Shipping and Greenhouse Gases in the Seas of East Asia-Pacific

The International Situation and its Implications for the Port of Incheon

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Introduction

This discussion paper on the practices and opportunities to adapt in ASEAN and East Asia for lower greenhouse gas emissions from maritime shipping was prepared by the PEMSEA Resource Facility (PRF) for the use of the Incheon Port Authority.

This is part of a larger collaboration relating to the upcoming Incheon International Ocean Forum (IIOF). This forum aims to bring together marine logistics scholars, entrepreneurs, officials, and other stakeholders from around the world to share and generate ideas on the improvement of maritime shipping.

The objective of this paper is to briefly assess the current situation and expected future pathways for maritime shipping in East Asia, and provide recommendations based on this.

The paper is broadly divided into the following sections:

1. An overview of current and expected technologies and innovations that can and will reduce greenhouse gas emissions in maritime shipping
2. The enabling policy and investments related to maritime shipping emissions in RO Korea and the rest of East Asia, both in practice and in policy
3. International standards for greenhouse gas emissions in maritime shipping, and analogous shifts that have occurred in maritime shipping
4. Actions undertaken by port authorities both in East Asia and in other areas of the world to reduce the greenhouse gas emissions associated with port activities
5. Examples of regional and international cooperation on addressing these emissions
6. A summary of the outlook for the Port of Incheon and associated recommendations

Background

When the Paris Climate Agreement was signed in 2015, the pledges made by the signatory countries did not cover international transport. Coverage of international shipping was left to the International Maritime Organization (IMO), which in 2018 passed the *Initial IMO Strategy on Reduction of GHG Emissions from Ships*, which pledged to reduce the greenhouse gas emissions of international shipping by 50% before 2050 (IMO 2018). Such a goal is not expected to be achieved through reduction in shipping, and overall shipping is actually expected to continue growing into the future. Instead, emission reduction is expected to come via the reduction of the carbon intensity of shipping activities.

Over the past decade, shipping emissions have increased in absolute amount and relative amount, reaching 1076 million tons in 2018, or 2.89% of total greenhouse gas emissions (IMO 2020). Much of that is likely to be driven by growth in the seas of East Asia. These seas are surrounded by countries with growing populations and growing economies, driving both export and import demand. These seas already carry over 90% of the world's shipping trade, and are bordered by the world's busiest ports. Going forward demand is expected to triple over the next 25 years (PEMSEA 2018).

The importance of East Asia for global shipping means that any adjustments to shipping efficiency and thus to overall greenhouse gas emissions will have to take into account the needs and possibilities of this region. Countries in the region are diverse, including both developed and developing countries. Many have long coastlines or are archipelagos, making goods shipping a domestic as well as international necessity.

The importance of these issues are recognized by the countries in the region. All countries in the region have submitted their national determined contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). In 2020, China, Japan, and RO Korea announced commitments to net-zero GHG emissions goals (UNEP 2020), which strengthened previous commitments made on the matter. These three countries have large shipping industries, and all are already engaging in research and action to reduce shipping emissions.

Effecting a change in the shipping industry is challenging. While the industry is important, change requires significant capital investment and long lead times. While some changes are possible within existing paradigms, moving towards a minimal or non-carbon shipping industry will require a paradigm shift in an industry that is essentially globally reliant and built around a single fuel source. Benefits from this system, such as ease of fuel access around different areas of the world, consistent engine designs and requirements, and established global supply chains and practices, may be tricky to replicate with new systems. The shipping industry has already faced economic difficulty, amid concern that the oceans are currently over-saturated with cargo ships. Developing new low or non-carbon ships, or requiring the scrapping of old ships, may disrupt existing markets and economic systems.

Shipping is also not an isolated economic system. It developed in tandem with the development of value chains that move products on land, and with port systems that provide the interface between marine goods and its hinterland consumers.

Despite the challenges, the alternative to change is a situation where an expanding shipping industry continues to exacerbate climate change, the deleterious impacts of which will directly affect the shipping industry (Sarwar 2006). The industry itself is directly calling for “market-based measures”, together with the provision of viable fuel alternatives (ICS 2021). Thus it is worth looking at potential changes with benefits and challenges in mind, studying current policy and investment tools, innovative research and examples of model port actions, and fostering trans-boundary cooperation.

Potential improvements and technologies

There are different methods that can be used to reduce shipping carbon emissions, often with a trade-off between ease and effectiveness. It is expected that less effective, but easier, fuel reduction options will become more ubiquitous in the immediate future. These mainly rely on modifications to existing ships. Medium-term changes may involve new fuel sources and more substantial modifications. In the long-term, entirely new ship designs may be needed.

Emission reduction devices are often viable for immediate use, rely on existing technologies, and can be retrofitted into currently operating ships (Smith et al. 2019). Such devices include sulphur dioxide scrubbers, nitrogen oxide scrubbers, fine dust filters, exhaust gas recirculation systems, and ballast water treatment. There may be scope for more efficient burning of existing fuels.

