Green Ports in Theory and Practice

Chapter · January 2019

DOI: 10.1016/B978-0-12-814054-3.00001-3

2 authors:

Rickard Bergqvist
University of Gothenburg

Jason Monios
Kedge Business School

Green ports in theory and practice

Rickard Bergqvist and Jason Monios

This is the pre-published version of the text. The final published chapter can be found in:

Bergqvist, R., Monios, J. (2019). Green ports in theory and practice. In: Bergqvist, R., Monios, J. (Eds). *Green Ports; Inland and Seaside Sustainable Transportation Strategies*. Elsevier: Cambridge, MA. Pp.1-17.

Abstract

This chapter introduces the topic of green ports and establishes the background and motivation for this volume. The chapter provides an overarching view of the key elements of environmental issues in shipping, particularly from the port perspective. This is followed by a discussion of the current, emerging and potential strategies to introduce more sustainable practices, the different actors involved and also the importance and changing nature of national and international regulation. The structure of the book is introduced and a brief outline of each chapter is presented. Finally, the chapter concludes with thoughts on developing trends and the future environmental performance of the port sector.

Keywords: green port, environmental, sustainability, shipping, emissions, hinterland, vessels

1.1. Why green ports?

Ports today play a greater role than simply handling cargo on the quayside. The sources of their competition and the extent of their influence stretch across the sea and also deep into the hinterland. Their management and operational strategies are entwined with stakeholders on several scales and in many spheres, from local to global and from business to government. The port's role in the transport chain has the potential to shape the social and environmental performance of transportation systems extending across the globe. While many ports choose not to act beyond complying with existing environmental regulations in their city, region or country, in many cases they have exercised their potential for addressing both social and environmental externalities.

While the Kyoto Protocol (adopted in 1997 and entering into force in 2005) introduced legally binding emissions targets, aviation and shipping were not included (Cullinane and Cullinane, 2013). Researchers have in recent years analysed and quantified the emissions from the maritime sector, which may form a potential baseline for future targets. While the primary focus of this book is on the port perspective, attention to emissions in the maritime sector has focused for the most part on the output of vessels while at sea. These emissions can be divided broadly into greenhouse gas (GHG) emissions affecting climate change and local air pollution, primarily sulphur oxides (SOx), nitrogen oxides (NOx) and particulate matter (PM). In 2007-2012 shipping accounted for 2.8% of global GHG emissions or double the level produced by air travel (Smith et al., 2014). Local pollutants are a more pressing issue in coastal areas due to their impact on human health. The World Health Organization (WHO) considers air pollution a major environmental risk to health, estimating that it results in three million deaths per year (World Health Organisation, 2016). Shipping contributes a significant amount to this risk, especially in coastal areas. Worldwide, shipping accounts for approximately 15% of NOx and 5-8% of SOx emissions (Zis et al., 2016) which cause serious harm both to human health and the environment. As discussed in chapter 2, Brant et al. (2011) found that emissions from shipping caused about 50,000 premature deaths in Europe alone in 2000.

In the years leading up to the economic crisis, a common view was that the approach of peak oil would continue to drive an increasing oil price which would naturally lead to decreased demand for fossil fuels, but we have now had a low oil price for several years, therefore the economic incentive to switch to alternative fuels has been reduced (see Figure 1.1).

