The Shipping Sector and Ports as Central Actors in the Decarbonization Effort: A Case Study of China

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Abstract

This article carves out China's maritime state-of-play with regards to GHG mitigating measures with a special focus on CO2 emission. The article commences with an overview of IMO's GHG strategy taking into account the critical targets, proposed plans, schemes and measures aimed at the shipping sector. Discussions then segue into a twofold discussion pertaining to China's current policy and port governance actions highlighting some of the existing gaps and challenges. Reference is made to remarkable developments from countries considering three vital key elements for an effective green port policy framework before drawing concluding remarks.

Keywords

China, GHG Emission, International Maritime Organization, Green Ports, Green Policy

1 Introduction

GHGs are emitted from a wide array of sources including electricity production, transportation, industry, agriculture, land use and forestry.[4] Transportation alone accounts for twenty nine percent of global GHG emissions.[5] 95 percent of the sector continues to remain dependent on petroleum-based fuels.[6] Maritime transport is not only a source of GHG emissions, but a major source of air pollution, accounting for 15 percent of nitrogen oxides (NOx) and 5-8 percent of sulphur oxides' (SOx) emissions worldwide.[7] This speaks to the multiple challenges facing the transport sector on a global scale.

The oceans produce oxygen and play a role in weather and precipitation patterns. They also act as carbon-reservoirs that absorb the most common greenhouse gas (GHG), carbon dioxide (CO_2), which is responsible for three-quarters of total global emissions. [8] In short, the oceans play a vital role in efforts to balance the global carbon cycle, currently taking up fifty percent of the CO_2 produced from fossil fuel burning processes.[9]

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[4] United States Environmental Protection Agency, Greenhouse Gas Emissions: Sources of Greenhouse Gas Emissions, available at https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[5] Id. See also K. Levin, D. Rich, Y. Bonduki, M. Comstock, D. Tirpak, H. McGray, I. Noble, K. Mogelgaard, and D. Waskow, Designing and Preparing Intended Nationally Determined Contributions (INDCs) (World Resources Institute, UNDP, Washington, USA, 2015).
[6] Id.
[7] T.W.P. Smith; J. P. Jalkanen, B. A. Anderson, J. Corbett, J. Faber, S. Hanayama, E. O'Keeffe, S. Parker, L. Johansson, L. Aldous, C. Raucci, M. Traut, S. Ettinger, D. Nelissen, D. S. Lee, S. Ng, A. Agrawal, J. J., Winebrake, M. Hoen, S. Chesworth and A. Pandey, Third IMO GHG Study 2014, International Maritime Organization, London, UK, 2014.
[8] D. Herr and G. R. Galland, The Ocean and Climate Change: Tools and Guidelines for Action, 1-77 (International Union for Conservation of Nature and Natural Resources, Gland, Switzerland), at 11-14.
[9] N. Benson, "Carbon Cycle", in G. Philander (Ed.), Encyclopedia of Global Warming and Climate Change, Edition 1 (Sage Publications, 2008) at 161.

Nevertheless, the absorbing-capacity of the oceans has its limits. As noted by the researchers of the National Aeronautic Space Administration (NASA), carbon intake will slow down once surface-water becomes saturated because of decelerated ocean circulation caused by global warming resulting in ocean acidification.[10] Ultimately, this complex interplay between human activities and oceans point to the need to decarbonize human activities as quickly as possible, including shipping and port operations as key elements of the global transportation system.

This conclusion is supported by the International Panel on Climate Change (IPCC), which has stressed the need for swift, integrative and all-encompassing global action to reduce and eliminate anthropogenic sources of GHG emission as soon as possible.[11] The Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCCC), in turn, calls for coordinated actions to limit global temperature increase to well below 2°C above preindustrial levels in this century while striving for 1.5°C, and aiming for carbon neutrality by the second half of this century.[12] Actions are already underway as one hundred and eighty-six countries from Asia, Europe, North America, South America, Africa and Australia have submitted targets in the form of nationally determined contributions (NDCs) containing emission-reduction commitments to be updated every five years. Many countries have or are in the process of updating their NDCs for the first time in the lead up to COP26 in Glasgow.

Decarbonization efforts remain fragmented as measures vary across transportation sectors and across countries and regions. While domestic modes of transport are covered under NDCs, international shipping, while it could in theory be included, has remained outside the scope of NDCs, and instead are covered by IMO efforts. What adds to the complexity is the fact that GHG emission from domestic shipping and ports are not covered under the initial International Maritime Organization (IMO) strategy, but are covered by most NDCs.[13] Individual ports tend to operate in isolation of other decarbonization efforts, which creates a barriers to broader decarbonization efforts. Ideally, as we explore below, ports consider their role to support decarbonization beyond their own operations.

Moving forward, the European Sea Port organization (ESPO), a founding member of the World Ports Climate Initiative (WPCI), has initiated efforts to decarbonize various European ports. The Canadian and US government are also re-evaluating and re-assessing national strategies in line with the Paris Agreement. As we explore in this article with a case study of China, some Asian countries have also implemented initiatives to decarbonize their ports.

The Asian region plays a crucial role in the international arena as it dominates maritime trade, with developing countries in the region accounting for 76 percent of all goods

[10] See H. Riebeek, The Ocean's Carbon Balance (2008), available at https://earthobservatory.nasa.gov/features/OceanCarbon

[11] O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen and S. Schlömer (2011); Summary for Policymakers in: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation.

[12] Conference of the Parties, Adoption of the Paris Agreement, 12 December 2015 U.N. Doc. FCCC/CP/2015/L.9/Rev/1 (Dec. 12, 2015).

[13] Initial IMO Strategy on Reduction of GHG Emissions from Ships, Resolution MEPC.304(72) (International Maritime Organization, 2018, Adopted on 13 April 2018. London, UK).

loaded and unloaded.[14] Most major shipyards are located in China, South Korea, and Japan, representing 92.5 percent of the newbuilt vessel delivered in 2019.[15] China takes the lead in international trade thanks to its robust supply-chain network and knowledge base. The country is a leading manufacturer and exporter of consumer products, as well as a dominant supplier of intermediate inputs for manufacturing companies located in other parts of the world.[16] Geo-economic policies such as the Belt and Road Initiative (BRI) is expected to expand its role and seaborne trade even further. Presently, Singapore ranks second to the Shanghai business port in Asia based on the overall number of twenty-foot equivalent units (TEUs) of transport.[17] China is one of the most efficient global trading hubs due to its efficient port infrastructure, ranking in seventh place out of one hundred and sixty countries in the latest Logistics Performance Index[18]. The Maritime Port Authority (MPA) has taken drastic measures for wider industry adoption of digitalization initiatives, such as electronic bills of lading (eBL), digital platforms for port clearances and trade documentation. However, as explored below, more efforts are required at the national level.