Exhaust gas cleaning systems, used to remove sulphur oxides and other particulate matter from engines, can be divided into two types: wet and dry. Wet systems use water, including seawater, as part of the cleaning process (EGCSA 2012).

Other smaller changes are also expected as part of more immediate changes. Technology and modelling have significantly improved operational efficiency, including voyage optimization, different coating and maintenance, and improved port turnaround time (Smith et al. 2019). Better streamlining designs are already being used globally, as are improved propeller designs and operational efficiency improvements. Changes in construction material provide opportunities to reduce corrosion friction. Material changes can also decrease overall shipping weight. Energy harvesting, such as capturing waste heat, and carbon dioxide capture and storage are also pathways that may be adopted. Using on-shore power reduces fuel expenditure for docked ships.

The use of alternative but similar fuels has been considered as a potential bridging strategy. An example is biofuel, which is compatible with existing oil and LNG propulsion engines due to its similar composition. These fuels can also be mixed with existing fuels in some cases. However, it raises concerns surrounding food security and other negative environmental impacts, so any adoption is likely to be minimal and limited.

Switching to completely different fuel sources is another possibility. There are a variety of existing options, such as methanol, ammonia, and hydrogen. These fuel sources produce less greenhouse gas emissions than bunker fuel oil, and so their use would improve shipping efficiency. While engines can be developed to use these fuels, challenges remain with fuel storage, with these fuels having lower energy per unit volume (although not per unit weight) than bunker fuels. Methanol takes up 2.3x the space of equivalent fuel, ammonia 4.1x, and pure hydrogen 7.6x (MOTIE & MOF 2020). Other storage issues exist, such as hydrogen needing to be stored at very low temperatures. Hydrogen can also be created through an electrolysis process, which may be carbon-neutral. One drawback for hydrogen and related derivatives are potential greenhouse gas emissions associated with the production of fuel material (Smith et al. 2019).

The most common alternative, already in use around the world to a limited extent, is liquefied natural gas (LNG). LNG provides an immediate benefit to various air pollutants found in bunker fuel, although its use reduction of greenhouse gas emissions is more modest. Nonetheless, it is a proven alternative both for domestic and international shipping (Smith et al. 2019). While it requires substantial initial investment, its operating costs are low (IMO 2016).

Such fuels can also be used as auxiliary power, rather than a complete replacement. This principle is similar to that of on-shore power. Such a system may allow for easier transition as it limits the larger space needed for fuel storage, but will still promote the development of the supply network and safety technology needed for alternative fuels. Hydrogen fuel cells will need supporting technology, such as high pressure tanks and gaseous hydrogen fuel supply systems.

Fully electric propulsion is one possibility for non-carbon shipping, assuming that the electricity is drawn from non-carbon sources. However, its potential for long trips is highly limited, and current use is restricted to inland and coastal travel. In general, such vessels are not competitive due to costs of equipment such as batteries. Given historical progress towards cheaper and more effective batteries (Ziegler & Trancik 2021), fully electric ships may become more viable for domestic and short-range international shipping, but currently the technology remains rare.

The majority of the various changes that are under consideration for emissions reductions are technically and/or economically complex, making it difficult to predict costs beforehand as well as actually implementing various changes (IMO 2015). It is thus imperative that actions be taken as soon as possible both to ease transition and to build up technical capacity and economic support.

Enabling policies and investments

A shift towards low and non-carbon shipping will require government assistance, especially if it is to be accelerated. Governments can intervene in multiple ways, such as providing subsidies or research grants, implementing targeted taxes and other financial mechanisms, and creating an enabling market environment for R&D and voluntary actions from industry.

The impact of ports on pollution is widely understood by port stakeholders. In past port improvement efforts, the actions and policies of regulators, both national and international, have been key drivers towards reduced port pollution (IMO 2015).

Traditional policies often lean in the other direction, such as towards subsidizing fossil fuels, but in recent years governments have begun to innovate with a focus on shifting shipping, along with other modes of transport, towards less carbon-intensive fuels. Within East Asia, different countries have been innovating in different ways.

Republic of Korea

RO Korea is steadily developing various policy options to reduce carbon in shipping. Highly integrated into global supply chains, and reliant on trade to sustain its economy, RO Korea is highly invested in the health of global shipping. The country is exposed to the impacts of climate change, the effects of which have been noted for areas such as weather and agriculture (Chung et al. 2004; Kim 2010; Nam et al. 2018). The concern over climate change has led to policies such as the Green New Deal, and the country's net-zero commitment (Cheong Wa Dae 2020).

Korean ships were estimated to produce around 118.11 million tons of greenhouse gas emissions in 2017, including 13.34 million tons from domestic shipping, 27.66 million tons from fishing, and 77.1 million from international shipping (MOTIE & MOF 2020). The international shipping is calculated as the percentage the Korean fleet (0.8%) has out of the total emissions of the 4^{th} IMO GHG study (IMO 2020). For RO Korea, 2017 serves as the baseline for IMO's 50% reduction target. The Carbon Neutrality in Marine and Fishery Sectors Roadmap, from March 2021, calls for full carbon neutrality by 2050 including absorption and removal. The more ambitious target is expected to be added into the First Basic Plan Modification Plan for 2026-2030.