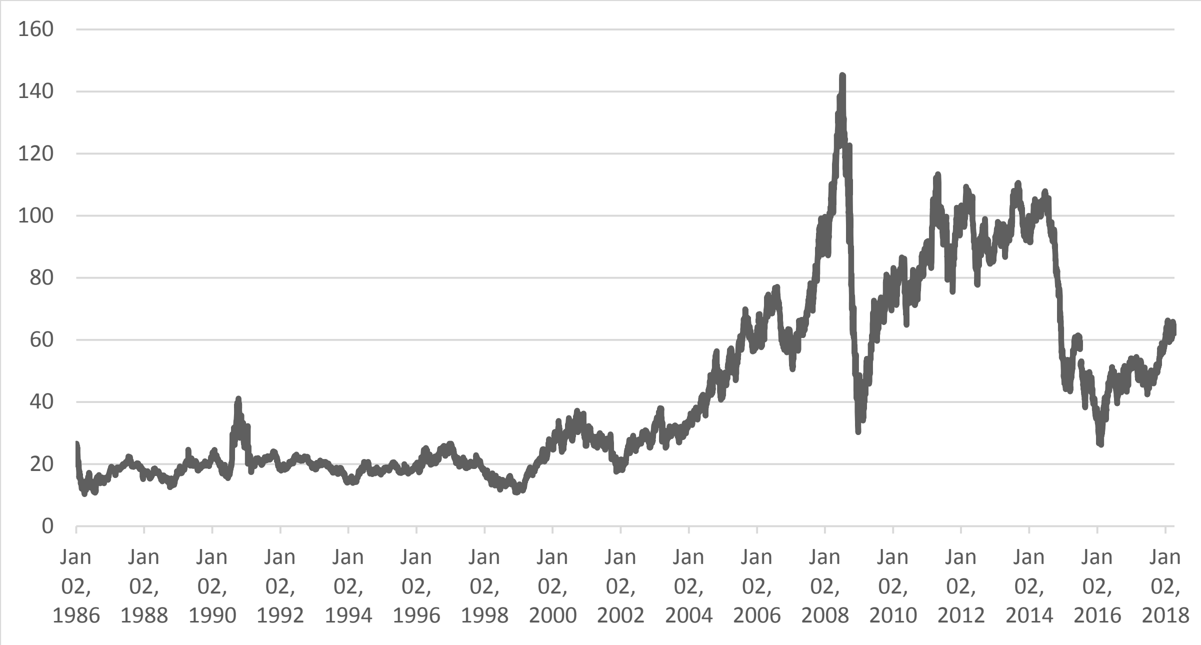

Figure 1.1. WTI crude oil (USD/barrel), 1986-2018

Source: Authors, based on data from EIA (2018)

There are also other environmental challenges at sea, including accidents, oil spills and water pollution from ballast water. EMSA (2016) reports on figures for EU-flagged vessels and/or within EU waters, revealing that in one year alone there were 3,296 incidents involving 3,669 ships, including 36 lost ships and 115 fatalities. 62% of these have been attributed to human error and 278 of these incidents resulted in pollution to the water through release of bunker fuel and other residual oils and lubricants. Ballast water is another important topic that has taken decades to address. Microorganisms can be transported across the globe in ballast water and result in extreme devastation of local species as a result of the ballast water discharge. It has taken decades of work by various organisations to produce the IMO ballast water management convention, coming into force in September 2017, 13 years after its adoption, reflecting the challenges of global environmental governance (David and Gollasch, 2015).

As environmental problems at sea (particularly emissions) are more extensive than at ports, a significant body of research has emerged on shipping emissions in recent years (see chapters 2 and 3). This book, therefore, focuses primarily on the port perspective where there has been somewhat less attention. When thinking of sustainability in shipping and ports, most of the focus tends to be on air pollution; however, as shown through the diversity of topics covered in this volume, there are many other areas of importance for green ports such as noise, dust, waste and water pollution (Ng and Song, 2010; Lam and Notteboom, 2014). Green port management must also include the broader topic of ecosystem protection through port sustainability plans and environmental planning regulations (Schipper et al., 2017). In addition, we also consider the issue of socioeconomic analysis and planning (Dooms et al., 2015) as relevant to a complete understanding of green ports. As the first book on environmental issues in the port sector, this volume aims to bring together all the up-to-date and state-of-the-art knowledge on the identification and evaluation of environmental issues, practical applications to address them by ports, carriers and regulators and also the wider institutional and political understanding of related issues and the difficulties of moving forward in a sometimes contentious arena.

1.2. Actions currently being taken by shipping lines

Shipping lines are already applying several strategies to reduce their environmental impact, mostly to do with reducing emissions as mandated by international regulation. The most obvious issue to consider first is fuel use. Ocean going vessels continue to rely on heavy fuel oil (HFO) which is actually a by-product of the refining process, therefore it is very cheap but also the most polluting kind of fuel available (Cullinane and Cullinane, 2013). Vessels using HFO will often switch to other fuels such as marine gas oil (MGO) in mandated SECA areas (see section 1.4) unless they employ scrubbers. Smaller vessels use MGO or marine diesel oil (MDO), the former being lighter and also commonly used in the auxiliary engines of larger ships for hoteling needs.