China is a party to the Paris Agreement and submitted its first NDC on 3 September 2016.[19] Although the government has declared its determined position with regards to achieving carbon neutrality by 2060, the Climate Action Tracker's assessment is that "China's NDC and national actions are not yet consistent with limiting warming to below 2°C, let alone 1.5°C".[20] Against this backdrop, this article centres its discussions on China's shipping policy and port governance measures. The discussion is predicated on the view that more efforts are required to keep pace with international developments for controlling GHG emission from ships and that ports need to play a central role in curbing emissions for achieving sustainability in the maritime domain. Supporting and adapting to new trends and developments in IMO's decarbonization efforts is important to major maritime nations such as China. The authors view those trends and developments encapsulated in four spheres of influence, namely, decarbonizing of port operations; supporting the decarbonization of shipping, both international and domestic; supporting the decarbonization of inland transportation; and supporting the decarbonization of the geographical region surrounding the port. It is our contention that these four spheres of influence offer a useful frame to guide the development of decarbonization strategies for ports around the world. When turning to the Chinese context, the authors have limited the scope to the first two spheres due to the current void in evidence-based literature without which discussion of the last two spheres cannot proceed. We consider the first two spheres through the lens of three key elements of an effective environmental policy framework for ports, which we have identified elsewhere as essential components of a gold standards for environmental policy framework for ports. The elements are green policies, stakeholder engagement and management, and rigorous scientific monitoring of results. [21]

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[14] See UNCTAD, Review of Maritime Transport 2020, available at https://unctad.org/system/files/official-document/rmt2020_en.pdf
[15] Id.
[16] Id.
[17] See Lloyd's List, One Hundred Ports, 2020, available at https://lloydslist.maritimeintelligence.informa.com/one-hundred-container-ports-2020
[18] See OECD Competition Assessment Reviews SINGAPORE 2021, available at https://www.oecd.org/daf/competition/oecd-competition-assessment-reviews-singapore-2021.pdf
[19] NDC Registry, available at https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx
[20] China: Climate Action Tracker, available at https://climateactiontracker.org/countries/china/
[21] C.F. Wooldridge, C. McMullen, and V. Howe, Environmental management of ports and harbours — implementation of policy through scientific monitoring (1999) 23 (4-5) Marine Policy: 413-425; See also T. Parviainen, A. Lehikoinen, S. Kuikka and P. Haapasaari, How can stakeholders promote environmental and social responsibility in the shipping industry? (2018) 17 WMU Journal of Maritime Affairs: 49–70.

2 IMO's GHG Strategy

The Fourth Greenhouse Gas study conducted by the IMO estimated that the surge in global maritime trade led to a 9.6 percent increase in total emissions from shipping, from 977 million tonnes in 2012 to 1,076 million tonnes in 2018[22]. The study concludes that ship-source emission rates increased from 2.76 percent in 2012 to 2.89 percent in 2018, an increase of 0.13 percent in 6 years.[23] During this time, carbon intensity was on the decline, in fact, the overall carbon intensity of international shipping was approximately 20 to 30 percent lower in 2018 compared to 2008.

Decarbonization of shipping is technically and economically viable, but has proven politically challenging. The global maritime community would have to adopt, implement and monitor a broad range of technical and operational measures to fully decarbonize. The sector has the potential to decarbonize, or at a minimum be carbon-neutral, before 2050, with a view to making a fair contribution to the emission reduction and temperature targets of the Paris Climate Agreement.[24] In 2018, the IMO adopted Resolution MEPC. 304(72) entitled the "Initial IMO Strategy on ship GHG emissions reduction" which entails an amalgam of short-, mid- and long-term measures related to shipping design, operation and efficiency, cleaner fuels and propulsion.[25] The strategy sets two critical targets that are reasonably ambitious but fall far short of full decarbonization: a) reduction of CO2 (carbon intensity) emissions by at least 40 percent by 2030; and, b) reduction of the total amount of GHG emissions by at least 50 percent by 2050 compared to the levels of 2008.[26]

Various specific measures have been tabled in support of the goals of the IMO strategy, e.g., slow-steaming, speed reduction, speed limits and speed optimization of vessels to achieve the GHG reductions stipulated in the IMO strategy.[27] The confusion on the conceptualizations of speed optimization and speed reduction has led stakeholders to propose mandatory speed limits as a measure to achieve GHG emissions reduction.[28] Mandatory slow steaming has been rejected by IMO and the focus is instead on mandatory power cut-off for existing ships. Discussions on "speed limits" are being abandoned by IMO in favour of ''power limits'', focusing on Japan's Energy Efficiency Existing Ship Index (EEXI) that specifies the standardized CO2 emissions related to installed engine power, transport capacity and ship speed.[29] The EEXI was adopted on 17 June 2021 at MEPC 76. From 2023 onwards, all oceangoing cargo and passenger ships above 400 gross tonnages (GT) falling under MARPOL

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[22] See IMO, Fourth IMO GHG Study 2020, available at https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20-%20Full%20report%20and%20annexes.pdf
[23] Id.
[24] M. Doelle & A. Chircop, Decarbonizing international shipping: An appraisal of the IMO's Initial Strategy, 28(3) Review of European, Comparative & International Environmental Law 268-277 (2019). doi.org/10.1111/reel.12302
[25] Initial IMO Strategy, supra note 13.
[26] Initial IMO Strategy, supra note 13.
[27] A. Pastra, P. Zachariadis & A. Alifragkis, "The Role of Slow Steaming in Shipping and Methods of CO2 Reduction", in A. Carpenter, T.M. Johansson & J.A. Skinner Editors (Eds.), Sustainability in the Maritime Domain. Strategies for Sustainability, 337-352, (Springer International Publishing, New York, 2021). ISBN: 978-3-030-69325-1
[28] H.N. Psaraftis, Speed Optimization vs Speed Reduction: The Choice between Speed Limits and a Bunker Levy, 11(8) Sustainability 2249 (2019) doi:10.3390/su11080000
[29] Pastra et. al., supra note 27.

Annex VI are expected to comply with the Index. Accordingly, an EEXI Technical File is to be issued for most types of ships, calculating the attained EEXI, which must be below a specified value. The Technical File are to be submitted to the Class for approval during the first annual, intermediate or renewal surveys after the EEXI requirements come into effect[30].

