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Environmental upgrading in global value chains: The potential and limitations of ports in the greening of maritime transport

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Abstract

Ports are crucial hubs in the functioning of the global economy, and maritime transport is a major emitter of air pollutants. Ports have considerable potential for promoting environmental upgrading in maritime transport and along global value chains more generally, but so far have been only partially successful in doing so. We examine results, limitations and future potential of voluntary initiatives that have been carried out by selected European and North American port authorities, which are considered frontrunners in environmental management. Drawing from the insights of global value chain analysis and organizational theory, we find that low 'tool implementation complexity' and high 'issue visibility' concerning emissions are key facilitators of environmental upgrading. We suggest that ports can intervene in two main ways to improve the environmental performance of maritime transport beyond their organizational and physical boundaries: by lowering tool implementation complexity through stronger collaboration within global value chains; and by enhancing emission visibility through alliances with cargo-owners and regulators.

Keywords: environmental upgrading, ports, maritime transport, global value chains, emission visibility, tool implementation complexity

Highlights

- We examine ports' potential for greening maritime transport and global value chains
- Ports hold considerable potential for facilitating environmental upgrading
- High visibility of emissions is key for upgrading and should be further enhanced
- High tool implementation complexity can be tackled by enhanced collaboration
- Ports should forge alliances with cargo-owners to green maritime transport

1. Introduction

Sustainability has become a mainstream concern in the operation of the global economy, as indicated by the reframing of the international development agenda from the Millennium Development Goals to the recently-adopted Sustainable Development Goals (SDGs). The 2015 Paris Agreement on Climate Change will have important implications on economic activity as well, as it seeks to limit greenhouse gas (GHG) emissions. The SDGs and Paris Agreement goals have to be attained in a world that over the past century has seen a true trans-nationalization of economic activity and a movement away from market exchange and vertical integration within transnational corporations – and towards the operation of Global Value Chains (GVCs) (Ponte and Sturgeon, 2014, Gereffi, 2014).

Ports are crucial hubs in the functioning of GVCs, as they integrate different transport modes. More than 80% of world trade travels over the quays of ports (UNCTAD, 2017), and maritime transport is a major emitter of greenhouse gases (mainly CO_2), Sulphur Oxides (SO_x), Nitrous Oxides (NO_x), and Particulate Matter (PM), the latter including Black Carbon (BC) (Smith et al., 2014). Maritime transport is expected to grow in coming decades, and forecasts show that maritime emissions will increase in absence of further environmental upgrading (Smith et al., 2014). An urgent need for emissions reduction in maritime transport is thus needed to cope with its impact on global climate, human health, ocean acidification and marine environments – and to minimize the environmental impact of GVC operations more generally.

Port authorities, who are responsible for managing the landside and seaside of ports, can play important roles in facilitating environmental upgrading (Chang and Wang, 2012; Giuliano and Linder, 2013, Merk, 2014, Gibbs et al., 2014, Davarzani et al., 2015, Erdas et al. 2015, Wang and Notteboom, 2015, Styhre et al., 2017) through four key functions they perform: (1) as landlords (providing land and basic infrastructure); (2) as regulators (setting tariffs, environmental standards for tenants and other port users, and engaging in spatial planning); (3) as operators (having their own fleets of harbor craft and equipment to provide safe fairways and basic infrastructure); and (4) as community managers (bringing together a variety of port stakeholders to improve collaboration and port performance) (Verhoeven, 2010, Acciaro et al., 2014a). An array of organizational and technological tools available to port authorities has already been identified, including pricing and incentives, monitoring and measuring, market access control, environmental standards regulation, alternative energy supply and demand, and a range of emission reducing technology (Solomon and Bailey, 2004, Lam and Notteboom, 2014, Gibbs et al., 2014, Acciaro et al., 2014b). However, their potential for environmental upgrading has not been assessed, and no comparative study has yet examined what factors lead port authorities to voluntarily adopt certain tools but not others.

Several port authorities have already launched voluntary abatement initiatives, and in 2008 a consortium of 55 ports established the World Ports Climate Initiative (WPCI) (Fenton, 2017). In a joint declaration, WPCI members argued that ‘ports occupy a unique place as key “hubs” in global supply chains, which enables them to influence the sustainability of those supply chains’ (WPCI, 2008). However, the impacts of these initiatives have been geographically limited to a minority of ports, and even in these ports they have applied mainly to their operational areas – so far with minimal effect on ships’ operations while sailing between ports.

In this article, we examine what factors facilitate or hinder the uptake of environmental upgrading tools by ports, what limits these tools have in abating air emissions in particular, and what can be done to improve this situation. We focus on selected ports that have engaged in emission abatement for at least a decade, which we identify as ‘frontrunners’. We analyze two key dimensions that can shape the uptake of environmental upgrading: (1) tool implementation complexity; and (2) emission visibility. Each combination of these two dimensions is examined through the lenses of the four main functions of ports (landlords, regulators, operators and community managers). We find that high issue visibility concerning maritime emissions is a key facilitator in the adoption of environmental upgrading tools. While low tool implementation complexity helps as well, higher implementation complexity can be tackled through stronger collaboration and information sharing within maritime GVCs. At the same time, we observe that increasing the levels of emission visibility is more challenging outside the operational areas of ports, and we provide suggestions on how to tackle this challenge. Our results feed into current reflections on the potential and limitations of environmental upgrading in maritime transport, and in GVCs more generally.

2. Environmental Upgrading

2.1. Environmental Upgrading in GVCs

The concept of value chain refers to 'the full range of activities that firms and workers perform to bring a specific product from its conception to its end use and beyond' (Gereffi and Fernandez-Stark, 2011:4). This includes activities such as design, production, marketing, transport, retail, and disposal or recycling. The concept of '*global* value chain' (GVC) refers to the configuration of these coordinated activities that are 'divided among firms and that have a global geographical scale' (Gibbon and Ponte, 2005: 77). GVCs result from the outsourcing and offshoring of functions previously operated within multi-national corporations, and/or from the development of contractual linkages with suppliers that were previously approached through open market transactions (Gereffi, 1994, Cattaneo et al., 2010). The emergence and expansion of GVCs have increased the importance of logistics (Memedovic et al., 2008, Coe, 2014) and transport – including maritime shipping. In the context of rising trade in intermediate products, leaner and more agile procurement and inventory systems, and heightened flexibility of supply systems (Dicken, 2003, Gereffi, 2014), maritime transport remains essential in the operation of the contemporary global economy (UNCTAD, 2017).

