Williams College-Mystic Seaport Maritime Studies Program's
Marine and Coastal Policy Research Group

Pollution in Port: Cruise Ship Emissions - Problems and Solutions

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EXECUTIVE SUMMARY

Cruise ships have an astounding impact on air pollution - in 2017, sulfur oxide emissions from Carnival cruise ships around European coasts totaled ten times that of all European cars that same year.[1] But they also bring massive economic injections into port cities, generating $4.2 million worth of economic activity every time a cruise ship docks at the Port of Seattle.[2] With 214 cruise ship berths at the Port of Seattle in 2019, it totals almost $900 million annually.[3] Cruise lines, local officials, environmentalists, and community members all have a stake in cruise ship industry operations - air quality protection and minimizing long term climate change impact is being balanced with the economic value of the cruise industry, leading to a wide range of approaches that address the issue.

Current solutions involve global sulfur regulations, the use of cleaner and more expensive fuel, exhaust gas cleaning systems that remove sulfur oxides from emissions, liquified natural gas that minimally affects air quality, and localized shore power systems that allow ships to draw from the port city's electrical grid. But none of these methods implement a comprehensive solution that solves both air quality and greenhouse gas emissions, while at the same time being economically viable to allow for implementation on a large scale. Methods that only solve air quality issues leave concerns for environmentalists who worry about longer term greenhouse gas issues. Ships that

Cruise ships in Port Melbourne, Australia. (source: https://research.qut.edu.au/ilaqh/projects/koala-sensors-port-of-melbourne/)

use scrubbers introduce concerns over water quality, and solutions that use liquified natural gas cause concerns for citizens who see it as "bringing a bomb to the waterfront".[4]

Port cities along cruise routes would strongly benefit from forming a coalition that provides a "network of incentives" that encourages the establishment of large-scale shore power infrastructure, giving economic viability to the solution that satisfies all stakeholders.[5]

CONTEXT OF THE ISSUE

The cruise ship industry provides essential business for many coastal destinations around the world. At the Port of Seattle alone, each docking creates $4.2 million in economic activity, which adds up to almost $900 million annually.[6] But when these ships come to port, they idle for many hours while they restock, load and unload passengers, and give their customers time to explore the area. All the while these ships are consuming immense amounts of power, usually produced by burning fuel, which then has significant impacts on local air quality. The heavy fuel oil that ships burn "contains sulphur which, following combustion in the engine, ends up in ship emissions. "Sulfur oxides (SOx) are known to be harmful to human health, causing respiratory symptoms and lung disease. In the atmosphere, SOx can lead to acid rain, which can harm crops, forests and aquatic species, and contributes to the acidification of oceans."[7] In Long Beach, CA, the second-busiest container port in the U.S., "14 percent of residents suffer from asthma, compared to 12.5 percent in Los Angeles and 8 percent in the U.S."[8] Ports must balance the economic benefits with the impact on humans and the unquantifiable environmental damage, ideally finding a solution that manages to encourage business while limiting pollution.

In an effort to mitigate the negative impact of global shipping on air quality, the International Maritime Organization (IMO) has set restrictions on sulfur content in fuel, reducing the amount of sulfur oxides that can be emitted from combustion. In January 2020 a new IMO regulation took effect for all member states, requiring their ships' fuel not to exceed 0.5% sulfur content by mass, as opposed to the previous limit of 3.5%.[9] However, IMO regulation "allows [member States] to approve 'equivalents'", such as "accepted and approved scrubbers - otherwise known as 'Exhaust Gas Cleaning Systems', [in order to meet] the requirements for sulphur oxide reduction".[10] These scrubbers filter exhaust by mixing it with seawater (washwater) which absorbs the sulfur

Map of existing and possible future ECAs as outlined in MARPOL VI and by the IMO's Marine Environmental Protection Committee, 2012.15 (source: https://www.amnautical.com/blogs/news/5833134-north-american-eca-will-change-shipping-forever#.XsdfqhNKh25)

oxides before the exhaust is ultimately released into the atmosphere.