Regarding new vessels, the Energy Efficiency Design Index (EEDI) ensures that new ships of 400 GT and above are more energy-efficient than the baseline.[31] In 2011, the resolution MEPC.203(62) on "Inclusion of regulations on energy efficiency for ships in MARPOL Annex VI" introduced mandatory short and long-term technical and operational measures for the energy efficiency of ships of newbuilding. It is observed that the long-term technical measures to monitor the amount of CO2 and harmful emissions from ships are relevant to the Energy Efficiency Design Index (EEDI). In addition, there are provisions for a mandatory Ship Energy Efficiency Management Plan (SEEMP) for all ships. Ship-specific SEEMP comes as a structured plan for monitoring and improving vessels and fleets' fuel consumption and efficiency performance through acquisition of data. Energy efficiency improvements in ships' operation over time lies at the heart of SEEMP.

Aside from vessel-specific plans and schemes, there are a range of port-related measures to reduce GHG emission in place across the globe. As we have explored elsewhere, ports play a crucial role in the reduction of GHG emissions as they bear the capacity to promulgate constructive GHG policies, monitor operations in the shipping sector by supporting NDC/INDC commitments and leading the path towards the decarbonization of the whole supply chain.[32] Indeed, four distinct but interrelated spheres of influence have been identified. One deals with emissions from port operations, and another with the role of ports in supporting the decarbonization of shipping, including the implementation of the IMO strategy. There are two other spheres of influence, which do not tend to get the same level of attention. One is the role of ports in decarbonizing the remainder of the inland transportation system, particularly transportation of goods and personnel to and from the port. The other is the role of ports in decarbonizing the geographical region within which the port operates, such as for example opportunities to support the decarbonization of electricity generation. We will return to these four spheres of influence later in this article.[33]

We now turn to the connection between the IMO's strategy to decarbonize international shipping and its related efforts to engage ports in supporting the implementation of the strategy. In this regard, the Marine Environment Protection Committee adopted Resolution MEPC.323(74) on 17 May 2019 encouraging port and shipping sectors of Member States (MS) to engage in voluntary cooperation for reducing GHG emissions from ships. Port Authorities are now encouraged to adopt technical and operational measures by looking into onshore power

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30 See DNV, EEXI Technical File, available at https://www.dnv.com/maritime/insights/topics/eexi/advisory-service-technical-file.html

31 Det Norske Veritas, EEXI -Energy Efficiency Existing Ship Index, available at https://www.dnv.com/maritime/insights/topics/eexi/index.html

32 Reduction of GHG Emissions from Ships: Draft MEPC resolution that invites Member States to encourage voluntary cooperation between the port and shipping sectors to reduce GHG emissions from ships Submitted by Argentina, Canada, Cook Islands, Islamic Republic of Iran, New Zealand,
Panama, Singapore, ICS, IAPH, IMPA, WWF, RINA, IHMA and FONASBA, International Maritime Organization, MEPC 74/7/10, 8 March 2019, available at https://www.ics-shipping.org/wp-content/uploads/2020/08/draft-mepc-resolution-that-invites-member-states-to-encourage-voluntary-cooperation-between-the-port-and-shipping-sectors-to-reduce-ghg-emissions-from-ships.pdf

33 A. Christodoulou, A. Pastra, M. Doelle and T. Johansson, Four Spheres of Influence: The Critical Role of Ports in Global Decarbonization Efforts, 35 Ocean Yearbook (2021).

supply (OPS), port incentive schemes that go beyond IMO requirements, bunkering of alternative low-carbon fuels, digital optimization of port calls' process as well as reliable and trustworthy data exchange between vessel and shore.[34] Recent international developments include the "Ship-Port Interface Guide" that contains the following eight pragmatic measures to support GHG emission efforts:

> Measure 1: Facilitate immobilization in ports;
> Measure 2: Facilitate hull and propeller cleaning in ports;
> Measure 3: Facilitate simultaneous operations (simops) in ports;
> Measure 4: Optimize port stay by pre-clearance;
> Measure 5: Improve planning of ships calling at multiple berths in one port;
> Measure 6: Improve ship/berth compatibility through improved Port Master Data;
> Measure 7: Enable ship deadweight optimization through improved Port Master Data; and,
> Measure 8: Optimize speed between ports. [35]

With the advent of the United Nations (UN) 2030 Agenda for Sustainable Development, many ports around the world are taking actions to comply with national and international regulatory requirements to measure their carbon footprint[36]. As and where the Sustainable Development Goals are implemented in a meaningful way, ports stand to benefit from sustainability-oriented actions that enable the integration of economic, environmental and societal factors in a triple bottom line (TBL) approach.[37] Environmental sustainability, as a branch, relates to the "greening of ports" and refers to ''principles and practices supporting this development by ensuring eco-friendly production and selection of resources on the one hand, and efficient use of resources, disposal of waste, and reduction of GHG emissions, on the other hand"[38]. To ensure environmental sustainability, port authorities are urged by the IMO to improve their environmental performance by utilizing available governance instruments for implementing green port objectives[39]. Although the conceptualization of green ports remains vague, Acciaro (2015) describes them as ports that engage in the proactive development, implementation and monitoring of practices that reduce the ports' environmental impacts at the local, regional and international levels beyond regulatory compliance[40].

Important conclusions drawn by the authors in light of the four spheres of influence refer to a number of strategic actions to be considered in global decarbonization efforts.[41] In the first sphere, the authors have concluded elsewhere that reliance on the structured framework

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[34] Id.

[35] IMO-Norway GreenVoyage2050 Project and members of the GIA, 2021: Ship-Port Interface Guide – Practical Measures to Reduce GHG Emissions (GreenVoyage2050 Project Coordination Unit, UK, 2021).

[36] T. Zis, "Green Ports", in H.N. Psaraftis Editor (Ed.), Sustainable Shipping: A Cross-Disciplinary View. 407-432 (Springer, New York, 2019) ISBN 978-3-030-04330-8

[37] J. Elkington, Cannibals with forks: Triple bottom line of 21st century business (Stoney Creek, CT: New Society Publishers, 1997. See also P. Donner, G. Theocharidis and T. Johansson, "Methods to promote Improved Governance in Maritime Administrations of Developing Nations", in L. Froholdt (Ed.), Corporate Social Responsibility in the Maritime Industry, World Maritime University Studies in Maritime Affairs, Volume 5, 63-89, (Springer, Cham, 2018).

[38] E. Lalla-Ruiz, L. Heilig & S. Voß, 'Chapter 3 Environmental Sustainability in Ports', p. 66, in J. Faulin, S. Grasman, A. Juan & P. Hirsch Editors (Eds.), Sustainable Transportation and Smart Logistics, (Elsevier, New York, 2019)

[39] J. S. L. Lam & T. Notteboom, The Greening of Ports: A Comparison of Port Management Tools Used by Leading Ports in Asia and Europe, 34(2) Transport Reviews 169-189 (2014).

[40] M. Acciaro, Corporate Responsibility and Value Creation in the Port Sector, 18(3) International Journal of Logistics Research and Applications 291-311 (2015).