At the same time, business actors operating along GVCs are increasingly assessing and seeking to address the environmental impact of their activities and those of their suppliers and service providers. This trend arises in the context of increased consumer awareness of the environmental impact of production and transportation of goods, of numerous environmental campaigns by civil society groups, and of the multiplication of national, international and transnational environmental regulation. Because production activities have become geographically fragmented but organizationally coordinated, GVC actors seeking to reduce their environmental footprint need to coerce, convince, provide incentives and/or nudge their buyers and suppliers (including those providing maritime shipping services) to do the same – in order to avoid reputational risk (Nadvi, 2008).

One of the ways in which this set of issues has been examined is through the lenses of upgrading in GVCs. In GVC research, the concept of upgrading has been used to identify paths for actors to 'move up the value chain' for economic gain. The literature has highlighted a complex set of upgrading and downgrading trajectories (Gereffi, 1999, Humphrey and Schmitz, 2002, Giuliani et al., 2005, Ponte and Ewert, 2009, Taglioni and Winkler, 2016), which can variously combine improvements in product, process, volume and/or variety, and may involve changing, adding and/or abandoning value chain functions (Ponte et al., 2014). What is most important in relation to the focus of this article is that recent efforts have also attempted to go beyond the discussion of 'economic' upgrading to also examine 'social' upgrading trajectories, and the interactions between the two (Barrientos et al., 2011, Barrientos et al., 2016, Lee et al., 2015).

This research agenda is now expanding to unpack the environmental aspects of upgrading in GVCs, the relation between 'green business strategies' and GVC upgrading, and the effect that *environmental upgrading* has on further consolidation in GVCs – as buyers can use it to extract concessions from suppliers (Jeppesen and Hansen, 2004, Ivarsson and Alvstam, 2011, De Marchi et al., 2013a, De Marchi et al., 2013b, Goger, 2013, Khattak et al., 2015, Poulsen et al., 2016, Khattak and Stringer 2017; Krishnan, 2017). In this context, environmental upgrading is conceived as the process of improving the environmental impact of value chain operations – including production, processing, transport, consumption, and waste disposal or recycling. It can be carried out reactively (e.g., in response to regulatory or customer demands) and/or proactively (e.g., as part of greening strategies, optimization of energy use, the development of new product/service portfolios, and brand repositioning). In this article, we focus on environmental upgrading in the maritime transport function of GVCs, and the particular potential of ports in this process.

2.2. Environmental Upgrading in Maritime Transport

The specialized literature on maritime transport has so far focused mostly on the main *internal* drivers of environmental upgrading within shipping companies: fuel savings and energy prices. Much of this literature is focused on energy efficiency gaps, examining the causes for failures in implementing cost-effective fuel saving measures (Johnson et al., 2014, Johnson and Styhre, 2015, Jafarzadeh and Utne, 2014, Poulsen and Sornn-Friese, 2015, Poulsen and Johnson, 2016, Adland al., 2017).

To some extent, the literature on internal drivers of environmental upgrading also covers port operations. Acciaro et al. (2014b) investigated port energy management practices in Genoa and Hamburg, and advocated a more active role for port authorities, and Cerceau et al. (2014) showed the potential for industrial symbiosis in ports through densified interactions between port stakeholders. Chen et al (2013) discussed emissions from different sources in ports and proposed a methodology to optimize truck arrival patterns to reduce emissions from idling truck engines at marine container terminals. Gibbs et al. (2014) suggested that emissions generated by ships during transit between ports are far greater than those generated by activities in the port. This suggests that ports might have more impact by focusing their efforts on reducing shipping emissions rather than on reducing their own emissions. Johnson and Styhre (2015), Eide et al. (2011), Gibbs et al. (2014) and Moon and Woo (2014) emphasized the need to look beyond ports' organizational and physical boundaries, because port efficiency influences energy efficiency along the entire value chain. With a similar view, Golias et al. (2010) presented a berth-scheduling model to reduce vessel turnaround time and thus minimize the total emissions and fuel consumption for all vessels in transit between ports. Idle time for ships translates into higher service speed and significantly higher emission levels. Johnson and Styhre (2015) conservatively estimated an energy efficiency potential in European short sea shipping of 2-8% from increased port efficiency. In ports around the world, ships berth on a first-come, first-served basis and port congestion often causes ships to wait at anchor off port for berth availability. With a guaranteed berth upon arrival the ship can slow steam, avoid idle anchor time, and reduce GHG and air pollution at sea (Eide et al., 2011, Gibbs et al., 2014, Johnson and Styhre, 2015). Jia et al. (2017) estimated a GHG saving potential from 7% to 19% from reduction in 'excess' port time for crude oil tankers. Another estimate shows that a round-trip from Shanghai to Rotterdam, slow steaming instead of regular steaming, would bring a reduction in CO_2 emissions of 5,000 metric tons (Golias et al., 2010).

The GVC literature on the other hand has contributed to the discussion of environmental upgrading in maritime transport by examining its *external* drivers (Wuisan et al., 2012, Mackinnon, 2014, Lister et al., 2015, Poulsen et al., 2016, 2018, Rahim et al., 2016): multi-level regulation; various forms of business-to-business and multi-stakeholder cooperation; and buyer-driven demands for environmental upgrading (i.e., the requirements posed by cargo-owners to shipping companies when conditions for maritime transportation are negotiated between them). Their results suggest that without the explicit governance traits of either strong buyer or supplier power (as, e.g., in dry bulk shipping), environmental upgrading is difficult to achieve. And even where there is strong buyer power (oil majors in tanker shipping), the lack of a direct link between the goods transported and the final consumer considerably narrows the scope of environmental upgrading (resulting, e.g., in the exclusive focus on oil spills). However, in relation to the shipping of branded consumer goods, cargo-owners have started probing into container shipping companies regarding their GHG emissions. Still, only very few cargo-owners integrate environmental performance into their procurement decisions in relation to carrier selection, and even fewer have included these considerations into pricing models (Poulsen et al. 2016). Finally, non-alignment of voluntary 'green shipping' initiatives with the International Maritime Organization (IMO), the European Union (EU) and state regulatory requirements limits the potential of further improvements (Lister et al. 2015).

2.3. Ports as Environmental Stewards

The mobility of ships and the global nature of ship operations continue to challenge environmental upgrading in maritime shipping, which lags behind land-based industries in terms of emission mitigation achievements (Lister et al., 2015, Bows-Larkin, 2015). Ports can play an important role, as they are based on relatively immobile assets and bind together various GVC operations. Because of their 'localized' nature, ports are increasingly subject to pressure from residents and stakeholders in adjacent communities and have a material interest in maintaining their 'social licenses to operate' (e.g., Dooms et al., 2004, 2013, de Langen, 2007). Giuliano and Linder (2013) showed how the ports of Los Angeles and Long Beach introduced the Clean Air Action Plan in response to strong local community pressures, and Santos et al. (2016) documented how ports in Europe increasingly engage in sustainability communication in response to institutional pressures.