While policy on low-carbon shipping is currently fragmented, having been developed without a systematic framework, there is an emerging vision of the future driven by both the zero-emissions targets and a desire for RO Korea to become a world leader in an expected upcoming global market (MOTIE & MOF 2020). Plans encompass not just the existing shipping fleet and markets, but the potential shipbuilding markets. Having the most LNG ship orders in 2020, RO Korea hopes to extend this to having the most low and non-carbon ship orders in 2030.

This idea of a "green ship" (known as the Greenship-K concept) ties a reduction in greenhouse gases with reductions in other air pollutants and overall energy efficiency. Such activities also occur within the framework of sustaining a clean marine environment in a seafood-loving country with an engaged populace.

Key legislation and directives include

- Plan to strengthen the competitiveness of the shipbuilding industry
- Plan to strengthen the competitiveness of the shipping industry
- Act on the promotion and dissemination of eco-friendly ships
- Plan to activate the LNG-propelled ship-related industry
- Comprehensive measures for fine dust management
- Revision of the 2030 Greenhouse Gas reduction roadmap
- Special Act on Air Quality Improvement in Port and Other Areas
- Green Growth Basic Law
- Declaration of Carbon Neutrality in 2050
- 2050 Carbon-Neutral Strategy
- NDC as submitted for the Paris Agreement

Together, these policies form a framework to reduce greenhouse gas emissions in the shipping sector, encompassing a breadth of possible actions, such as supporting innovation in alternative fuels and new technologies, and conversion of existing shipping fleets using current and expected future technologies. They cover both low-carbon shipping with immediate and expected technologies, and explore the possibility of future non-carbon shipping. Much of this is very recent work. The Act on the promotion and dissemination of eco-friendly ships passed on 31 December 2018. The basic plans were developed from September 2019 until December 2020.

These plans are expected to be a first step, and are planned to be reviewed as technologies and the global market change. Basic Plans are set to be produced regularly. It is thought that decarbonization will accelerate over time, so while only a 3% overall reduction is expected by 2030, there is a targeted 25% reduction by 2040 and 50% by 2050. The early plans serve to establish foundations for later change. Other plans contradict this with more ambitious aims. The

Green Growth Basic Law aims for an overall national decrease of 24.4% compared to 2017, and specifically targets the shipping sector for a 15.1% decrease by 2030, of which fishing is only 0.7%.

Responsibility for these plans stretches across the government. The current ones were established on a legal basis between the Minister of Trade, Industry, and Energy (MOTIE) and the Minister of Oceans and Fisheries (MOF). While the MOTIE is responsible for overall technology development, and core technology projects, MOF provides key R&D support. Monitoring progress is the joint responsibility of the Ministry of Industry and the Ministry of Maritime Affairs. Both will engage in data collection and analysis, as well as solicit expert advice.

Through its plans the government intends to lead, although taking into account the opinions of the public and of industry. Following public consultations and the collection of opinions from experts and various government ministries, in 2020 a “New eco-friendly ship market creation project” was founded as part of the Green New Deal. This targets the conversion of government ships to more efficient use through the installation of emissions reduction devices. Meanwhile, the Green Growth Basic Law envisions a significant expansion of on-shore power.

Under the country’s current regulations, the installation of emission reduction devices and efficiency improvement would be enough to meet requirements (MITIE & MOF 2020). However, due to long-term goals such as the net-zero commitment, it is expected that stricter standards will continue to be brought in over the next few decades. A 30% reduction by 2025 will require an expansion of low-carbon fuels of mixed fuels, in addition to energy efficiency measures. The IMO’s goal of 50% reduction by 2050 can not be met simply through an upgrade of all new ships, but will require existing ships to be actively replaced by non-carbon fuels.

Inventories of the government fleet have already been taken, and the initial stages will see such devices fitted on 80 ships. By creating an initial demand, governments can stimulate overall market availability. It is expected that non-government owned shipping fleets and private commercial ships will be able to make similar conversions. Under current assessments, only 346 of RO Korea’s 10,038 non-fishing vessels use some form of green technology (MITIE & MOF 2020). 320 of these have emission reduction devices, 22 use LNG, and 4 are electric.

The Ministry of Maritime Affairs and Fisheries aims for all of its ships to be converted to lower-carbon models by 2030 as part of the 2030 eco-friendly government ship conversion plan. While government conversion became mandatory beginning in 2020, private sector conversion is currently passive due to concerns about the burden of upgrading. Ship prices are rising, so private sector conversion will require government stimulus and policies to ease cost burdens.