[41] See Christodolou et. al., supra note 33.

of ISO 5001 can be a good way forward.[42] ISO 5001 is a tool for implementing an "energy efficiency" management plan that integrates an energy management system within the organizational framework of ports that will effectively monitor energy consumption leading to reduction (in consumption) in the long run.[43] Other tools include developing emission inventory, scientific monitoring programs as well as implementation of training programs for ports; and improving energy performance through the renovation of buildings and using LED technologies or alternative energy sources for lighting and heating.[44]

The second sphere titled "supporting efforts to decarbonize shipping" is rather self-explanatory in so far as it refers to the Initial IMO Strategy. Short-term measures under this sphere includes installing OPS, or cold ironing that will substantially reduce SOx, NOx and PM emissions.[45] GHG emissions can be curbed by sourcing electricity from renewable energy sources.[46] Other measures include revisiting strategies to reduce ships' waiting time at berth and implementing green port fees as an incentive schemes for green operations in shipping.[47] It also includes supporting the transition to alternative fuels, and cooperating in ensuring adequate supply of green ammonia, hydrogen, methanol and/or electricity. The third sphere pertains to decarbonization of inland transport by supporting modal shifts such as rail and road modes of transport as well as decarbonization of port transport services.[48] Finally, the fourth sphere relates to "supporting decarbonization efforts in the geographical location of the port". Ports have the opportunity to support and cooperate with communities and jurisdictions within which they operate, which should include an integrated approach to their respective decarbonization efforts. Despite ongoing efforts by many ports to improve their environmental policies, no long-term strategic plans have been developed by ports that fully integrate all four spheres into a coherent, comprehensive decarbonization plan.[49]

3 Case Study: The People's Republic of China

Over the past two decades, China has been a leading contributor to global maritime commerce. In terms of container throughput, seven of the world's top ten container ports are located in China.[50] The major ports include Shanghai International Port (Group) Co., Ltd. (SIPG), Ningbo-Zhoushan Port Company Limited, Shenzhen Port, Guangzhou Port Company Limited, Qingdao Port International Limited, Hong Kong and Tianjin Port (Group) Company Limited.

With increased industrial activities, China's CO_2 emissions have remained close to all-time high levels. Reports published in 2020 suggest that China contributes about 28 percent to global greenhouse gas emissions and about 30 percent to global CO2 emissions".[51] In the past, only a handful of research-based publications have sought to estimate the amount of GHG

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[42] Id.
[43] Id.
[44] Id.
[45] Id.
[46] Id.
[47] Id.
[48] Id.
[49] Id.
[50] Lloyd's List, One Hundred Ports, 2020, available at https://lloydslist.maritimeintelligence.informa.com/one-hundred-container-ports-2020
[51] J.G.J. Olivier and J.A.H.W. Peters, Trends in Global CO2 and Total Greenhouse Gas Emissions (2020 report. PBL, Netherlands Environmental Assessment Agency, The Hague) at 36.

emissions from China's shipping and maritime activities.[52] Attempts have largely been futile given that reliable and detailed datasets needed in relation to emission rates have tended to be unavailable.[53] However, a recent national survey compiling data from a variety of stakeholders, including the National Bureau of Statistics, the National Energy Administration, China's Electricity Council and China Customs, seems to confirm that China's overall rate of CO2 emissions have indeed increased during the first quarter of 2021.[54]

Considering the limitations and gaps in evidence-based research, it is difficult to verify China's progress with regards to all four spheres of influence in reducing GHG emissions. Therefore, the analysis developed in subsequent sections focus only on certain areas of influence, and for each of those, consider three key elements considered crucial for an effective green port policy framework, namely: 1. adoption of green policies; 2. inclusion of strategic stakeholder management in the port strategy; and, 3. scientific monitoring of port activities. Due to constraints of space and available data, these three elements of effective environmental policy are applied in this case study to the first sphere, i.e., port operations, and to the international shipping element of the second sphere of influence.

3.1 China's National Green Policy

A national circular containing strategic guidelines was issued in early 2021. Helping the Chinese economy and society transition to a green and sustainable future is central to the voluminous circular. The 14th five-year plan (FYP) sets out key measures, targets and broad policies for the next five years, i.e., from 2021 to 2025.[55] The FYP notes several important transitions, some of which are worth highlighting:

- Development of green, low-carbon technologies for accelerating the application of scientific-technology outcomes;
- Intensify international cooperation in sectors such as, energy saving and green energy;
- Promote green renovations of data centres;
- Promote green and low-carbon and circular development and contribute to building a community of a shared future for mankind.[56]

The FYP is not specifically aimed at ports but it also does not exclude ports. The current FYP depicts the Chinese government as insightful and ambitious with respect to the reduction of GHG emissions. In 2009 and 2015, the Chinese government declared its aim to reduce carbon emissions (per unit of Gross Domestic Product) by 40 percent to 45 percent by 2020, and by 60 percent to 65 percent by 2030, respectively. However, at the national level, especially in the case of maritime affairs, a number of issues require further investigation when

[52] See Q. Wei and S. Zhao, Estimating CO2 Emission and Mitigation Opportunities of Wanzhou Shipping in Chongqing Municipality, China, in Proceedings of the International Conference on Logistics Engineering and Intelligent Transportation Systems, Miami, FL, USA, 26–28 November 2010; pp. 1–4. See also H. Hao, Y. Geng, and X. Ou, Estimating CO2 emissions from water transportation of freight in China, 7 International Journal of Shipping and Transport Logistics, 676-694
2015.

[53] H. Yang, X. Ma, and Y. Xing, Trends in CO2 Emissions from China-Oriented International Marine Transportation Activities and Policy Implications, 10(7) Energies 980 (2017) https://doi.org/10.3390/en10070980, at 3.

[54] China's carbon dioxide (CO2) emissions have grown at their fastest pace in more than a decade, increasing by 15 percent year-on-year in the first quarter of 2021, new analysis for Carbon Brief shows, available at https://www.carbonbrief.org/analysis-chinas-carbon-emissions-grow-at-fastest-rate-for-more-than-a-decade

[55] A New Plan Ahead, available at https://sdg.iisd.org/commentary/guest-articles/a-new-plan-ahead/

[56] Official homepage of the State Council of the People's Republic of China, available at http://english.www.gov.cn/policies/latestreleases/202102/22/content_WS6033af98c6d0719374af946b.html

undertaking initiatives to implement port-specific green policy: do GHG emissions fall under the definition of "pollution"? Can GHG emission be fully governed through existing law and regulation? What are the best practices from major maritime countries that could be taken into account to meet China's NDC?