Multiple environmental governance structures meet and interact in ports. National regulations on air quality and climate change mitigation apply to port authorities, port tenants, and onshore transportation. In the case of European ports, EU air quality and climate change regulation also apply. Emissions from ships, on the other hand, are regulated by the IMO, and enforcement of IMO regulation falls on the shoulders of flag and port states. Flag states, which register ships, have a mixed record in the enforcement of IMO regulation, but Port State Control, which is exercised by national maritime authorities while ships are in port, has been an effective enforcement mechanism (DeSombre, 2006).

Since the 1990s, privatization has taken place in numerous ports around the world (Brooks and Cullinane, 2007, Brooks et al., 2017), transforming port authorities into hybrid organizations (van der Lugt et al., 2013, Verhoven, 2010, Giuliano and Linder, 2013) with a commercial mindset and financial autonomy from governments and municipalities. Much of their revenues come from port dues and land leases, while the main port operations (e.g., terminals, stevedoring, warehousing, trucking, towage) are left in the hands of private actors.

3. Methods

We examine five ‘frontrunner’ ports with clear ambitions to become global sustainability leaders. They are located close to densely populated areas and have voluntarily engaged in air emissions abatement for at least a decade: Port of Antwerp (POA), Port of Hamburg (POH), Port of Los Angeles (POLA), Port of Rotterdam (POR) and Port of Vancouver (POV) (Table 1). All are major container import and logistic centers. POA and POR are also major tanker ports, hosting large oil refineries. With the exception of POA, all ports furthermore handle large volumes of dry bulk cargoes. Cruise shipping is expanding in all five ports. The three European ports recently called for stricter global regulation on NO_x emissions from shipping (POR, 2016b), and POR played a key role in the formation of the WPCI (Fenton, 2017). POLA pioneered the port sector with regard to air emissions self-regulation, introducing the Clean Air Action Plan in 2006 (Giuliano and Linder, 2016). Any air emission reduction tools not adopted by these five frontrunner ports are unlikely to be adopted elsewhere. Our study does not consider Asian ports. Lam and Notteboom (2014) have shown that major Asian ports generally have less comprehensive environmental management systems than European ports.

Table 1. Cargo volumes in selected ports (million tonnes), 2016.

Port	Liquid bulk	Dry bulk	Containers	Breakbulk	Ro/Ro	Total
Antwerp	69.2	12.6	117.9	9.8	4.6	214.1
Rotterdam	223.5	82.3	127.1	5.9	22.4	461.2
Port of Los Angeles*	14.3	1.2	167.3	-	-	182.8
Metro Vancouver	6.3	87.5	25.1	16.2	0.4	135.6
Hamburg	14.2	30.7	9.7	1.8	-	138.2

Note: *For the period: July 1, 2015-June 30, 2016.

Sources: Port of Vancouver (2017b), p. 1-3; Port of Rotterdam (2017), p. 190; Port of Hamburg (2017), p. 2; Port of Los Angeles (2017a).

We carried out the study in two phases. We first identified a comprehensive list of port tools for reducing air emissions (Table 2) and examined which tools the five selected ports have adopted. To do so, we analyzed their sustainability reports since first publication (from around 2010), their websites (2016-2017), and the sustainability reporting available on the WPCI website. To triangulate these sources, we investigated recent changes in the discourses on air emissions in the maritime business community, as reflected in articles published in the leading global shipping newspaper, *Lloyd's List*. Specifically, we searched the electronic archives of the newspaper by using seven keywords (virtual arrival, Environmental Ship Index, cold-ironing, onshore power, LNG, World Ports Climate Initiative, and port congestion) going as far back as 1990 – enabling us to follow industry discussions on ports and air emissions that preceded the publication of the first port sustainability reports. In a second phase, we identified the key players involved in the rolling out of these tools in the five ports and conducted semi-structured interviews (interview guide in Appendix 1).[1]

[1] Telephone interviews were conducted in 2017 by one of the authors with the following key informants: (I1) Fer van de Laar, Managing director, WPCI (March 2); (I2) Lisa Wunder, Marine environmental manager, POLA (March 23); (I3) Annika Beiersdorf, Environmental manager, Hamburg Port Authority (March 31); (I4) Peter Mollema, Senior manager and past Director of Environmental Management, POR (April 7); and (I5) Ronan Chester, Manager, Strategic Environmental Initiatives, POV (April 11). The numeration used here is applied in the text to refer to specific interviews (e.g., I1, I2).

Table 2. Tool implementation complexity

Tool implementation complexity	Port authority function	Emission abatement tool	Emitters addressed	Stakeholders (in addition to port authorities)
Low	Operator	Energy management	Port authority operations	None
		Low emission technologies	Port authority operations	None
		Electricity from renewables	Port authority operations	Utility company
	Landlord	Hinterland traffic management	Trucks; Trains	None
		Environmental concession criteria	Tenants	Tenant
	Regulator	Environmental standards regulation	Trucks; Trains	Trucking company or railway company
High	Community manager	Circular economy measures	Tenants	Several tenants
		Financial advice and technical support	Trucks; Inland waterway vessels	Trucking companies; In-land waterway shipping companies
		Onshore power supply	Ships	Ship-owners; Ship managers; Utility companies; Equipment suppliers
		Liquefied natural gas	Ships	Ship-owners; Ship managers; Bunker suppliers; Equipment suppliers
		Green port dues	Ships	Ship-owners; Charterers; Ship managers; Equipment suppliers; Third party data verifiers/auditors
		On time incentive program	Ships	Ship-owners; Charterers; Ship managers
		Voluntary speed reduction	Ships	Ship-owners; Charterers; Ship managers
		Lobbyism in IMO	Ships	172 IMO member states; Ship-owners; Other IMO stakeholders
		Information sharing to reduce vessel turn-around-time in port	Ships	Ship-owners; Ship-managers; Charterers; Shippers; Pilot; Towage; Ship chandlers; Stevedores;
		Virtual arrival system	Ships	Ship-owners; Ship-managers; Charterers; Shippers; Pilot; Towage; Ship chandlers; Stevedores; Seafarers

Sources: Own development.

4. Analysis

4.1. Tool Implementation Complexity and Emission Visibility

To understand the potential of port authorities for emissions abatement in GVCs, we borrow from organizational theory and group air emission reduction tools in a matrix along two dimensions: tool implementation complexity; and emission visibility.