Timetables for future changes are ambitious. Greenhouse-gas reduction technology is expected to be in use by 40% of ships by 2025, and 70% by 2030. It is expected new LNG ships will make up 50% of production by 2025, and 75% by 2035. The conversion rate to eco-friendly ships is expected to be 15% by 2030, and around the same time non-carbon ships are expected to enter the market. There is a possibility current fuel vessels will be withdrawn by 2040 (MITIE & MOF 2020). Research on alternative fuels is already being supported by MOTIE and MOF, including on hydrogen fuel ships. Ammonia research is in early stages, and more research on LNG storage and electric shipping is expected. Research is slated to lead into land and marine demonstrations, followed by a full technology development system, then commercialization.

Investment and pilot projects already exist. As noted above, LNG and electric ships have been put into use in small numbers. Some submarines already use hydrogen fuel cells for auxiliary power. The Ulsan Metropolitan City special regulatory zone has set up a small-sized hydrogen fuel ship technology development project. This developed a proton-exchange membrane fuel cell from 2017 to 2020, and commercialization is hoped for a 12m ship within 2021. An eco-friendly hydrogen fuel ship R&D project is ongoing from 2019 to 2023, with testing expected from 2023 to 2027. Development and field tests for liquid hydrogen storage are expected from 2022 to 2026, and an independent hydrogen-only ship is expected by 2029. A 10MW fuel cell will be required for international voyages. Safety and evaluation technology for the fuel tanks will be developed simultaneously, from 2026 to 2030.

Some domestic shipyard capability is thought to exist for ammonia fuel. Korea Offshore & Shipbuilding (Hyundai Mipo Shipbuilding) acquired certification from Lloyd's Register in July 2020. Daewoo Shipbuilding and Marine Engineering Co., Ltd. acquired certification for ammonia-powered super-large container ships (up to 230,000 TEU) in October 2020, and has targeted 2025 for commercialization.

In addition to direct research support, there is a need for overall enabling policy. New technologies uptake can be risky if issues such as liability, management protocols, and the procedure for safety and risk assessment are not clearly established. The Ministry of Maritime Affairs is looking to create a hydrogen ship safety standard development project, which will take into account potential IMO international regulation of such technologies. Overall government strategy includes testing and evaluation facilities for new technologies, which will aid with building policy frameworks. Such facilities can also support market entry and commercialization. One example of lacking legislation is for hydrogen fuel. Hydrogen is not included in the Safety Standard Code for international voyages, or in domestic legislation. MOF is expected to develop standards for transport and storage from 2020 to 2024. Similarly, there is no Safety Standard Code for ammonia.

Other East Asian initiatives

There is a wide variation in the current fleet size, age, and efficiency between the various countries in the East Asian region. There are also significant variations within countries, for example some countries have inland fleets which operate with significantly lower environmental standards than their marine fleets (GloMEEP 2020).

Shipping is expected to be an important area for Japan not just internationally, but domestically. Japan is made up of islands, and there are plans to shift even more goods transport to shipping from trucks, which are more polluting (MLIT 2019).

Japan launched the Industry-Academia-Government collaborated International Shipping GHG Zero Emissions Project in August 2018, which will cover both shipping and shipbuilding. It aimed to influence not just domestic action, but international, hoping for an IMO agreement on shipping efficiency by 2023. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of the Environment (MoE) are working together to promote hydrogen fuel cells.

The country is also developing floating LNG bunkering and other LNG equipment. Kawasaki Heavy Industries launched the world's first liquefied hydrogen carrier. This ship is able to transport liquefied hydrogen on long voyages. It is a step in developing a liquid hydrogen supply chain, shipping hydrogen from Australia to Japan (Kawasaki 2019). Direct ship-to-ship LNG bunkering has also been tested (Central LNG 2021).

Japanese shipping company NYK looked to support a transition to more sustainable shipping by offering its own "green" bonds. These were first sold in 2018, and last 5 years. They are part of wider capital financing for low-interest green loans, and specifically target LNG fuel and LNG bunkering, alongside other environment-related shipping issues (NYK).

China, deeply involved in maritime supply chains, is supporting the development of a cleaner shipping industry. The marine shipping industry was selected as one of the 10 core industries in the Made in China 2025 plan.

While the Chinese fleet is more efficient than most developing countries, it has room to expand its implementation of existing energy reduction tools to match average developed countries (GloMEEP 2020). Modernizing the shipping industry has become an official policy. Subsidies for new ships were established in 2013, and a policy promoting the eventual removal of old ships was adopted in 2014. This policy is intended to accelerate the adoption of new technologies in the shipping fleet, as well as provide market incentives to the shipbuilding industry.

Among the various research programs and institutions set up in the country is the establishment of the Shanghai International Shipping Center. Shanghai is a significant port, and the center is designed to build upon this and provide a platform for further development in the industry, including greener shipping.

Singapore serves as another major international port, and the city-state has committed to supporting a global shift to more sustainable shipping. Singapore is tightly embedded in global trade networks. This linkage is leading it to pursue international cooperation on this issue. Together with the IMO, it is setting up the NextGEN (Green and Efficient Navigation) research center for maritime decarbonization. They also support the development of IMO Research Funds for low and zero-carbon technologies and fuels. The Singapore Maritime Foundation has already set up an international advisory panel of local and international business leaders to advise on decarbonization.