The most promising alternative fuel being considered is liquefied natural gas (LNG). LNG is cheaper than HFO and MGO, has no SOx or PM emissions and much lower NOx, but only produces a 25% CO_2 reduction compared to conventional fuel. In November 2017, the third largest global carrier CMA CGM ordered nine ultra-large container ships of 22,000 TEU capacity which will all have capability of running on LNG. These will be the first vessels of such size to use this fuel. According to the WPCI, the total world fleet using LNG (excluding LNG carriers) remains small at under 100 vessels, mostly ferries. The main barrier to wide uptake of LNG is the lack of refuelling locations but this may change as demand increases as well as responses to promotion by the EU for member states to install LNG bunkering facilities (see section 1.4). However, LNG is still a fossil fuel producing only a 25% reduction on GHG emissions, and there is also some concern regarding the ability to supply the required quantities if a significant portion of the world fleet were to switch (Wang &

Notteboom, 2014). Moreover, methane slip in the engine means that methane, a far worse GHG than CO_2, is emitted, thus reducing the overall potential reduction in GHG emissions.

Some other options are being investigated but they remain in their infancy. Hydrogen has been considered a promising fuel for different modes of transport for some time. As its only emission is water vapour, it is obviously an attractive possibility from the environmental perspective. On the other hand, like electricity, hydrogen is a form of energy storage and transportation rather than a genuine fuel source so the energy is still being produced by other means that may not be green, e.g. coal. Also large investments for infrastructure will be required and their range remains limited, so this is likely to remain a niche fuel (Cullinane and Cullinane, 2013). Biofuels are also being considered a possibility for many modes of transport. In shipping they can be blended with conventional fuel but growing concerns around production methods and land use suggest that biofuel will not become a large source of maritime fuel (Cullinane and Cullinane, 2013). Electricity stored in batteries has some promise for short-distance trades. Lindstad et al. (2017) reported that oil industry supply vessels could use this technology and gain significant environmental and economic benefits (although retrofitting existing vessels may not be economically viable), and they note that future battery and fuel prices play an important role on the likelihood of takeup. An additional advantage is that an increasing use of shipboard batteries could also support installation of cold ironing which can then be used not just to fuel ships while at berth but also to charge their batteries (Sciberras et al., 2017). Other options include wind (direct propulsion from sails as well as wind turbines on the vessel) and solar panels, but these remain niche options at present.

Besides alternative fuels, other strategies to reduce emissions include slow steaming and improved hull design. Slow steaming has become a popular way to reduce emissions and cost, as fuel usage increases approximately cubically in relation to speed, therefore decreasing speed from the usual 23-25 knots to around 20-22 knots can achieve significant reductions (see chapter 2). A speed reduction of 20% can reduce fuel consumption by around 40% and CO_2 by about 7% (Cullinane and Cullinane, 2013). Cariou (2011) showed that, in the years immediately after the economic crisis, slow steaming led to an 11% decrease in CO_2 emissions from containerships between 2008 and 2010. Importantly, however, this reduction is only attractive when bunker prices are relatively high, at least USD350–400 per tonne for the main east-west trades (Cariou, 2011). The popularity of this strategy was not, however, due to environmental reasons, but rather because after the economic crisis it became a handy way to soak up excess tonnage as slow steaming requires more vessels to serve each market. Whether this remains a long-term strategy will depend to some degree on the oil price and fleet capacity but also the willingness of shippers to accept longer shipping times. Improved hull design and slow-steaming were investigated by Lindstad and Eskeland (2015), who found that more slender vessels and slower speeds can reduce emissions significantly at only a moderate cost. Hull design developments have been driven by IMO directives such as EEDI and SEEMP (Cullinane and Bergqvist, 2014; Lister et al., 2015) (see section 1.4).

1.3. Actions currently being taken by ports

1.3.1 Actions near and within the port

Vessel emissions in ports are increasingly of concern, especially for SOx, NOx and PM which affect the health of local populations. Vessel emissions in ports are mainly addressed by the methods of cold ironing, use of LNG and vessel speed reduction in the port.