Tool implementation complexity (TIC) refers to the number of GVC stakeholders (as a measure of organizational span and scope), whose involvement is required for the tool to work effectively. Air emission reduction tools may themselves be characterized as technologically complex, depending on the extent to which they are systemic (i.e., comprising hierarchies of sub-systems), have multiple interactions and feedback within and between sub-systems, and are non-decomposable (i.e., cannot be separated into their component parts without seriously lowering their overall effects) (Singh, 1997). Their adoption within and across organizations however depends crucially on their transferability, implementation complexity, and divisibility, which constrain the way that decision-makers operationalize their strategies (Leonard-Barton, 1988).

In the following, we will focus on the implementation complexity of air emissions reduction tools, which increases with the number of market players (e.g., carriers, terminal operators and logistics companies) and other stakeholders involved for their proper functioning. This is more so, because port tenants and other users, especially multi-national carriers with limited affinity to the port city and the port's local community (Slack, 2007), often have greater bargaining power than the port authorities and tend to view port authorities mainly as assistants helping them realize their own business objectives (Suykens and Van de Voorde, 1998). We expect a negative correlation between tool implementation complexity and tool adoption. The identified technological and organizational tools are generally independent emission abatement measures, and the successful implementation of a tool does not hinge on the implementation of other tools.

We distinguish between high and low tool implementation complexity based on the number of stakeholders involved (Table 2). Implementation complexity is low when port authorities and a maximum of one other stakeholder are involved. This is typically the case when port authorities act as landlords, regulators and operators. When port authorities engage two or more stakeholders simultaneously, tool implementation complexity is high. This is generally the case with the community manager function, where port authorities bring several stakeholders together to improve performance.

Table 3. Emission visibility

Emission visibility	Emissions	Emissions from	Data sources	Current visibility in port sustainability reports
High	SO_x, NO_x, and PM in port	All emitters	Port tenants and/or real-time monitoring equipment in cities and ports	Visible in all five ports' sustainability reports and municipal air quality measurements.
	CO_2 scope 1	Port authority equipment, buildings, vehicles and vessels	Port authorities	Visible in all five ports' sustainability reports
	CO_2 scope 2	Port authority electricity consumption	Port authorities; Utilities	Visible in all five ports' sustainability reports
Low	SOx, NOx and PM at sea	Ships	Real-time monitoring equipment onboard ships	Absent in all five ports (monitoring equipment is not installed onboard ships)
	CO2 scope 3	Port authority employees (business travel and commuting)	Port authorities and employees	Visible in Antwerp, Rotterdam and Vancouver
		Port tenants	Port tenants	Visible in Antwerp, Los Angeles, Rotterdam and Vancouver
		Trucks and trains in port hinterlands	Trucking and rail companies	Absent in European ports' sustainability reports. Some emissions estimations available for minor parts of the hinterlands of Vancouver and Los Angeles
		Ships during ocean voyages	Shipping companies	Absent in all five ports (currently unavailable from individual ships, but expected with upcoming MRVs)

Sources: Port of Antwerp (2017); Port of Vancouver (2017); Port of Los Angeles (2017b); Hamburg Port Authority (2015); Port of Rotterdam (2017).

Emission visibility (EV) in our analysis has two dimensions: one refers to the direct visibility of emissions to port city residents (dark exhaust that can literally be seen or sensed from their homes)[2]; the other is more indirect and has to do with publicly available information about emissions. Firms whose activities are associated with issues that are highly visible to stakeholders tend to act in a more socially responsible manner (Brammer and Millington, 2006), and visibility can be a useful construct for predicting organizational response (Bowen, 2000).[3] This is because organizational

[2] Noise pollution is another important concern for port city residents.
[3] The notion 'emission visibility' is used throughout this paper to describe 'issue visibility in the context of port and maritime emissions'. While issue visibility has been used in organizational theory to predict organizational response more generally, Bowen (2000) was the first to do so in an environmental context.

responses to visible issues are easily observable by stakeholders, and therefore a high degree of issue visibility may restrict an organization's choice among the spectrum of strategic responses available to them (Neustadl, 1990). Since ports increasingly engage with adjacent communities to defend their social license to operate, we expect tool adoption to increase with emission visibility.

We use emission inventories available in port authorities' sustainability publications as a proxy for emission visibility (Table 3). If emissions are quantified in all the five ports' publications, they have high visibility. If no estimates of emissions are presented in any of the ports' external communication, emissions have low visibility.

Local air pollutants have high visibility. Port authorities have measured air quality in real-time in several port locations for a number of years and data is available in port authority webpages/sustainability reports and on municipal webpages. In the cases of Los Angeles and Hamburg, real-time data are available online (Clean Air Action Plan 2017; Hamburger Luftmessnetz 2017). In contrast, air pollution at sea has low visibility, because real-time monitoring equipment is not installed in the world fleet and emissions depend specifically on ship and engine operations (Corbett et al., 2007, Viana et al., 2014, Chen et al., 2016).

Emission visibility for GHG differs among emitters. Under the lead of POLA, the WPCI has developed methods for port authorities to calculate scope 1, 2 and 3 emissions (WPCI, 2010). Scope 1 relates directly to port authority operations, while scope 2 concerns electricity purchased by port authorities, and both have high issue visibility. Scope 3 covers a diverse group of major emitters (e.g., port employees, tenants, trains, trucks, and ships) with low issue visibility. Scope 3 is defined in different ways by the five ports (Table 3) and "[n]o universal rule for determining the geographical boundaries when planning an OGV [ocean going vessel] inventory" has been agreed upon in the WPCI (WPCI, 2010: 52). While GHG from industrial plants and hinterland transportation are counted in national emission inventories, this is not the case for ships where only globally aggregated emission figures are available (Smith et al., 2014). From 2018, the EU will implement a Monitoring, Reporting and Verification (MRV) scheme for individual ship voyages to/from EU ports, according to which shipping companies shall report on GHG and transport work performed (European Commission, 2016). The IMO is setting up a separate global MRV-scheme, in which transport work is not included (IMO, 2017). None of the MRVs will include air pollutants. How MRV will affect emission visibility is yet an open question. The relatively new Automatic Identification System (AIS), which tracks the movements of individual ships in real-time, can also provide future opportunities to estimate GHG emissions from individual ships (Miola et al., 2011; Goldsworthy and Goldsworthy, 2015; Coello et al., 2015). All our port interviewees welcome higher emission visibility, arguing that transparency will facilitate further environmental upgrading.

The WPCI has developed the Environmental Shipping Index (ESI) to enhance emission visibility for ocean-going ships. Individual ships receive scores when they exceed IMO requirements for engine ratings (which relate to NO_x), fuel Sulphur content (for SO_x) and report on their fuel consumption (for GHG). Emission levels depend on operational conditions for ships and engines, but ESI is not based on real-time, onboard emission monitoring, and this limits emission visibility. Even though the number of enrolled ships is rising (WPCI, 2017), only approximately 5,500 vessels of the world fleet of 48,500 vessels (above 100 GT) are now included (WPCI, 2017).