Whether or not emissions can be abated through an amendment following international practices, such as the manner in which the United States of America's (US) Clean Air Act of 2009 defines "hazardous pollutants" in s. 202, is an important policy question for China. Some have asserted that the inclusion of GHG as a type of pollutant under the existing law may not be feasible given that it has the potential to create an additional layer of responsibility for the government as there will be a need to implement additional processes and engage more resources to monitor units of emissions from all sectors.[57] This would also entail the creation of a penalty-regime that could potentially hinder industrial growth.

3.2 Strategic Stakeholder Management as a Part of Port Strategy

Many short-term policies, such as low carbon cities and other carbon emission reduction efforts, have been put in place, and some have resulted in policy-overlaps and crucial development-disruptions.[58] There appears to be a substantial divergence of opinion between local and central governments on the topic of curbing atmospheric emission in China with the former at times protecting local carbon-intensive industries for Gross Domestic Product (GDP) increase over decarbonization. This divergence at the local level in turn can undermine strategic stakeholder management efforts to set uniform emission policy-based standards for the shipping sector and port operations at the national level in support of international objectives.[59] Moreover, the socioeconomic differences among the many different regions of China are a barrier against developing uniform policies covering all regions of country.

Energy-saving and emission-reduction work is at the forefront of most of the domestic ports located at various regions of China whereby ports have announced mid- and long-term plans for energy conservation and emission reduction. While significant steps have been taken by Chinese ports on energy conservation, waste management, dust and noise reduction; more strategic measures are in order to incentivize and reduce ship emissions and fossil-fuel based energy dependence.[60] Key strategic measures would include consultation followed by strong cooperation among Chinese port stakeholders (i.e., port authorities, port companies, government bodies and their representatives, and community stakeholders) as well as solidarity between both central and local governments. One particularly important area that needs to be further explored is the effective cooperation between central and local governments on decarbonization.

Observing China from a port governance perspective, it is clear that different mechanisms are deployed for different ports in part due to different ownership and management approaches.

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[57] Y. Liu, "Development of Legislation for Ship Greenhouse Gas Emission Reduction, and Suggestion of Enforcement for China MSA" (2014), Maritime Safety & Environment Management Dissertations 184, World Maritime University, available at https://commons.wmu.se/msem_dissertations/184, at 18-29.

[58] W. Yang, R. Zhao, X, Chuai, L. Xiao, L. Cao, Z. Zhang, Q. Yang and L. Yao, China's Pathway to a Low Carbon Economy, 14(14) Carbon Balance and Management (2019) available at https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-019-0130-z

[59] Id.

[60] K. Du, J. Monios and Y. Wang, 'Chapter 11 - Green Port Strategies in China', in R. Bergqvist & J. Monios, Editors (Eds.), Green Ports: Inland and Seaside Sustainable Transportation Strategies, 211-229, (Elsevier, Amsterdam, 2019) ISBN 9780128140543

Port ownership currently ranges from central government-owned ports to co-owned (by central and local governments) ports, to entirely local government owned ports.[61] The port governance principles, as laid down in the "Port Law of 2004" and the "Rules on Port Operation and Management" separated the dual role of regulator and operator of port authorities and paved the way for the decentralization and corporatization of port authorities.[62] Implications are positive as port integration initiatives are visible. What is also noteworthy is the role that national shipping companies and shipping organizations play in the ongoing work of the Chinese government.

Despite past initiatives, which reflect incremental transformation of the existing port governance since 2004, Chinese ports, however, have yet to integrate individual initiatives for developing a strategic management plan. The elements for a strategic Fragmented efforts must be avoided. Central and local governments should combine strengths, identify opportunities, weaknesses and threats in consultation with proactive national shipping companies and organizations to expedite the role of ports in national GHG emission reduction from shipping in a synchronised fashion.[63] In all cases, if Chinese ports are to keep pace with and lead evolving international emission standards, they will require a more cohesive strategic stakeholder management approach, as well as a stronger focus on enhancing ports' sustainable development capabilities.

3.3 Scientific Monitoring of Port Activities

China's major container ports have taken some meaningful steps to green their operations. For example, one of the main goals of the Shanghai port is to develop smart and green technology-driven operations. Shanghai port has developed strict Domestic Emission Control Areas (DECA), which is a unique development by the port for controlling air pollution from shipping activities in Yangtze River Delta (YRD). Moreover, materializing the "green port" concept is already a mission for the Ningbo-Zhoushan Port authorities in so far as they stress the environmental dimension by prioritizing environmental protection, preservation and conservation against pollution.[64] Shenzhen and Guangzhou ports have taken some notable steps toward integrating economic, environmental and societal factors and applying a triple bottom line approach.

Noteworthy in this discussion is the work of Qingdao Port International Limited that also endorsed a sustainability approach focusing on superior organizational performance in an environmentally friendly manner, relying on technological innovation and energy-efficient solutions. Energy-saving and carbon-reduction measures, transportation method optimization, green lighting projects inside the area, and green finance have all been implemented to establish a world-class, smart and green port.[65] Notwithstanding the progress to enhance performance through the use of new technologies and technologies with emerging

[61] Id.
[62] T. Notteboom and Z. Yang, Port Governance in China Since 2004: Institutional Layering and the Growing Impact of Broader Policies, 22 Research in Transportation Business & Management 184-200 (2017).
[63] Id.
[64] Ningbo Zhoushan Port Co., Ltd. 2019 Social Responsibility Report available at https://www.nbport.com.cn/ztwzww/c/2020-04-27/715825.html
[65] Qingdao Port International, Qingdao Port International Co., Ltd. Sustainability Report of 2019, available at https://www.qingdao-port.com/bootlgfiles/2020-04-23/b1d614cc-d374-4df7-82cb-59e666cccfab.pdf/

applications, there is no indication that technological tools are used to facilitate monitoring activities in Chinese ports.[66]

We use the term scientific monitoring to refer to processes for assessing and examining the general quality of the environment within the port area and the various impacts of port operations.[67] A study by Hua (2020) indicates that efforts must concentrate on monitoring energy consumption and pollutant emissions in addition to utilizing technological applications when greening Chinese ports.[68] Examples of scientific monitoring are ripe at the international level with many port authorities actively engaged in developing air quality monitoring programs that aim to collect air data in the harbor area through monitoring stations. A study conducted in 2018 by Gonzalez-Aregall et. al. (2018) notes the use of monitoring programmes by seventy-six out of three hundred and sixty-five ports as a part of green hinterland goal that includes reducing air emission.[69] In cases where results from monitoring indicates that the concentration of pollutants in the air has exceeded acceptable limits, port authorities should take advantage of innovation and energy-efficient solutions and aim to reduce the rate and further monitor progress to maintain and further enhance the performance of the port. In all cases, scientific monitoring is an essential process for measuring GHG rate fluctuations and other impacts of port operations.