In order to meet this sulfur requirement, ships are now choosing between using cleaner, more expensive fuel and investing in scrubbers. However, ships that opt for scrubbers are causing concerns over water quality. Washwater from scrubbers gets discharged into marine ecosystems, and while discharge requirements are in place for pH and nitrates, much goes unregulated on a global scale.[11] For example, "the IMO requests shipowners to sample and analyze washwater for a suite of metals".[12] Clearly these metal pollutants cause concern, yet there are no IMO regulations, only requests. Despite the IMO continuing to study potential impacts from washwater discharge, it is difficult to understand the full effects and it remains a possibility that damage is being done in ways that haven't yet been discovered.[13]

While cruise ship emissions are a global issue, the situation is not the same everywhere. Certain locations have additional rules and regulations in place that offer more protection while others are only governed by global IMO standards. For example, the IMO's international convention in 1997, MARPOL VI, established Emission Control Areas (ECAs) off the coasts of North America and in the Baltic and North Sea.[14]

In the ECAs, IMO regulations established in 2015 require sulfur content in fuel oil used on board ships to be no greater than 0.1% by mass, five times less than the current global requirement and thirty-five times less than the global requirement that was in place from 2012 through 2019.[16] In addition to location-specific requirements from the IMO, different localities also create their own regulations. In the Pacific Northwest, the Washington state government has established a no-discharge zone in Puget Sound, meaning that wastewater from ships, treated or not, is prohibited from being released into the water.[17] The multilayered levels of regulation introduce complexities that make each port different.

The unique situation at each port heavily depends on local stakeholders including cruise lines, local officials, environmentalists, and community members concerned about local air and water quality. On the business side, the livelihood of a giant economic motivator is at stake. On the environmental side, pollution has real and imminent dangers as seen with the nearly doubled asthma rates in port cities.[18] There are high stakes on both sides of the issue, which is why it's imperative that this situation is handled correctly.

CRITIQUE

Many different approaches across multiple levels of government are being taken to combat this issue, ranging from temporary mitigations to long-term solutions. On the global scale, the air pollution issue is primarily addressed with sulfur regulations, leaving member states to independently implement further measures that mitigate environmental concerns. One such measure is shore power, which enables cruise ships to plug into the power grid of the port city, eliminating the need to burn fuel in port. Another is transitioning to liquified natural gas, which burns much cleaner and emits zero sulfur oxides. However, many of these methods also include drawbacks that introduce new problems, and some are difficult to implement on a larger scale.

Despite the IMO's increasingly strict regulations, the impact is minimal. Advancement of these regulations is too slow because they're severely limited by the member states who struggle to implement the necessary changes. Although the IMO is capable of using a phased approach such as with Environmental Control Areas, it must provide a solution that works for all member states. A primary motivation for joining the IMO and being subjected to these regulations is the understanding that everyone is treated equally and that all are working together to reach a common goal. The system falls apart if not all member states are able to comply with IMO regulations. This means that progress is restricted by the weakest members. For example, a major challenge in implementing the 2020 global sulfur limit was ensuring that all member states had the required refinery infrastructure to provide compliant fuels to ships, as poorer countries struggled to implement required changes.[19]

While baseline improvements do make a positive impact, for many states already ahead of those baselines such as the U.S. and Canada, these regulations are overdue and don't have any impact. It might take decades for the global baseline to reach the current levels in Emission Control Areas. Even still, sulfur regulations only solve half of the problem - air qual-

Cruise ships docked at Seattle's Terminal 91, which is equipped with shore power infrastructure. (source: https://www.portseattle.org/places/smith-cove-cruise-terminal-pier-91)

ity is reduced, but nothing is changed in the way of greenhouse gas emissions and wash water discharge.

In order to completely eliminate emissions in port, high-voltage shore power has been implemented at ten ports across the U.S. as of March 2017.[20] When using shore power, cruise ships disconnect their fuel-burning power systems and instead draw from the port city's electrical grid. While this appears to be an effective way to reduce emissions, it heavily depends on how the city gets its power. At the Port of Seattle, over ninety percent of electricity is generated from hydroelectric power, and in this case shore power is the "silver bullet"[21]. But in other ports like New York Harbor, the energy source is not as clean. Less than "23 percent of New York's electric power today comes from a variety of renewable sources".[22] Avoiding emissions in port at the expense of burning fossil fuels at the power plant does not solve greenhouse gas and air quality issues, it only moves the problem elsewhere.

In the few cases where shore power could operate in a best case scenario, infrastructure is costly and there is currently little motivation for investment. From the ships' perspective, upgrading their fleet to comply with shore power is a costly endeavor. Additionally, destination ports might not even have the infrastructure to supply them with power, and if they do, it's more expensive to pay for the city's power than to burn more fuel on the ship.[23] From the ports' perspective it's also a significant monetary investment, with no guarantee that the docking ships would be equipped to accept shore power. And if they only permitted ships compatible with shore power, they would lose significant business.