In the next sub-sections, we examine the tools included in the matrix presented in Table 4, which combines tool implementation complexity and emission visibility.

4.2. Low TIC and High EV

Simple tools directed towards highly visible emissions have been a logical starting point for the frontrunners' voluntary environmental action. Two are particularly important: improvements in the port authorities' own operations; and tools that port authorities apply to tenants and mobile emitters. For their own operations, port authorities often engage in energy efficiency initiatives, and procure electricity from renewable energy sources. They moreover employ various new low emission technologies. For their own fleet of vessels, for example, POH has adopted "a strict modernizing policy, so every new-built ship follows strict environmental guidelines which are beyond regulation (concerning ship design and engines)" (I3). They have also introduced electrical cars, and their harbor craft partly operate on bio-fuels, which are almost entirely absent in the world merchant fleet. According to our interviewees and the shipping press (e.g., Lloyd's List, 2017), the business case for alternative fuels and low emission technologies has rarely been convincing to ship-owners. Port authorities, however, are willing and able to bear the costs to achieve their sustainability commitments and to showcase new technologies and inspire other GVC actors. In this respect, port authorities differ from shipping companies, which often take a shorter time perspective (see, e.g., Poulsen and Johnson, 2016).

Table 4. Adoption of air emission reduction tools

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Tool implementation complexity</td></tr>
<tr><td>Low</td><td>High</td></tr>
<tr><td rowspan="2">Emissions visibility</td><td>Low</td><td></td><td>• Virtual arrival (not implemented)
• Reduced vessel turn-around-time measures (uncommon)</td></tr>
<tr><td>High</td><td>• Energy management for port authority operations (common)
• Electricity from renewables for port authority operations (common)
• Low emission technologies for port authority equipment (common)
• Environmental concessions criteria for terminals (Rotterdam, Los Angeles)
• Maximum emissions standards for trains and trucks (common)
• Hinterland traffic management (common)</td><td>• Circular economy measures (Rotterdam, Antwerp)
• Financial and technical advice to owners of trucks and inland waterway ships (Rotterdam, Vancouver, Los Angeles)
• LNG infrastructure (available in European frontrunner ports; adoption elsewhere still limited)
• OPS (available in the five frontrunner ports for liner ships, but entirely absent for tramp vessels)
• Green port dues (applied in all frontrunner ports; adoption in world fleet increasing but still limited, in particular for vessels in tramp services)
• Vessel on time incentives program (Vancouver)
• Incentive program for vessel speed reduction in coastal zone (Los Angeles)
• Lobbyism at IMO (recent development by some frontrunner ports)</td></tr>
</table>

Sources: Own development.

Emission inventories in the five case ports indicate that emissions from tenants and mobile port users greatly exceed those from port authority operations. In their capacity as landlords, some port authorities use sustainability criteria in terminal concessions for facilitating emission abatements. For instance, POR has established sustainability criteria for companies wishing to locate on its new container terminal (POR, 2016a). Similarly, POLA uses sustainability-related lease provisions to encourage air pollution prevention among tenants (POLA, 2015). One of the first projects in which the WPCI engaged concerned the development of sustainability criteria for leases and concessions (I1).

In recent years, port authorities have gradually imposed stricter emission standards for trucks and trains operating within their boundaries. In their regulatory capacity, port authorities aim for gradually phasing out old, highly polluting mobile emitters. In North America, the threat of law-suits against such actions is high, however. Both the POLA and POV port authorities had to defend their new environmental standards in court (I2, I5). Finally, major ports and cities around the world face rail and road congestion challenges. All five port authorities employ intelligent traffic management tools to alleviate this problem and improve local air quality – including extended terminal opening hours and the provision of dynamic traffic signs.

The environmental upgrading potential of these tools is generally limited by competition among ports. For instance, Rotterdam, Antwerp and Hamburg have partly overlapping hinterlands, where they compete intensely for cargo. If sustainability criteria become too costly for port customers, cargo volumes might divert elsewhere.

4.3. High TIC and High EV

Frontrunner ports seem willing to adopt tools with high implementation complexity when emissions have high visibility (Table 4). In ports with large industrial agglomerations, port authorities can facilitate collaboration between diverse tenants. POR facilitates the creation of "circular economy" provisions, ensuring that exhaust heat from industrial tenants is used by nearby "green houses" and for local heating of houses (I4; de Langen and Sornn-Friese, 2018), and POA engage in similar measures (POA 2017). This requires effective spatial planning and the simultaneous engagement of several tenants, leading to high implementation complexity. This tool appears to have the most relevance in POR and POA, which host larger industrial plants than POH, POV and POLA.

Port authorities also act as community managers vis-à-vis mobile emitters. To facilitate adoption of low emission technologies among truck and train owners, the port authorities in Los Angeles, Rotterdam and Vancouver provide technical and financial guidance. They also facilitate a switch to cleaner marine fuels for ships, supporting the development of new infrastructure for liquefied natural gas (LNG), which can almost eliminate air pollutants, and for onshore power supply (OPS or cold ironing), which allow ships to plug into onshore electricity grids while at berth (Zis et al., 2014). Both tools are directed towards mitigation of highly visible local air pollution. According to the shipping press (Lloyd's List 2013a, 2014, 2015) and our interviewees, however, many shipping companies see alternative fuels as technically demanding and risky, because they require major investments onboard ships and depend on the simultaneous development of a comprehensive fuel infrastructure. All five port authorities have provided OPS at some berths for several years, and the WPCI has also developed a project to facilitate OPS adoption (WPCI, 2017b). Focus is directed towards liner vessels with frequent calls at the same ports (cruise, container, ferry, and inland waterways), because regular trading patterns reduce implementation complexity. For the major share of the world fleet trading with complex tramping patterns (most tankers, dry bulk and general cargo ships), the adoption of OPS remains very limited. LNG adoption also remains low, though is slowly increasing in liner shipping. In Northern Europe, the first LNG bunker tankers have entered service, enabling bunkering from ship to ship.