Cold ironing[1] (or onshore power supply [OPS] or shore-side electricity [SSE]) is the process whereby ships at berth connect to shore side electricity rather than running their auxiliary generators in order to provide power for hoteling. Its efficacy in terms of emission reduction depends on the proportion of renewable energy generation in that country, so countries with less environmentally friendly electricity production will simply be transferring emissions elsewhere. Winkel et al. (2016) estimated that, if all ports in Europe were to use shore power, in 2020 an estimated €2.94 billion of health costs could be saved as well as a potential reduction of carbon emissions of 800,000 tons. Vaishnav et al. (2016) found that USD70-150 million could be saved on health costs by retrofitting OPS equipment to a quarter to two-thirds of all vessels calling at US ports. According to the WPCI (2017), there are only 28 ports in the world with cold ironing installed, which represents how low the takeup has been so far. Almost all are large ports with high total energy demand, also in most cases concentrated in a small number of berths, such as a specialised cruise or container terminal, particularly the former as they have higher hoteling requirements than other vessels due to the number of passengers on board. The primary barriers are the expense of installation and the fact that each vessel must also install the connecting technology on board, which they will only do if they are likely to use it frequently (Sciberras et al., 2015; Innes and Monios, 2018).

[1] As engines are constructed from iron, turning the engine off while in port means the vessel is obtaining their energy requirements while the iron is cold, hence the vessel is said to be "cold ironing."

However, for those vessels that do call frequently at the same ports, they can make significant savings by paying for electricity rather than fuel, especially as fuel costs rise (particularly for MGO which is used for smaller vessels but demand is rising due to larger vessels using it in SECAs). Moreover, ports can incentivise use by subsidising the electricity price, and indeed the Port of Gothenburg currently charges nothing for the electricity provision.

Just like using LNG while in the open sea, using LNG in vessels approaching the port and in the port area is an attractive option for reducing emissions (Styhre et al., 2017). The same challenges occur as with use at sea regarding refuelling points and supply. Using LNG at berth can be an alternative to cold ironing, particularly as it almost eliminates local air pollution which is the key issue for ports in city locations with local populations. As Winnes et al. (2015: 81) point out: "since the share of total GHG emissions in port areas are low compared to emissions during voyage, a port city might be more benefited from prioritising local issues before global." Thus while LNG only partially reduces GHG emissions compared to cold ironing, its performance with local air emissions is almost equal and it does not require the same infrastructure investments as cold ironing. On the other hand, it will not reduce engine noise as cold ironing does, and there remains an expense for vessels to be able to adapt their engines. Similarly, just as at sea, slow steaming at and near the port can also be used to reduce fuel consumption hence emissions, although the savings are not the same at lower speeds, particularly below the vessel's design speed (Winnes et al., 2015).

Emissions actually produced by port activities contribute less of the total emissions but can be addressed through various methods, although in general only a small number of ports actually measure their emissions. Wilmsmeier and Spengler (2016; see also chapter 7) explored ways of increasing energy efficiency by means of more modern handling equipment, differentiated port and terminal charges and implementing energy management systems. Acciaro et al. (2014a) discussed ports implementing energy demand management strategies as well as generating their own green energy onsite (e.g. wind turbines, solar panels, heat plants) and showed that, while ports do not necessarily consider energy production as a source of external revenue, managing both supply and demand can reduce their costs and environmental footprint.

As well as modelling emissions reductions through various strategies (e.g. Yang et al., 2012; Gibbs et al., 2014), some authors have taken a management perspective on the kind of measures available for port managers and the challenges associated with each one (e.g. Lam and Notteboom, 2014; Acciaro et al., 2014b). Successful identification and implementation of more sustainable practices entail a strong governance component. Acciaro et al. (2014b: 481) argue for a multi-faceted understanding of the port, including not just operational functions but also the port's roles as landlord, regulator and community manager, noting that "efficiency, growth, regulatory compliance and environmental sustainability . . . can at times lead to diverging priorities." Lam and Notteboom (2014) point out that port authorities are not the only actor involved in setting regulatory policies thus they often focus on voluntary schemes such as clean ship indices and discounts. Indeed, as discussed in chapter 9, some ports around the world have implemented various indices to incentivise greener vessels by offering discounts on port dues to carriers calling at their ports according to certain criteria. This is an indirect way to influence the environmental performance of vessels at sea, in addition to their actual emissions within the port area.