One of the objectives of the IMO Initial GHG Strategy is the monitoring of GHG emissions from international shipping, but not from port operations. What is currently missing across major ports in China is a model for developing carbon footprint inventory to closely monitor emissions of GHG from port operations. This will enable port authorities to better understand the sources of these emissions "culminating to the development of a structured inventory of activities and energy requirements within and around the ports".[70] A carbon footprint inventory could serve as a foundation for developing advanced models for "energy integration and activity synergies" for calculating "efficient energy usage and/or improved ports operations" leading to both economic and environmental gains.[71]

4 Port Practices of Major Shipping States

International ports that are currently focused on environmental concerns to satisfy the objectives laid out in respective environmental legislation can serve as best practice examples for China. Noteworthy take-aways are many. When looking at best practices within the European Union (EU), it is apparent that current measures for some ports go far beyond the criteria set forth in national legislation. For example, the Port of Rotterdam (PoRA), which is a leading green port within the EU, has set specific objectives for a CO_2-neutral port by 2050 that will be accomplished through a three-step approach:

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[66] J. S. L. Lam and W. Y. Yap, A Stakeholder Perspective of Port City Sustainable Development, 11(2) Sustainability 447 (2019). https://doi.org/10.3390/su11020447

[67] C.F. Wooldridge, C. McMullen, V. Howe, Environmental Management of Ports and Harbours - Implementation of Policy through Scientific Monitoring, Volume 23 (4-5) Marine Policy 413-425 (1999)

[68] C. Hua, J. Chen, Z. Wan, L. Xu, Y. Bai, T. Zheng, & Y. Fei, Evaluation and Governance of Green Development Practice of Port: A Sea Port Case of China, 249 Journal of Cleaner Production 119434 (2019). https://doi.org/10.1016/j.jclepro.2019.1194342020

[69] M. Gonzalez Aregall, R. Bergqvist and J. Monios, A Global Review of the Hinterland Dimension of Green Port Strategies, 59 Transportation Research Part D: Transport and Environment, 23-34 (2018)

[70] Collins I. Ezeha, Ulf H. Richter, Juergen H. Seufert and C. Pengd, Greening of Chinese Ports: Case Study of Ningbo Zhoushan Port, in 6th Workshop on EU-China Relations, Taiwan (2017)

[71] Id.

Step 1 Efficiency & Infrastructure: companies in cooperation with the port authority are developing innovative technology to improve sustainability in the port area, whereas new infrastructure is under development;
Step 2 Large scale projects: for a new energy system that will utilise green hydrogen, solar, wind and hydropower forms of energy; and,
Step 3 Circular Economy and Energy Transition: Involves the replacement of fossil fuels through the use of biomass, recycled materials, green hydrogen, and CO_2.[72]

PoRA is also proactive through a number of innovative initiatives: stakeholder engagement, green policies and scientific monitoring of the activities; effective stakeholder management approach based on the principles of mutual gains; providing stakeholders the "license to operate" as well as the "license to grow" beyond the borders of their territory; based on the Environment Ship Index (ESI), award vessels that achieve low- or zero-carbon emissions with discounts on port dues; monitor water quality, fauna, sediments and CO2 footprint, inter alia .[73] In terms of strengthening the working relation between public and private sector entities of the national port system, the Greek port of Piraeus has in place Law No. 4389/2016 that establishes the Regulatory Authority for Ports (RAFP) that supervises the legality of the relations between public and private sector entities of the national port system.[74]

On the US front, the ports of Long Beach, Seattle- Tacoma, New York/New Jersey and Virginia have incorporated the three key elements of an effective environmental policy we have previously identified, i.e., green policies, stakeholder engagement and scientific monitoring for an effective framework. The Port of Long Beach (POLB), which is primarily a landlord port, assists tenants in meeting legal requirements, offers incentive programs, and has adopted a number of policies and programs, such as its Green Port Policy, Clean Air Action Plan, Community Grants Program, and Green Flag Incentive program to assure its compliance with state requirements and improve air quality, reduce water pollution, and lessen impact of port operations on wildlife.

The Ports of Seattle and Tacoma governed by the Northwest Seaport Alliance (NWSA) has established an environmental governance regime that, like its fellow West Coast state California, is among the most stringent in the country. Consequently, the NWSA has adopted policies and programs, such as the Northwest Ports Clean Air Strategy,[75] clean truck

[72] See Port of Rotterdam, In three steps towards CO_2 Neutral, available at https://www.portofrotterdam.com/en/doing-business/port-of-the-future/energy-transition/all-about-energy-transition/in-three-steps
[73] Note that PoRA aligns its activities with the Paris Climate Agreement objectives through the following three steps approach towards a CO_2-neutral port by 2050: Step 1 Efficiency & Infrastructure: requires the port to handle energy and raw materials efficiently as well as to develop adequate infrastructure to achieve step 1; Step 2 Projects towards a new energy system: includes all the projects for the transition from oil and gas to electricity, green hydrogen, solar, wind and hydropower forms of energy; and Step 3 Circular Economy and Energy Transition: involves the replacement of fossil fuels through the use of biomass, recycled materials, green hydrogen. See also Official Homepage of Port of Rotterdam Authority N.V., available online: https://www.portofrotterdam.com/en
[74] Decree Law No 4389/2016 (Government Gazette A'94/27-05-2016) "Urgent provisions for the implementation of the Agreement on budgetary objectives and structural reforms and other provisions", (2016). See also Official Homepage of The Regulatory Authority for Ports (R.A.F.P.), available at http://www.raports.gr/en
[75] Northwest Ports Clean Air Strategy, Port of Seattle (n.d.) available at https://www.portseattle.org/page/northwest-ports-clean-air-strategy

programs,[76] and clean fuel programs,[77] to ensure its adherence to Federal and State of Washington obligations and to improve air quality, reduce water pollution, and lessen the impact of port operations on wildlife. The NWSA is subject to a variety of policy mechanisms, such as legislation, regulation, and guidelines. The State of Washington requires public outreach for certain projects, and local communities and stakeholders are very active and engaged with the NWSA on issues that do not require, but do merit, public engagement.

The Port of New York/New Jersey (PANYNJ), has grounded its environmental programs in overarching policies such as those elucidated in its Comprehensive Port Improvement Plan,[78] Thirty-Year Port Master Plan,[79] Clean Air Strategy,[80] and organizational commitment to abidance by the Paris Agreement. PANYNJ has a dedicated Environmental Initiatives department that identifies funding needs and assists in obtaining funding to support the initiatives and incentive programs.