Act as community managers, port authorities provide port fee incentives to facilitate the adoption of low emission technologies in the world fleet. All five ports have offered reduced port fees to high performing vessels (based on ESI scores or similar) for a couple of years, and have increasingly allocated funds to that purpose. For 2012-2015, for instance, POLA paid USD 539,500 in incentives to qualifying vessels, with incentives per call ranging from USD 750 to 5,250 (POLA, 2015). In addition to the data challenges pertaining to environmental benchmarking of ships, a number of other factors currently limit the potential of port fees for environmental upgrading. As of 2017, only 49 ports and canals, including the Panama Canal, provide incentives world-wide (WPCI, 2017a). The rebate criteria vary between ports, and liner ships with frequent calls at the same ports generally have higher uptake than tramp vessels. The fact that port dues represent a minor share of ship operational costs (Stopford, 2009) weakens the incentive for shipping companies. Some of the port interviewees see reduced port fees mainly as a tool to enhance environmental awareness within the shipping community.

Incentive schemes are also used by POLA and POV to reduce local air pollution from ships. POV has implemented an on-time incentive program for liner ships. Late vessel arrivals challenge port productivity, cause onshore coordination challenges and lead to unnecessary emissions in port (POV, 2017). POLA has pioneered a voluntary speed reduction program in coastal zones to reduce maritime air pollution close to land. The program may, however, have unintended consequences. If ships speed up outside the zones to maintain transport capacity, local air quality benefits will be counterbalanced by extra GHG emissions during ocean voyages (San Pedro Bay Ports, 2017).

Finally, port authorities have weak regulatory authority vis-à-vis emissions from oceangoing ships, which are subject to IMO regulation. All interviewees support stricter regulation and some of the frontrunner ports exercise lobbyism in the IMO through their membership of the International Association of Ports and Harbors (IAPH). IAPH holds consultative member status in the IMO, and can thus contribute to environmental agenda setting. Port lobbyism has so far mainly addressed NO_x emissions, which are clearly visible in city air quality measurements.

4.4. High TIC and Low EV

A combination of high TIC and low EV appears to be a limiting factor for environmental upgrading. Further abatement of emissions at sea, which have low visibility, could be addressed by existing, organizationally complex tools, yet currently these tools are not adopted by any port authorities. For example, congestion in ports cause idle ship time and unnecessary maritime emissions. Around 2010, during a period of high fuel prices, virtual arrival systems were tested in ports around the world. The aim was to replace first-come, first-serve port docking systems and enable ships to slow steam, thus reducing idle time, fuel consumption and emissions. Tanker shipping companies and oil majors showed enthusiasm about these systems (Lloyd's List 2011b). Today, however, problems related to idle time at anchor have not been resolved and the interest for virtual arrival has faded following the dramatic drop in energy prices in recent years. In Lloyd's List, there has been little writing about virtual arrival after 2012.

Virtual arrival schemes and measures to reduce ships' turn-around-time in port are remarkably absent in the sustainability reports of the five ports and from the WPCI. Our interviewees confirm that such systems are not common at the moment, and information about ships delays is rarely shared among actors in the GVCs. Communication in maritime transportation is often complex and actors are generally hesitant to share information about delays and other relevant measures, and this hampers improvement efforts (I1, I4). Considerable upgrading potential could be leveraged if port authorities were to bring together various stakeholders in the adoption of virtual arrival systems and facilitate information sharing to reduce vessels' turn-around-time in port. For virtual arrival systems to work, clauses must be specified and incorporated in the contract between the ship-owner and the charterer, thus allowing the ship-owner to adjust the speed of the vessel and defer arrival until a berth has become available. Port authorities do not find themselves in a position to single-handedly implement these systems. A diverse group of shipping companies, charterers, ship managers, cargo-owners, stevedores, terminal operators, port service providers, pilots and towage providers need to collaborate in order to make timely decisions on ships' slow steaming. If this group of stakeholders could share timely information, reduced port-turn-around time for ships could also be achieved, allowing for further slow steaming (Johnson and Styhre, 2015). However, all interviewees agree that enhanced emission visibility could facilitate environmental upgrading. This would require real-time monitoring onboard ships and substantial data sharing among several stakeholders – in addition to more flexible charter contracts for ships.

5. Discussion

Rising public concerns over local air quality increasingly threaten port authorities' social license to operate. Frontrunner port authorities have responded with a wide range of emission abatement tools. Some tools have diffused widely in the port sector, but others remain underutilized. We find that tool implementation complexity and emission visibility are key factors determining which tools port authorities are more likely to adopt. Organizationally simple tools are commonly used by port authorities, but generally only when they can reduce highly visible local air pollutants. If their visibility is low, even tools with a narrow organizational scope tend not to be adopted by ports (as indicated by the missing entries in the top-left quadrant in Table 4).

Port authorities have been more successful in improving efficiency and introducing low emission technologies in their own operations. They have also been relatively successful as landlords and regulators – raising environmental standards for tenants, trucks and trains through a combination of regulation and incentives. These tools, however, have a limited impact on environmental upgrading in maritime transport and for GVCs more generally, as they do not affect the operation of ocean-going ships, which are the main emitters. Port competition also restrains the effectiveness of these tools.

When local air quality improvements can be documented and thus made visible port authorities do not shy away from implementing tools, which require involvement of several stakeholders. In this case, they act as community managers by raising awareness and facilitating the adoption of cleaner technologies among tenants and mobile emitters, including ocean-going ships. Organizationally complex tools require port authorities to allocate sufficient resources and facilitate collaboration among several stakeholders. High implementation complexity explains why the potential for environmental upgrading has not been fully realized with these tools – e.g., cleaner marine fuels and low emission technologies are still very rare in the world fleet. This is where the five port authorities expect to focus their emission abatement initiatives in coming years, in particular with the aim of further abating NO_x emissions. Some highly complex tools, notably virtual arrival systems and information sharing measures to reduce vessel port turn-around time, hold considerable potential for emission abatement from ocean-going ships. However, they are not currently shaping environmental upgrading because of the current low visibility of emissions at sea. Reliable data on emissions from individual ships at sea are not yet available, even though pollutants are known to disperse over land. With the upcoming MRV schemes and improved AIS data on ship movements, visibility for GHG emissions at sea is expected to improve, although the specific effects remain to be seen. Emission visibility for air pollutants at sea, which are not included in MRV and require onboard monitoring, will likely remain low.

Table 5. Estimated emission reductions achieved in four ports recent years (%)

Port	Period	SO_x	SO_2	NO_x	DPM	PM_{10}	$PM_{2.5}$
Antwerp	2000-15		- 67%	- 21%		- 55%	
Hamburg	2013-14	- 45%		- 7%		- 6%	
Los Angeles	2005-16	- 98%		- 52%	- 87%		
Vancouver	2010-15	- 96%		- 19%			- 67%

Note: Data for Hamburg covers only Hamburg Port Authority emissions. For the other ports, all emitters within the port area are included.

Sources: POA 2017, pp. 77-85; POLA 2017b, pp. 3-4; Hamburg Port Authority 2015, p. 6; POV 2017a, p. 38.