All of these strategies relate to climate change mitigation, i.e. reducing environmental pollution. But we must also consider adaptation, which is dealing with the consequences such as sea level rise and storm surges, which are already occurring. Nicholls et al. (2008) estimated the value of assets in large coastal cities exposed to climate change at USD 3,000 billion in 2005, and predicted a rise to USD 35,000 billion or 9% of global GDP by 2070. Climate change adaptation by ports has become a significant area of study in recent years (Ng et al., 2016; see chapter 8).

1.3.2 Actions in the hinterland

There has been very little research exploring the environmental performance of the landside transport to and from ports, even though this aspect of the port's activities contributes to a range of externalities, especially emissions (both local and GHG) and congestion (Bergqvist and Egels-Zandén, 2012; Bergqvist et al., 2015). These externalities are normally calculated and accounted for within land transport figures; for example, the transport sector is responsible for about a quarter of GHG emissions in Europe, as well as the main source of local air pollution (European Commission, 2017). Yet, emissions from port hinterland transport only occur because of the port activity and indeed if they are to be improved then interaction between the port and inland actors will be required. Thus, while it may not be considered the port's responsibility in the same way as emissions within the port area, we argue nonetheless that the greening of hinterland transport is at least partly the port's responsibility. Gibbs et al. (2014) show that in an analysis of the UK's busiest container port Felixstowe, hinterland transport emissions (138kT CO_2) are about double the emissions produced by port activities (71.5kT CO_2) and they also argue that landside emissions should be considered by ports as within the scope of their carbon reduction activities.

While there is a growing literature on green ports, very little deals with hinterlands. Also, in the extant literature, of the few papers that develop lists of potential green ports measures, almost none include hinterland measures such as modal shift, with the exception of Lam and Notteboom (2014) and Acciaro et al. (2014b). Moreover, in the large literature on intermodal transport for modal shift, few authors have explicitly analysed the role of the port in promoting environmental hinterland transport. Giuliano and O'Brien (2008) examined extended gate operations at the ports of Los Angeles and Long Beach where the ports introduced the PierPASS programme. Bergqvist and Egels-Zandén (2012) focused on the use of differentiated port dues to incentivise a more environmentally friendly hinterland transport system. Van den Berg and De Langen (2014) explored the use of modal split obligations in port terminal concession contracts by the port of Rotterdam. Bergqvist et al. (2015) identified four types of measures to improve the environmental performance of hinterland transport: internalisation of externalities, road pricing, modal split quota and additional port dues. They performed a multi-actor multi-criteria analysis of several stakeholder groups, finding that road pricing and port dues were the most popular overall. Gonzalez-Aregall et al. (2018) reviewed a global set of ports and found that 76 out of 365 world ports reviewed were applying some form of green port hinterland strategy. They found that that the most common green hinterland goal of these ports was to reduce air emissions, which was usually done through monitoring programmes. Land congestion and modal shift also scored highly as goals, but dealing with noise in hinterland transport was much lower priority. The most popular measure for reducing land congestion was improved technology while the top measure to achieve modal shift was investing in infrastructure (see also chapter 10).

1.4. Actions currently being taken by policymakers and regulators

The International Maritime Organization (IMO) is the maritime branch of the United Nations, formally established in 1948, entering into force in 1958. Its role is the "responsibility for the safety and security of shipping and the prevention of marine pollution by ships." (International Maritime Organisation, 2017). An IMO convention is usually considered in force once it has been ratified by a certain number of member states but it does not apply to countries that have not ratified it, and enforcement is reliant on the individual member states rather than the IMO itself, resulting in different levels of enforcement. The major convention of relevance here is the International Convention for the Prevention of Pollution from Ships (MARPOL), adopted in 1973 but only entering into force in 1983 due to challenges with ratification. MARPOL establishes a global standard to prevent pollution of the marine environment by ships from operational or accidental causes. The original annexes focused only on preventing pollution to the marine environment, but it has been updated at various times and in 2005 MARPOL Annex VI came into force with the aim of preventing air pollution from ships (see chapter 3).