In terms of green initiatives, the Virginia Port Authority (VPA) has formally identified sustainability as one of its core values and employs a rigorous Environmental Management System (EMS) that complies with International Organization for Standardization requirements. Under the auspices of its EMS, VPA ensures that its own operations and the operations of its tenants comply with Federal and State regulations. Further, VPA has created programs, such as its Green Operator Program[81] and the James River Barge Line,[82] to address local concerns regarding the effects on air pollution of VPA operations.

Similar initiatives can be found in the case of the Australian Port of Botany that maintains an environmental management system conforming to international standards (ISO 14001) for compliance that includes an overarching Environmental Management Plan (EMP) at each of its sites. Through the Environmental Ship Index, New South Wales (NSW) Ports provide financial incentives to ships that surpasses the IMO's environmental performance requirements. The three key elements of an effective framework have also been incorporated in the Port of Botany. Moreover, the current Australian regulatory framework has allowed the Port Botany to operate through an annual reporting system in accordance with the government's five-Year Sustainability Plan.

As for Asia, examples are numerous in the Port of Singapore. The Maritime Singapore Green Initiative is an environmental performance scheme that certifies vessels that strive for excellence in reducing air emissions by going beyond current emission standards of IMO. The port of Singapore is also in the process of promoting eco-friendly shipping activities and, through proper financial mechanisms, has safeguarded sufficient funds to facilitate an innovation ecosystem for enhancing port environmental performance.

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[76] Clean truck programs, Port of Los Angeles (2008) available at https://www.portoflosangeles.org/environment/air-quality/clean-truck-program

[77] Clean Fuels Program, State of Oregon (2009), available at https://www.oregon.gov/deq/aq/programs/Pages/Clean-Fuels.aspx

[78] Comprehensive Port Improvement Plan, The Port Authority of New York / New Jersey, (n.d.), available at https://www.panynj.gov/about/pdf/cpip

[79] Port Master Plan 2050, The Port Authority of New York / New Jersey, (n.d.), available at https://www.panynj.gov/port/en/our-port/port-development/port-master-plan.html

[80] Clean Air Strategy, The Port Authority of New York / New Jersey, (n.d.), available at http://cleanports-nynj.com/?tx_category=all

[81] Green Operator Program, Port of Virginia, (n.d.) available at http://www.portofvirginia.com/stewardship/sustainability/green-operator/

[82] James River Barge Line program, Port of Virginia, (2014).

For an effective stakeholder engagement, the Port of Singapore formulates partnerships with various stakeholders that ensure transparency, synergy and strong cohesiveness in policy formulation and implementation. Tripartite partnerships among the government sector, the port industry, and unions have enabled Singapore to pave the way towards stakeholder engagement and the creation of an innovation ecosystem. For overcoming obstacles to infrastructure development, the PoRA has embraced the Green Deal approach - one of the most innovative programmes of overcoming obstacles that arise from the legislation and the lack of market incentives. For the integration of a Green Deal approach into the Chinese ports, strong cooperation has to be achieved between the various levels of government, port authorities regardless of existing types, research institutes, funds, private companies and other stakeholders. Partnerships promote "environmental citizenship" because individuals, communities, independent experts and businesses contribute equally to the to the green port agenda. Sufficient cooperation with port tenants and enhancement of port tenants' sustainability practices via implementation of training programs that measure and reduce GHG emissions through shared knowledge is another important initiative for efficient stakeholder management. [83]

5 Ways Forward

China is a party to a number of IMO Conventions that concerns vessel-source pollution, including the International Convention for the Prevention of Pollution from Ships (MARPOL).[84] Ergo, all amendments to MARPOL Annex VI that are in force will need to be taken into account by Member States (MS) by adjusting the national application range and emission standards. Relevant international laws and corresponding guidelines related to air pollution prevention from ships and energy efficiency of ships serve as guidance notes for MS, including China, in ameliorating the environmental, social and economic problems that result from GHG emission. Taking those into consideration, a strategic way forward for China could be to carve out ways of progressing towards a low-carbon and eventually a carbon neutral economy by developing stringent national implementation, compliance and monitoring protocols with reference to Article 62 of the Marine Environment Protection Law of the People's Republic of China (2017) (MELP 2017), and the Regulations of the People's Republic of China on the Prevention and Control of Marine Pollution from Ships (No. 19-019) – two instruments that conform albeit to the United Nations Convention on the Law of the Sea of 1982 (LOS) and IMO Conventions including MARPOL. Indeed, the aforementioned are refined instruments that mirror China's intentions to combat environmental pollution from shipping with a view to demonstrating "good environmental stewardship" – a cardinal feature of the LOS. Another way forward could be to revisit the FYP and integrate a "maritime element" taking into account the 2030 climate target with direct reference to the environmental dimensions of MELP 2017. Whatever pathways are explored, it is important for the government of China to bear in mind the global objectives so that there is adequate alignment and cohesion with its shipping and international trading counterparts (as observed from noteworthy developments highlighted in s. 4.4 below).

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[83] T. Parviainen, A. Lehikoinen, S. Kuikka & P. Haapasaari, "How can stakeholders promote environmental and social responsibility in the shipping industry?", 17 World Maritime University Journal of Maritime Affairs 49-70 (2018). https://doi.org/10.1007/s13437-017-0134-z

[84] International Maritime Organization, 1992, MARPOL 73/78: articles, protocols, annexes, unified interpretations of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 relating thereto, IMO London.

Other than technical and operational measures for shipping endorsed at the international level, the work of authorities engaged in operations, case-in-point being Chinese port operations, is an area that requires active coordination with sustainability initiatives. That is where, again, heavy reliance could be made on three vital key elements for an effective green port policy framework as described in the previous section.[85] The following sections underline the specifics under the headings derived from the three key elements based on noteworthy developments from countries (discussed in the previous section) that have taken the lead by focusing on one or more of the three key elements.

5.1 Green Policy Considerations

As an important part of the overall effort to adopt green policies, measures similar to PoRA, ports of Long Beach, Seattle- Tacoma, New York/New Jersey and Virginia, should be implemented that target GHG emissions from: port operations, oceangoing vessels, domestic vessels, and the whole supply-chain sector. Port measures that target GHG emissions from oceangoing vessels at berth include, and are not limited to, OPS or cold ironing infrastructure for shore-side electricity supply and development of refuelling points for access to liquefied natural gas (LNG) bunkering in port. However, it should be noted that these infrastructure-related developments, although crucial to the abatement of port-related GHG emissions, should safeguard external funding either from governmental sources or investment funds.[86] Just-In-Time (JIT) arrival of vessels by implementing pre-booking systems to minimize pre-berth delays and discounts in regular port fees offered to green vessels is another initiative that most major international ports of China should consider. As for the green policies for domestic vessels, one important target should be the green procurement for the towage sector, which specifies limits on GHG emissions from tugboats. In terms of reducing GHG emissions from inland transportation and the supply chain system, electrification for port operations and the use of alternative carbon-neutral fuels are considered particularly promising.