Table 6. Emissions from all emitters (selected ports; metric tons)

Port	Year	SO_x	SO_2	NO_x	DPM	PM_{10}	$PM_{2.5}$
Antwerp	2015	n/a	11,500	22,000	n/a	1,000	n/a
Los Angeles	2016	114	n/a	7,023	115	n/a	n/a
Vancouver	2015	250	n/a	10,500	n/a	n/a	300

Sources: POA 2017, pp. 77-85; POLA 2017a, pp. 3-4; POV 2017, p. 38.

Table 7. Improvements in air quality (Antwerp and Rotterdam, % reduction in average annual air concentrations of air pollutants within the port area; micrograms per M3)

Port	Period	SO_2	NO_2	PM_{10}
Antwerp	2000-16	n/a	- 18%	n/a
Antwerp	2006-16	- 76%	n/a	- 42%
Rotterdam	2006-15	- 67%	- 17%	- 51%

Sources: POA 2017, pp. 77-85; POR 2017, p. 198.

Table 8. Earliest and most recent estimates of GHG emissions in ports (tons).

Port	Emissions	Earliest estimate (year)	Most recent estimate (year)
Antwerp	CO2e - Energy consumption in port authority operations + port authority electricity consumption (kWh)	11,000,000 (2008)	8,500,000 (2016)
	CO2e - All port users (tons)	19,000,000 (2000)	17,500,000 (2015)
Hamburg	CO2e - Scope 1 (tons)	6,363 (1990)	6,095 (2014)
	CO2e - Scope 2 (tons)	10,071 (1990)	407 (2014)
Los Angeles	CO2e - Scope 1 (tons)	1,911 (1990)	3,818 (2013)
	CO2e - Scope 2 (tons)	6,232 (1990)	6,878 (2013)
	CO2e - Scope 3 (tons) – tenants (i.e. ships, harbour craft, cargo handling equiment, rail, heavy duty vehicles)	1,053,028 (1990)	884,496 (2016)
Rotterdam	CO2 - Scope 1 (tons)	6,800 (2010)	6,300 (2016)
	CO2 - Scope 2 (tons)	700 (2010)	100 (2016)
	CO2 - Scope 3 (tons) - business travel and employee commuting	2,400 (2010)	2,700 (2016)
	CO2 - All port users (tons)	24,000,000 (1990)	32,000,000 (2015)
Vancouver	CO2e - Scope 1 (tons)	402 (2010)	401 (2016)
	CO2e - Scope 2 (tons)	254 (2010)	264 (2016)
	CO2e - Scope 3 (tons) – Employee business travel, commuting, paper and waste	424 (2010)	629 (2016)
	CO2e - Tenants, ships in port, trucks, trains in immediate hinterland	950,000 (2010)	1,100,000 (2015)

Note: Antwerp port authority reporting concerns kWh energy consumption. All other reported figures are in tons.

Sources: POA 2017; Cannon 2014; POLA 2017b; Hamburg Port Authority 2013; Hamburg Port Authority 2015; POV 2013; POV 2017a; POR 2017.

Tables 5 to 8 show that frontrunner ports have made significant achievements regarding emission abatement and air quality improvements in recent years. The most striking improvement concerns SO_x, which our interviewees attribute both to the IMO's new Sulphur Emission Control Areas in the North Sea and along North American coastlines and to their own initiatives towards tenants, trucks, trains and ships at berth. NO_x emissions, however, remain a pressing challenge, because new engines or significant modifications to existing ones are required for abatement. In contrast, SO_x emissions can readily be abated with low-sulphur fuels. In 2021, stricter IMO NO_x regulation is expected for new ships, but “it will take long time to realize the environmental effects as the phasing out of the existing fleet is expected to take 20 to 30 years” (I3). In relation to CO_2 emissions, scope 1 and 2 emissions have recently started to decline in the case ports. For instance, the port authorities of Vancouver achieved carbon neutral operations through offsetting in 2010 (POV, 2017). But the impact of OPS on emissions depends on the energy source used by the utility company, and does not address emissions from ships at sea. In the best case scenario, LNG can achieve a 20% reduction in GHG from ships at berth and sea, but unintended methane slips might neutralize its beneficial effects entirely (Brynolf et al., 2016). In sum, local air pollution remains the main concern of port authorities, while CO_2 emission abatement is mainly seen as a “nice by-catch” (I1) of current initiatives.

6. Conclusion

Port authorities hold considerable potential for promoting and facilitating environmental upgrading in maritime transport and along GVCs more generally. Due to their hybrid organizational status, long-term strategic thinking and mounting public health concerns, port authorities are increasingly committing to voluntary environmental action. Protecting their social licenses to operate, the frontrunner ports of Antwerp, Hamburg, Los Angeles, Rotterdam and Vancouver have achieved significant local air quality improvements in the last decade, while cargo volumes have generally increased. However, the full potential for environmental upgrading, which lies beyond the boundaries of individual organizations, has not yet been achieved. The GVC literature has shown that environmental upgrading can be achieved more easily when efforts are directed towards the entire chain, and maritime transportation is no exception.

In this article, we showed how a combination of emission visibility and tool implementation complexity shapes port authority environmental action. Emission visibility refers to the direct visibility of emissions to port city resident, but also to the availability of publicly available information about these emissions. Tool implementation complexity concerns the number of stakeholders whose involvement is required for a tool to work effectively. Tool adoption decreases with implementation complexity and increases with emission visibility. Local air pollution is highly visible for port residents, and remains the main concern for port authorities. In contrast, emissions of GHG and air pollutants from ships at sea have low visibility and receive less attention. Port authorities have the capacity of handling organizationally complex tools, but will implement them only when emission visibility is high. Voluntary environmental measures by ports have only limited leverage to improve data availability and reporting from ships at sea. Only stricter regulation by the IMO or regional bodies can facilitate better emission visibility and thus help ports to be more effective as promoters of environmental upgrading. Port alliances should therefore step up their lobbying efforts at the IMO and within regional bodies.

Our study shows that there is further potential for environmental upgrading in many ports, which are located close to large cities and share organizational characteristics with frontrunners. Such ports are located in all continents. Moreover, all ports have a material interest in protecting their social license to operate. They could leverage the experiences made by frontrunners, now sharing their best practices (Fenton, 2017) through the WPCI. Other ports could start on this path by measuring local air pollution to set baselines and abatement goals, and by applying organizationally simple tools focused on their own operations. Subsequently, they could apply tools that involve other actors and further improve emission visibility. But the highest effects will occur only when port authorities act as community managers and successfully facilitate environmental upgrading beyond their physical and organizational boundaries. Other research has shown that cargo-owners – the main buyers of shipping services – can be influential players in stimulating environmental upgrading in maritime transport and in GVCs more generally (Poulsen et al., 2016). This is especially the case for container shipping and for cargo that consists of branded consumer goods – another case of high issue visibility. Frontrunner port authorities should start forging alliances with cargo-owners that are at the forefront of environmental upgrading in GVCs. The combined action of ports, cargo-owners and improved regulation could mitigate air emissions in maritime transport, and provide another component in facilitating the environmental upgrading of GVCs more generally.