Under the 2011 Maritime Singapore Green Initiative (MSGI), the Singapore Maritime and Port Authority (MPA) has begun research on four programmes: A green port program for cleaner fuels, a Green Ship Programme to promote ship designs that exceed current carbon efficiency standards and provides rebates for LNG ships, a Green Energy and Technology Programme that supports technology development and pilot studies, and a Green Awareness Programme that works with maritime companies to create more advanced sustainability reporting.

All Singaporean-flagged ships have been required since 2013 to follow the IMO's Energy Efficiency Design Index (EEDI). MPA has directly invested in LNG bunkering, explicitly targeting LNG as a bridging fuel until there are more advanced technologies. MPA is also looking into alternative fuels, such as biofuels, hydrogen, ammonia, and electricity.

For investment funding, Singapore has set up the Maritime Green Future Fund. This supports research such as a joint call by MPA and the Singapore Maritime Institute for electric-powered harbour craft development in September 2020. At the end of 2021, MPA will release the Maritime Singapore Decarbonisation Blueprint 2050, charting its strategies.

Malaysia is creating a Code of Practice for Bunkering and Specification for Quality Management for the Bunker Supply Chain that will cover LNG as well as bunker fuel. New tanks and bunkering services will have to align with the country's Green Port Policy, which includes as an aim the improvement of shipping efficiency.

Decarbonization incentives and investment elsewhere

The European Union (EU) is investing in research into sustainable shipping. One method is through their Horizon 2020 program, which has taken a lead on efficiency studies (European Commission 2015) along with other ship-related technology development. The EU has also set a goal for existing ships to be fitted with emissions reduction devices and other modifications over the next decade, but sees a future with ships using more novel technologies beyond that. LNG and electrification are under particular study. The European Commission expects change will require cooperation with a variety of stakeholders, including ship operators, builders, equipment manufacturers, and fuel suppliers. They aim for EU efforts to exceed the IMO 50% by 2050 reduction target. Some research efforts are funded from the Commission budget (European Commission 2020).

The JOULES project has already laid groundwork in the EU for a number of shipping innovations (JOULES). Political pressure is also growing, and the European Parliament has voted that shipping emissions be included in the bloc's carbon markets, including for international voyages that start or finish in the EU (CNA 2020).

The European Investment Bank has developed a Green Shipping Loan Programme that supports up to 50% of an investment. Other investments support up to 50% of debt financing, or 100% of green component retrofitting (Gaudet 2016).

The United States has set up the Maritime Environmental and Technical Assistance (META) Program to cover a range of environmental shipping issues, including emissions from shipping and from ports. There have been incentives for port and ship diesel emission reductions since 2006, and since 2017 established subsidies for technologies that exceed minimum standards (MOTIE & MOF 2020). They are carrying out research into biofuels, fuel cells, LNG, and electricity, along with other emissions reduction technology (Maritime Administration 2020).

The META biofuel research project began in 2010. This is looking at blended and fully alternative fuels in comparison to ultra-low sulphur diesel, which is the current standard. Fuel cell research began in 2014, and in addition to researching technology the project also seeks to develop regulatory standards and use protocols. Fuel cell research includes the SF BREEZE study, which was for a short-range coastal passenger ferry powered by hydrogen fuel cells. It was found to have a cost premium above diesel ferries under current market conditions, but may be economically competitive in the near future (Pratt & Klebanoff 2016).

Germany supports the e4ship project through its National Innovation Programme. As of April they have used fuel cells to complement traditional generators in a hybrid system, which provides emission-free anchorage as well as emission-free travel (NIP).

International standards and similar situations

IMO standards and discussions have taken greenhouse gases into consideration prior to the establishment of the 2050 goal. Regulations such as MARPOL have contributed significantly to providing an international framework for reducing the environmental impact of shipping. As IMO conventions can only come into effect with a certain number of signatories, they reflect global will and a consensus-based mechanism. They have had significant impacts, with their provisions being widely followed and adopted into national legislation around the world.

One specific greenhouse gas related requirement is the IMO ship design standards for new ships, through its Energy Efficiency Design Index (EEDI). Part of the MARPOL system, these standards apply to new ships, and cover a range of specifications (MEPC 2018). These have been updated multiple times since their creation, and it is likely they will continue to be updated as global focus continues to be applied to greenhouse gas emissions.

The Korean government expects that the commercialization of carbon-free ships will occur by 2030, and by 2050 they are expected to make up 70% of new constructions, with the rest likely being low-carbon options such as LNG (MITIE & MOF 2020). Such actions would likely be followed by changes in new ship design standards, such as those of the IMO EEDI.

The international project to decarbonize shipping is not the first shipping fuel related project that has been taken on by the international community. Sulphur oxides, emitted from standard heavy fuel oil, received international attention in the early 21st century, for example under MARPOL VI. IMO regulations put in place global limits for sulphur content in fuel, which came into force in 2015, with stricter regulations coming into force in 2020. Some areas set their own even stricter limits (ITF 2016).