5.2 Stakeholder Management Considerations

Inclusion of strategic stakeholder management in the port strategy is the second vital element for a robust green port governance framework. It is observed that there are four principal groups of stakeholders, which include internal stakeholders (leadership team, employees, owners, operators), public sector (i.e., port state control, ministry, national agencies), market players (i.e., supply chain companies and sea transport operators) and community groups (inhabitants and non-profit organizations).[87] Cooperation among stakeholders could be achieved through identifying all entities that could contribute to decarbonization efforts, assessing the nature of influence and importance, and monitoring and maintaining pathways for continuous collaboration.[88] In order to further support decarbonization efforts in their geographical location, ports need to ensure inclusion of all above groups in their long-term strategy.

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[85] J.S. L. Lam & K. X. Li, Green Port Marketing for Sustainable Growth and Development, 84 Transport Policy 73-81 (2019).

[86] See Christodolou et. al., supra note 33.

[87] F. Coppens, F. Lagneaux, H. Meersman, N. Sellekaerts, E. Van de Voorde, G. van Gastel, T. Vanelslander & A. Verhetsel, "Economic Impact of Port Activity: A Disaggregate Analysis, Working Paper Document" (National Bank of Belgium, Brussels, Belgium, 2007). See also J. S. L. Lam & W. Y. Yap, A Stakeholder Perspective of Port City Sustainable Development, 11(2) Sustainability 447 (2019). https://doi.org/10.3390/su11020447

[88] N. Bellefontaine and T. Johansson, "Effective and Efficient Maritime Administration and Corporate Social Responsibility", in L. Froholdt (Ed.), Corporate Social Responsibility in the Maritime Industry, World Maritime University Studies in Maritime Affairs, Volume 5, 103-110, (Springer, Cham, 2018).

Moreover, for smooth integration of a Green Deal approach (as noted in the previous section) into the Chinese ports' strategy, strong cooperation has to be achieved between the government, port authorities regardless of existing types, research institutes, funds and private companies. Partnerships promote "environmental citizenship" especially if designed to ensure that individuals, communities, independent experts and businesses contribute fairly to the green port agenda. Sufficient cooperation with port tenants and enhancement of port tenants' sustainability practices via implementation of training programs that measure and reduce GHG emissions through shared knowledge is another important initiative for effective stakeholder management. [89]

5.3 Considerations for Implementing Scientific Monitoring Systems

Finally, crucial to greening of ports is scientific monitoring that will enable the estimation of environmental impacts is another crucial aspect of green ports. A proper energy efficiency management plan will enable a port to integrate energy management in their organization and reduce the energy consumption of their operations. The IMO Port Emissions Toolkit could be useful to port authorities when recording direct and indirect air emission sources, e.g., particulate matter (PM), volatile organic compounds (VOCs), carbon monoxide (CO), CO2), CH4 and N2O.

5. Conclusion

Effective maritime governance is seriously and fundamentally challenged by climate change.[90] Pursuing a green recovery is essential for all regions, most notably Asia that to date remains as the highest emitter in the shipping world. Much can be achieved at the national level by reducing and eliminating GHG emissions to keep global warming within the goals of the Paris Agreement. An important stepping-stone would be a national environmental policy framework for ports that integrates national decarbonization efforts with global efforts to decarbonize international shipping, including through the integration of national law and regulation governing GHG emissions and further align it with IMO's prescribed mitigation strategies and eventual full decarbonization of international shipping and transportation more generally. It is also worth exploring feasible alternatives through the FYP green initiatives that could open pathways for stringent monitoring, reporting and verification.

Considering that ports can act as hubs for sustainable and green initiatives, the government of China should target major ports and introduce resources for accelerating carbon neutrality. The current Chinese seaport system is heterogeneous; therefore, a rigid, one-size-fits-all green port approach cannot be applied.[91] What is needed is better coordination and cooperation among ports to identify potential new roles for port actors.[92] Proper governance instruments and policies for each type of ports are essential to enable the implementation of

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[89] T. Parviainen, A. Lehikoinen, S. Kuikka & P. Haapasaari, "How can stakeholders promote environmental and social responsibility in the shipping industry?", 17 World Maritime University Journal of Maritime Affairs 49-70 (2018). https://doi.org/10.1007/s13437-017-0134-z

[90] R. Warner and C. Schofield, "Climate Change and the Oceans: Legal and Policy Portents for the Asia Pacific Region and Beyond", in R. Warner and C. Schofield (Eds.), 1-20, Climate Change and the Oceans Gauging the Legal and Policy Currents in the Asia Pacific and Beyond, (Edward Elgar Publishing, 2012).

[91] See Notteboom &. Yang, supra note 62.

[92] Id.

green port objectives.[93] A national systematic roadmap to guide port plans, port policies and port actions under the umbrella of an established environmental policy framework is critical.

Considering that ports are key national assets, environmental matters would be best driven by joint central and local government leadership supported by strong political will for a concrete outcome that mitigates environmental concerns, including GHG and atmospheric pollution, guided by developmental decision-making. Ports and port cities certainly play a vital role in the reduction of GHG emissions from shipping and broader decarbonization efforts in China. Best practice examples are readily available from other international ports. Be that as it may, and as noted earlier, there remain significant differences between China and other jurisdictions where there is significant private port ownership. Best practices need to be tailored to suit the Chinese context. It is important to consider all four spheres of influence, and, for each to adhere to the three key elements of a gold standard for developing an effective environmental policy framework for ports.[94] As observed in the work of countries that are leading green initiatives in relation to ports and port cities, China needs to consider going above and beyond current international and domestic regulatory requirements and lead the way toward full decarbonization for other countries of the Asia-Pacific region.

The objective behind GHG reduction is clear and simple: combat global warming. Scientific evidence points to the fact that complex articulation of human activities and increased impacts resulting from atmospheric pollution, among others, contribute to both small-scale and large-scale planetary changes, otherwise known as Global Environmental Change (GEC) --- one that will severely impact Asia.[95] The daunting challenges posed by shipping and port operations need to be overcome for strategies and targets tabled by IMO to be successful. Major maritime nations, including China, need to work with international counterparts to ensure a coordinated, integrated and effective approach to the global effort to decarbonize shipping specifically, while supporting broader efforts.

[93] See Lam & Notteboom, supra note 39.
[94] See Christodolou et. al., supra note 33.
[95] P.M. Vitousek, "Beyond Global Warming: Ecology and Global Change", 1861–1876 75(7) Ecology 1861-1867 (1994), http://dx.doi.org/10.2307/1941591