Annex VI has undergone several revisions over the years, and an amendment came into force in 2010 with an aim to progressively impose more stringent limits and introduce emission control areas (ECA). The ECAs are located in the North Sea, the Baltic Sea, North America and the United States Caribbean area. ECAs are often referred to as SECAs because of their prominent sulphur limit of 0.1% as of 2015 (Cullinane and Bergqvist, 2014), but North American ECAs also include NOx restrictions. In addition, the amendment set a reduced global cap of sulphur levels from 3.5% to 0.5% by 2020. Carriers address this by switching to low sulphur fuels or installing scrubbers on the exhaust system. There has also been some concern raised in the industry regarding whether sufficient low sulphur fuel could actually be produced if regulations require increased use (Notteboom et al., 2010; Cullinane and Bergqvist, 2014). However, it is worth keeping in mind that, from another perspective, the SECA limits can be considered rather weak. Lister et al. (2015) point out that the lowest level of sulphur for SECAs is still 100 times the allowed level of sulphur in road truck diesel. Moreover, the current SECA locations do not cover all parts of the world, particularly poorer areas such as the highly concentrated shipping lanes in Asia, and there are none in Africa or South America.

The revised MARPOL also imposed tighter restrictions on NOx by introducing regulation 13. This imposes NOx restrictions on ships depending on when they were built by separating vessels into three categories; Tier I, Tier II and Tier III. Other requirements relate to vessel efficiency: the Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) were agreed in 2011 and adopted into MARPOL Annex VI, which requires that certain new ships must adhere to the EEDI and all ships to the SEEMP (Lister et al., 2015).

The glaring omission is that, while IMO regulations have focused on SOx and more recently on NOx, there has been no restriction or target on CO_2 despite the large contribution to global GHG emissions from shipping. While industry actors and organisations understandably prefer global regulations rather than a patchwork of national and local requirements, Lister et al. (2015) showed that ship owners have lobbied actively against IMO regulations such as ECAs, and, as discussed by Sköld in chapter 9, a recent study found evidence that shipping industry organizations such as the International Chamber of Shipping (ICS), the World Shipping Council (WSC) and the Baltic and International Maritime Council (BIMCO) have actively obstructed the development of climate change policies by the IMO (InfluenceMap, 2017). As an alternative to regulation, the IMO has been exploring the potential of market-based mechanisms (MBMs) to reduce CO_2 emissions such as emission trading schemes and bunker fuel levies (Franc and Sutto, 2013; Kosmas and Acciaro, 2017). These have the advantage of being the same for all carriers, thus providing more certainty to the market and being less likely to distort competition. These mechanisms remain under discussion by the IMO and, as yet, no action has been taken (IMO, 2018).

In April 2018, the IMO announced a commitment of the shipping sector to reduce emissions by 50% by 2050. Establishing a target for the first time is certainly a positive step but history shows that such ambitions do not always translate into action. The long timeframe allows the possibility of delay and further modification of the deadline, and the fact that the US was not in agreement may limit compliance with the target. Therefore, without clear and strong global regulations, meeting this ambitious target remains difficult.

In addition to IMO convention requirements, more stringent regulations can be imposed. The European Union (EU) white paper on transport (European Commission, 2011: 9) aimed to cut carbon emissions from transport by 60% by 2050, based on strategies such as reducing "CO_2 emissions from maritime bunker fuels by 40%." In 2005 Directive 2005/33/EC was published which defined emission control areas in the English Channel, North Sea and the Baltic Sea. In these areas, a sulphur cap of 1.5% was set and ships at anchorage or in an EU port were required to use fuel with maximum 0.1% sulphur. These regulations were much tighter than the MARPOL Annex VI regulations at the time. Directive 2012/33/EU set out further restrictions on the sulphur content of fuels in line with the revised MARPOL Annex VI and discussed the possibility of extending ECAs.

The EU also implemented directives incentivising cold ironing and LNG. Directive 2014/94/EU on the deployment of Alternative Fuel Infrastructures states that "Member States shall ensure that the need for shore-side electricity supply for inland waterway vessels and sea-going ships in maritime and inland ports is assessed in their national policy frameworks. Such shore-side electricity supply shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits" (Europen Commission, 2014). The directive also states that member states "shall ensure, through their national policy frameworks, that an appropriate number of refuelling points for LNG are put in place at maritime ports to enable LNG inland waterway vessels or sea-going ships to circulate throughout the TEN-T Core Network by 31 December 2025 at the latest." These directives fall short of mandating action as it would be politically difficult for the EU to demand that all EU ports must make large investments in cold ironing and LNG bunkering facilities.

More recently, the EU introduced the MRV (monitoring, reporting and verification) regulation as of January 2018, requiring compulsory monitoring of CO_2 emitted by vessels larger than 5,000 gross tonnage calling at EU ports as the first step towards potentially setting targets, but there are no limits or actions as yet. However, these all apply to ships and ship operators and not to the ports themselves, which are the primary focus of this book.