This global shift to very low sulphur fuel oil had minimal effects on shipping costs, with an overall magnitude smaller than variations in fuel prices. It is expected the 2020 increase will have a large increase in costs. For sulphur emissions, regional limits have a

Signatories of MARPOL VI in and around East Asia as of 8 June 2021:

- Australia
- Bangladesh
- China
- India
- Indonesia
- Japan
- Malaysia
- Philippines
- RO Korea
- Russian Federation
- Singapore
- Viet Nam
- Hongkong, China

significant global effect (ITF 2016) as they apply to all ships entering those waters. This means any noncompliant ships will have their operations severely limited.

China and RO Korea have both established their own ultra-low emissions control areas in 2020. China's policy applies to key inland waterways and to waters near its coast, with plans to increase strictness around Hainan in 2022. RO Korea has set up two zones, one in the north-west and one in the south-east, which also came into force in 2020 (Finamore 2019).

One concern regarding sulphur emission regulations is compliance. Port states can enforce regulations within their waters, but enforcement in international waters relies on flag states (ITF 2016). Similar considerations may apply for any international or regional regulations put into place regarding greenhouse gas emissions.

Sulphur emissions may provide an example of development in other ways. To address the 2020 global limits, Japan organized direct bilateral meetings between shipping and oil companies (MLIT 2019). This reflects what may be needed for decarbonization technologies, which will require cooperation across a range of stakeholders, including government, different business sectors, and regional and international organizations.

Norway has developed a specific fund to support conversions for domestic shipping, the Norwegian NOx Fund. This was an agreement between Norwegian businesses and the Ministry of the Environment that reduced taxes on these companies who provided contributions into the fund. This fund could then be applied to by companies to fund NOx reducing measures and modernizations (Johnsen 2013).

Specific port efforts

Globally, conversions towards the most current greenhouse gas reducing devices and technology remain rare. Only around 5.6% or 5763 out of 102,960 of the world's merchant fleet uses eco-friendly technology. Of these, 4,459 have reduction devices, 955 use LNG, and 339 use other alternative fuels (230 electricity, 32 LPG, 22 methanol, 3 hydrogen). Alternative fuel ships tend to be limited to coastal vessels or demonstration vessels. Overall, the average age of the fleet has been decreasing as older ships become replaced. In 1995, the average ship age in RO Korea was 15.1 years. In 2020, the average age was 11.4 years (MOTIE & MOF 2020).

On the other hand, the aforementioned sulphur regulations have had widespread effect. Most existing ships (94.4%) use low-sulphur oil, including ships currently under construction (MOTIE & MOF 2020). Such effects are in part prompted by certain regions developing stringent regulations that have a knock-on effect to all shipping that enters. Similar effects may be possible from ports, however, such change would likely require wider backing as an individual port action may find itself at a competitive disadvantage.

Ports play the crucial role of linking shipping with hinterland, and so in addition to their impacts on shipping, they can play a similar role in prompting shifts in hinterland emissions. Some issues overlap between both realms, efficiency of transport and alternative fuels. Numerous ports have taken actions that have had an impact on their contribution to greenhouse gas emissions.

A recent study on US ports studied the impacts of port electrification and the provision of on-shore power systems, and considered intermediate electrification. This study was able to calculate the potential difference in greenhouse gas emissions as the source of the electrical power was known. This knowledge also allowed for the calculation of cost, depending on the price of electricity in the region. It found that cargo handling electrification had variable effects depending on local factors regarding the port, but that on-shore power provided consistent benefits (Schenk et al. 2020).

Other port efforts cover a range of sectors, including improving and modernizing truck and rail transport, and improving and modernizing cargo handling equipment and harbour craft. Shore power is expected to be applied to ocean-going vessels. Vehicle and equipment replacement is seen as a first priority, and able to have an immediate large impact. Other activities across a range of different port handling aspects contribute in different ways, and different ports have different considerations. Reducing CO_2 was complementary with reducing other pollutants (OTAQ 2016).

Some ports in the US already run Clean Truck Programs. These both set minimum standards for trucks that deliver goods and thus enter the ports, while also providing funding support for conversion to more efficient trucks. The Port of Los Angeles claims a 90% improvement in port truck air pollution due to this program (LA 2020). The Port of Seattle publishes GHG emissions inventories, and sells itself as part of the “Green Gateway Supply Chain”, the most greenhouse gas efficient way to import goods from Asia to the United States.

Japan has a dedicated focus on port carbon emissions, not just on ships but on machinery, trailers, and other on-shore powered equipment. Wind farms are expected to supply clean energy to the ports, while blue carbon ideas are imagined as offsets (MLIT 2019).

Singapore is building a new port which is designed for a 50% reduction in emissions intensity, mainly through more intelligent design and technology that draws upon renewable energy and intelligently uses and stores it.

Singapore’s port has LNG powered harbour craft, and they are looking to develop electric vehicles for the same roles. Since 2017 it has been actively aiming to increase its LNG capacity. This year it will reach a capacity of 1 million tons per annum, which can refuel 300 large ships.