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Appendix 1. Interview guide

The key questions posed in the initial e-mail, contacting the interviewees:

- How can ports contribute to emission abatement from ship and shore operations?
- What are your experiences with emission abatement initiatives in your port?
- What have been the major achievements in your port in this regard so far?
- What are the main challenges you face looking forward?

Overall structure for skype interview:

- Firstly, open questions: What do you do? What are your experiences with different initiatives?
- Secondly, challenging questions: Why don't you do that? (more testing style of questions)
- Thirdly, testing questions, related to our key concepts, emissions visibility and tool implementation complexity: Can you recognize this description?

INTERVIEW GUIDE QUESTIONS

Ongoing initiatives in the port

According to your sustainability report/web-page, you have engaged in several emission abatement initiatives: Which ones did you select first? Why?

- Do you go after "low-hanging fruits"? How did you identify such?
- Did you achieve your aims?
  - How?
  - If no, why not?

Green port dues – incentives for ships

- Why do you offer such?
- Who receives the rebates?
  - Do ship-owners show interest in the rebates?
    - Which types of ship-owners are interested?
    - Do you see any differences in terms of green port dues interest among liner and tramp shipping companies?
  - What are your requirements for companies/ships to qualify for rebates?
    - Why are rebates and qualifying criteria not aligned across WPCI ports?
  - What would be required for more ships and shipping companies to join in the initiative?
    - Are port fees not such a small cost item for ship-owners that that they don't need to bother with it?
    - Is it correct that the numbers of incentive providers and shipping companies enrolled have stagnated recently?
- Do the rebates actually lead to emission reductions from ships?
  - In port?

- At anchor?
- At sea?

- Is it at all possible to **benchmark ships** based on their environmental performance?
  - Is the data of a sufficiently high quality to allow for this?
  - You use the ESI for benchmarking, but many other green rating schemes, e.g., CCWG, Rightship, CSI, exit out there, why not use them instead of your own?

Cold-ironing

- Who are interested in this?
- What is required for this to become widely adopted?
- You have a collaboration with the Port of Shanghai to facilitate adoption of OPS – what are your experiences from this collaboration?
  - Does it facilitate ship-owner uptake?

LNG

- A major issue in Northern Europe SECA, but it does not get much attention in the US – is this correct?
  - If yes, why not?
- Would it not be a good solution, seen from your perspective?
- What is required for this to become widely adopted?

Lease agreements which include sustainability clauses

- You argue that you can influence tenants' activities through sustainability clauses – could you give some examples of what that requires?
- Are they successful?
  - Do you achieve your aims?

Traffic management schemes

- How does traffic management onshore compare to traffic management at sea?
  - Is one more difficult than the other? Why?
- You do not specifically mention reduced port turn-around time as an emission abatement tool – why not?
  - What would be required for this to work?

Voluntary speed reduction programs for ships in coastal waters

- In your GHG tool box, you mention voluntary speed reduction for ships during their approach to port as a means of reducing GHGs - How does this work?
  - Are these initiatives not only effective for reduction of local air pollution, but not GHGs?
  - Does these initiatives not led to higher speeds for ships during the oceanic transit? And therefore to higher overall GHG emissions?

    - Is it not too narrow to focus GHG emission reduction initiatives only on port and coastal waters?
        - Would it not make more sense to focus on the entire value chain, at sea, in port and onshore?

Virtual arrival

- Is port congestion a problem at your port?
    - If yes, when?
    - And why?
- Do you have any experiences with Virtual Arrival schemes?
    - Do you think Virtual Arrivals could contribute to a reduction of air emissions?
    - Have anybody you know of shown interest in this concept?
- What would be required for virtual arrival…
    - to be widely used in your port?
    - to diffuse in the shipping and port industry more widely?
    - Which stakeholders would need to be engaged for this to happen?
- Could the WPCI help in any way with regard to the diffusion of virtual arrival?
    - If yes, how?
    - If no, why not?

You are a member of the **World Port Climate Initiative**

- Why did you join?
    - Did/do you experience pressures from anywhere, such as town council or local community?
    - Did you receive an invitation to join from other ports/WPCI members? If yes, who?
- Which WPCI activities have you engaged in?
- Do you learn anything from colleague, ports?
    - What? How?
- Main benefits for you from WPCI participation?
    - Further potential for collaboration within WPCI?
    - WPCI web-page seems somewhat inactive: Has WPCI lost moment recently?

Emission inventories – according to your sustainability reports you measure the following air-emissions:

- How do measure **SOx, NOx and PM emissions**?
    - Which emitters do you measure from?
    - How frequently do you measure? Do you use real time monitoring for air pollutants?
    - Where do you measure?
- How do you measure **GHG scope 1, 2 and 3**?
    - How do you define each of the scopes?
    - Which of these are the most difficult to assess?
    - Scope 3 - why do you include them in your emission inventory, when you cannot fully control the behavior of the emitters?
    - Do decisions in port/onshore affect ship air emissions in any way?

Ranking of air emission tools

- How would you rank air emission initiatives in terms of **complexity**?
  - Which tools or initiatives are the easiest for you to implement?
  - Any why are other initiatives more difficult?
  - Does the number of stakeholders influence the initiative in any way? If yes, how?
  - Which stakeholders would need to engage in each of the initiatives for it to be effective?
- **Visibility of results**: How do you document the results of your work?
  - For which of your initiatives is it most easy for you to show results?
  - Does it matter that you can demonstrate the effects to the public of your measures?
  - How do you communicate your results?
  - Who is the audience for your sustainability reports and emission inventories?

What can other ports learn from your experiences?

Other potential emission reduction tools

- Do you see a potential for further air emission reduction through voluntary measures?
- Are there still any low-hanging fruits?
  - Which?
  - How to realize them?
- What is your **view on regulation from IMO, EU** and others on air emission abatement?
- How do you view development of **environmental protection in shipping industry**?
- Some important topic that we not touched upon?

Your stakeholders

- Who are your stakeholders?
- Who is concerned about air emissions from ports and shipping?
  - Has this changed in recent years, during your time at the port?
  - How do you experience stakeholder concern?
- Do air emissions or other pollution issues affect your business opportunities in any way?
  - Do they threaten your social license to operate in any way?

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