Another solution that is more feasible but provides less overall benefit than shore power is ships' use of liquified natural gas. This fuel does not emit sulfur dioxides, although it still contributes to greenhouse gases, the amount of which depends on the infrastructure and supply chain.[24] New cruise ships are being designed to use liquified natural gas, which would have significant positive impacts on air

quality. However, some communities are wary of the dangers involved in supplying liquified natural gas at the waterfront.[25] In order to stay liquid, the gas must be contained under pressure and kept cool. If these systems fail, the liquid vaporizes back into natural gas, expanding to 600 times its volume and introducing the risk of ignition or explosion.[26] Even if the benefits outweigh the risks, many communities are strongly against building infrastructure to provide ships with liquified natural gas.[27]

POLICY RECOMMENDATION

Missing from the current approaches is a long-term plan that addresses both air quality and greenhouse gas emissions, and at the same time appeals economically in a way that motivates both cruise ships and ports. These can all be addressed by establishing a "network of incentives" that encourages development and use of shore power infrastructure.[28]

The major issue with current shore power solutions is that it's not widespread and there's little motivation for change. Right now, if shore power infrastructure is developed, it's difficult to ensure that it will be fully utilized. And when it is utilized, cruise ships pay more for electric power than if they were burning fuel.[29] From an economic standpoint, it's difficult to justify this. For this reason, ports along the same route would benefit from forming a coalition, all agreeing to subsidize electricity costs such that it makes up for the investment in shore power infrastructure.

According to the itinerary of the Carnival Panorama cruise ship, it spends four days per week in port[30]. Assuming an expected ship lifetime of twenty-five years and year-round service, this comes out to 5,200 days spent in port. If provided with an incentive of $1,000 per day for using shore power, each cruise ship would save $5.2 million over its lifetime. Using the Port of Seattle as a reference, the average cost for landside infrastructure was $1.6 million per berth, and the average cost to retrofit a ship was $860,000.[31] Assuming the shore power berth to be fully booked, a ship that spends four out of seven days in port would only be responsible for four sevenths of the cost of a single berth, or around $915,000. Adding this to the retrofit cost totals just

A typical round-trip cruise route in the Pacific Northwest, showing ports that could form a coalition. (source: https://www.alaska.org/advice/alaska-cruise-routes)

under $1.8 million to fund shore power for a single ship. Savings from incentives at $1000 per day docked would yield nearly 300% returns on the initial investment over twenty-five years, equivalent to an annual return of 4.5%.

While cruise lines would be satisfied with their return on investment, there would be significant costs from ports. In order to provide a $1,000 incentive to cruise ships, the cost of using shore power must be $1,000 cheaper than the cost of burning fuel. According to an estimate by Princess, a cruise line owned by Carnival, the estimated power cost is "$3,500/day for diesel fuel if engines were used while in port" compared to "$4-5,000/day for surplus hydroelectric power."[32] Reducing the price from $4-5,000 to $2500 would require a $2,000 subsidy, which would be provided by local government. When each cruise ship docking provides $4.2 million in economic activity as in the Port of Seattle, and generates $273,000 in tax revenue assuming the Washington state sales tax of 6.5%, it becomes easy to support a $2,000 subsidy that protects air and water quality and supports the longevity of the cruise industry.

In order for this plan of economic incentives to be realized, ports and cruise lines must work together. It doesn't make sense for a single ship to pay for four sevenths of the cost of a specific berth when it has multiple ports of call, or for cruise lines to invest without guarantee that all actors will hold up their end. Ports along cruise line routes must form a coalition and negotiate together, with cruise lines fronting the initial investment and ports agreeing to incentivize dockings. This investment would then be split among ports and ships in order to build the necessary shore power infrastructure, and cruise lines would receive guaranteed access to shore power at a discounted rate. Because of the risks involved with such a long-term investment, this strategy would be most effective for ports with long-term lease agreements.

One concern of this solution is over the environmental benefits if the port city's electrical grid is not powered by clean energy. While this scenario only redirects the problem of pollution, it sets up long-term infrastructure that aligns with overall renewable energy plans. If the electrical grid's power supplies are eventually transitioned to cleaner energy sources, then everything attached to the grid will reap the benefits. If cruise ships are not connected to shore power infrastructure, then the problem of clean energy must be solved independently, once for cruise ships and again for the power grid. By consolidating power sources, it becomes easier to transition in the long term. And for cities that already have cleaner power than burning diesel fuel, there is an immediate positive impact.

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