Malaysia has adopted a Green Port Policy, which aims to help individual port operators reduce their environmental impact while maintaining commercial viability. It operates from a broad perspective taking into account environment, community engagement, and sustainability. Its greenhouse gas emissions-related initiatives include electricity and fuel saving initiatives, and a study on fuel quality of ships in Malaysian ports.

The Laem Chabang Port in Chonburi Province, Thailand, is relatively new, having been established in 1987, and is focused on improving its environmental credentials. For example, it has an established rail link to inland distribution centers, allowing its goods to reach the hinterland in a very efficient manner. The business of the railway is leading to plans to consider expanding it. By connecting inland, the railway reached the Lat Krabang Inland Container Depot, which also receives goods from Bangkok Port and thus serves to provide a more efficient joint distribution center. The port area has windmills, to directly provide a source of clean energy on-site (HPS 2018).

The Port Authority of Thailand in addition manages Bangkok Port, Chiang Saen Port, Chiang Khong Port, and Ranong Port. Throughout its ports, it seeks to adopt more efficient equipment and use alternative energy sources, increase port automation and thus operational efficiency, and implement slow-steaming policies for relevant ships such as dredgers.

Aside from railways, an alternative modal shift is towards more domestic shipping. This was previously mentioned as a national strategy for Japan, but can also serve as a more direct port-to-port strategy. In the Philippines, land-based transport through Luzon and the national capital of Manila is constrained by geography. Railway services are underdeveloped, so most goods travel via truck, causing pollution and also raising expenses due to traffic related delays. The Port of Cavite is investigating the possibility of a dedicated ship to transport goods to the Port of Manila, thus bypassing a significant stretch of congestion. As this is mostly through a protected bay and over a relatively short distance, there is scope for the use of innovative technologies that are currently unviable for larger shipping.

Regional and international cooperation

Reducing carbon emissions is understood as a global mission, requiring participation and action by all countries. This is reflected in the international conventions aimed at dealing with climate change, with the Paris Agreement being the most significant recent example. Specific regulations at the IMO, such as the EEDI and restrictions related to sulphur fuel, rely on the participation and cooperation of the international community. Some countries have gone further with individual pledges, but regional and international cooperation remains key for greenhouse gas emission reduction, especially around inherently international issues such as shipping.

The first obvious point of cooperation is through joint regulations over an area of shared sea. The clearest example of this is Emissions Control Areas within the European Union, where countries have a pre-existing political structure to structure their cooperation within. However, similar situations are possible elsewhere. The North American Emissions Control Area was set up by the United States, Canada, and France. The three countries jointly petitioned the IMO for the designation of the area, which has extremely strict sulphur levels applying to vessels both from those countries and elsewhere. Approval came in 2010, with the area coming into force in 2012 (OTAQ 2010). This was a bespoke agreement created through the agreements of the countries involved.

The creation of Emissions Control Areas near China and RO Korea were significant steps in maritime regulation in East Asia, being the first outside of Europe and North America. Their geographic proximity makes it easy to imagine future cooperation, either formal or through coordination between the two areas. Similar areas may one day be created for emissions and/or efficiency requirements. The ASEAN Single Shipping Market ambition aims to streamline and standardise shipping regulations, allowing for a more efficient ship-port interface and thus increased shipping carbon efficiency.

Multilateral cooperation has been established for other aspects of maritime control as well. Indonesia, Malaysia, and Singapore established the Tripartite Technical Experts Group to coordinate navigation and environmental protection in the Straits of Malacca and Singapore, along with the Straits of Malacca and Singapore Revolving Fund which funds measures to tackle oil spills.

The creation of a national/regional Emissions Control Area helps address potential issues surrounding competitive advantages between different ports, who may face a first-mover disadvantage for emissions control activities. Such items however can also be addressed through port-to-port cooperation. Such systems can be useful for ports, as they are deeply connected to potential local air pollution in addition to greenhouse gases, and cooperation helps each port reduce such impacts.

An example of this is seen on the North American west coast, where a few major ports around the area of the US-Canadian border formed the joint Northwest Ports Clean Air Strategy in 2008. This created equivalent guidelines for truck emissions quality, as well as for ships and cargo handling (Port of Seattle). The strategy had clear goals for emissions reductions, particularly diesel particulates, and these were achieved. The strategy was updated in 2020, drawing on the more advanced global framework on emissions such as the Paris Agreement (Northwest Seaport Alliance). Ports may also be able to set up a joint process that helps reduce emissions, such as the proposed modal shift for goods transport between the Port of Cavite and the Port of Manila.

If the opportunity for implementation cooperation has not yet emerged, ports, countries, and other stakeholders are already working together on key research regarding shipping decarbonization. For example, Singapore is working with the Port of Rotterdam and Japan's MLIT in the Future Fuels Port Network, which is investigating how ports can adapt to provide the alternative fuels expected in the low and non-carbon future. This initiative is recent, signed in 2020, and aims to develop a roadmap for the future. The alliance benefits from Rotterdam's experience with the current largest LNG bunkering ship, with Japan and Singapore also far along in developing LNG bunkering. The alliance is open to expansion with new partners (Ovcina 2020).

