) M. Morsy El Gohary; Ibrahim Sadek Seddiek *Utilization of alternative marine fuels for gas turbine plant onboard ships* Published: International Journal of Naval Architecture and Ocean Engineering Volume 5, Issue 1, March 2013

(16) Yousri M.A. Welaya; M. Morsy El Gohary; Nader R. Ammar *A comparison between fuel cells and other alternatives for marine electric power generation* International Journal of Naval Architecture and Ocean Engineering Volume 3, Issue 2, June 2011

(17) International Maritime Association

(18) Washington State Department of Commerce

(19) ustrade#.com

(20) Patrick Sherry, Joseph Szyliowicz, Andy Goetz, Page McCarley *A Case Study of the Intermodal Issues Facing the Puget Sound Region and The Port of Seattle* University of Denver December 21, 2006

(21) Peter V. Hall *Geo Journal* 16 October 2008

(22) *Marine Digest & Cargo Business News* (2003)