Ports have the ability to consider hinterland cooperation as well, which can also stretch between countries. The United States set up the SmartWay Transport Partnership in 2004, to look at greenhouse gas emissions throughout the entire freight system. This is a collaboration with private companies, and includes measures to adopt new technology, develop reporting tools, and provide financing. The SmartWay Program later expanded to include Canadian logistics as well (EPA 2016), making it a regional operation.

In 2018 the GloMEEP project of the IMO released a Port Emissions Toolkit, which covered an example process that ports could go through to reduce their hinterland, maritime, and in-port emissions. Looking at both Assessment and Strategy development, it advocates a pollution-by-pollution system for environmental management (GloMEEP 2018).

Implications and suggestions for the Port of Incheon

The Port of Incheon finds itself not only in a rapidly changing international context, but in a proactive regional and domestic context. Significant innovation is already happening within the region on shipping activities which will create significant impacts for the port, even as the port must already prepare to deal with greater shipping activity in the near future.

Domestically, the port must already meet the challenge of existing regulations in the RO Korea, and the existing strategic frameworks such as the National Port Master Plan. It falls within the area covered by the new Emissions Control Area. Its strategic geographic location and closeness to population centers means that it is likely to receive much attention for its actions.

With the national declaration of a net-zero emissions target, it is to be expected that domestic regulations and requirements regarding emissions reductions will accelerate over the coming years and decades. Some domestic policies may help ports reduce emissions, for example regulations regarding land vehicles will directly reduce the hinterland impact of ports, whereas other policies will have to be adapted to.

Being an international port, Incheon will also be highly exposed to the policy of neighbouring countries, similarly to how the Emissions Control Area of the United States impacted Pacific trade. Nearby China and Japan's net-zero targets are likely to lead to similarly ambitious policy, and policies surrounding Chinese and Japanese ports will have a knock-on effect on ships that would transport goods from Incheon to these countries, or travel from those countries to Incheon.

Given this context, it would be prudent for the Port of Incheon to prepare for very ambitious targets, not only so as to not be caught unaware or unprepared by policy actions, but so as to establish itself as a leader in port modernization. While some potential needs may not be able to be easily anticipated in the current time, there are future scenarios that are likely enough that the port should be readying for them already.

Most obviously, the Port of Incheon will need to prepare itself for the accommodation and provision of alternative fuels. Some shifts will already need to be made for the Emissions Control Area. LNG is already in initial use in the country and in other ports, and its use can be reliably expected to grow. Electrification is highly likely to become more common, and perhaps dominant in some purposes such as coastal shipping and for small harbour craft. The position of the Incheon means electric ships may even be viable for international voyages across the Yellow Sea. Other fuel sources, such as biofuel, hydrogen, and ammonia, will also need to be considered for adoption.

To be able to provision such fuels with the reliability of the current provisioning of bunker fuel, it will be necessary to not only develop port-side infrastructure, including storage and bunkering services, but to also tap into national and international supply chains for these products. Japan's existing plan to bring LNG all the way from Australia provides a clear example of how such supply chains may be adapted to, and how reliant they may be on regional and international cooperation. These changes will have to be balanced with the continuing need to provide bunker fuel for many years, although perhaps in smaller quantities.

In the meantime, the port should be adopting best procedures on efficiency and turnaround time, both for goods ships and for hinterland transport. Idling causes unnecessary pollution on both land and sea. Further improvements might include supporting emissions reduction devices on land and at sea, and providing on-shore power to ships and electric charging stations for hinterland vehicles (which are more amenable to electrification efforts than ships).

Considering the significant changes large-scale shifts may require, and the ambitious targets of the region, it would be beneficial for the Port of Incheon to become involved both in the innovation of new technologies, and in the later commercialization of their use. Leveraging the ports' geographic position and business may provide opportunities for mutual growth and cooperation between the port and those involved in research and commercial industry, with partners being provided with the opportunity for effective pilot studies and the Port being directly kept abreast of rapid changes in the maritime sector.

Wider decarbonisation is worth considering, not just in fuels but throughout port operations. The benefit of such actions may be long-term efficiency bonuses, and a reduction in air pollution and thus a smaller impact on port workers and surrounding communities. Related issues such as the circular economy are likely to emerge, as they are also gaining domestic and international prominence and being steadily reflected in legislation and treaties.

Given the likely continued increase in global shipping, the need to future-proof for greater activity provides an opportunity to simultaneously future-proof for a low and non-carbon maritime shipping environment. By pre-empting regulations, and creating innovative pilots and small schemes, the port will be more easily able to transition if situations evolve to make such changes mandatory and universal. The Port of Incheon has a long history of growth and development, supporting the country and trade throughout the world's oceans. In the upcoming crucial decades for maritime shipping, the port will be able to demonstrate that this legacy remains true in the present, continuing its contribution to the port's success.

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