In addition to governments and regulatory bodies, national, regional and international port organisations exist that are working towards more sustainable activities. In Europe, the European Sea Ports Organisation (ESPO) promotes environmental management, policies and plans in European ports. In order to promote the ESPO Green Guide, in 1999 this institution established the EcoPorts Foundation, a network of European ports to identify the significant environmental aspects of port activities, products and services. The current top ten environmental priorities of ESPO ports, in order of importance, are air quality, energy consumption, noise, relationship with local community, garbage/port waste, ship waste, port development, water quality, dust and dredging operations. Similarly, in the Americas, the American Association of Port Authorities (AAPA), with 150 members in North, Central and South America, has developed a guide for environmental management, the Environmental Management Handbook (EMH).

Various international initiatives provide new steps towards becoming greener. In 2008 the International Association of Ports and Harbors (IAPH) requested its Port Environment Committee, in collaboration with regional port organizations, to provide a mechanism for assisting ports to combat climate change. As a result, in 2008 the C40 World Ports Climate Declaration was adopted, leading to what is now the World Port Climate Initiative (WPCI), numbering 55 ports worldwide that pursue various green measures such as giving discounts to vessels scoring above a certain threshold on the Environmental Ship Index (ESI). This initiative has since been expanded with the launch in 2018 of the World Ports Sustainability Programme (WPSP). This is a joint initiative by the International Association of Ports and Harbours (IAPH), the American Association of Port Authorities (AAPA), the European Sea Ports Organisation (ESPO), The Worldwide Network of Port Cities (AIVP) and the World Association for Waterborne Transport Infrastructure (PIANC). The programme aims to follow the 17 sustainable development goals set by the United Nations. The five key themes are resilient infrastructure, climate and energy, community outreach and port-city dialogue, safety and security, governance and ethics. While such initiatives that focus attention on more environmental practices at ports through sharing of best practice and commitments to emission reduction are welcome, the voluntary nature of such schemes means that progress on significant emission reductions remains slow. GHG reductions from voluntary port schemes remain low (see chapter 9) and it will be a long time before they are both sufficiently stringent and widely adopted. This is understandable, given the commercial nature of seaports, but that is why regulators and policymakers must be prepared, not merely to nudge and incentivise, but to take more concrete action.

1.5. The chapter contributions

The selection of chapter topics covers the breadth of issues associated with green ports, starting with the shipping sector and global policy, then moving towards the port perspective.

Chapter 2 examines fuel use and related emissions in the shipping sector. It details the levels of emissions produced and identifies the different types according to fuel use and vessel types. International shipping activities consume about 300 Mtonnes of fuel annually resulting in about 3% of total anthropogenic CO_2 emissions. The chapter shows the challenges of switching to alternative fuels and recent regulatory initiatives to combat these issues.

Chapter 3 continues this theme by focusing on global regulation and policy initiatives from the IMO and other organisations, such as emission control areas, vessel design incentives and shipping line operational practices. The chapter concludes that, although the shipping industry has been slow to improve its environmental credentials, a combination of regulation and technological innovation provides it with significant potential to dramatically reduce its environmental impact. Moreover, of essential relevance for this volume, the authors find that ports have a pivotal role to play in supporting this objective.

Chapter 4 explores the role of stakeholders in port planning and agenda setting. The authors discuss structural approaches such as sustainability reporting and license to operate measurement. The chapter discusses six major elements for consideration in future port planning and design processes, with the aim to achieve more sustainable port development.

Chapter 5 considers a similar dimension of port cities and the circular economy. The goal is that end-of-life (EOL) products are reused, re-manufactured or recycled, and the authors show that this has major implications for seaports, especially those located in cities, as in such areas large amounts of EOL products are available. The chapter identifies the main commodities in volume terms and the set of associated activities, as well as assessing resulting opportunities and threats for ports.

Chapter 6 reveals that, while ship emissions in ports are small compared to ship emissions at sea, as most ports are located in cities people are to a larger extent exposed to the emitted pollutants from ships in port areas. The chapter outlines the key environmental and technical aspects of ship emissions in ports and presents a brief guide for calculation of the emissions. The authors then review the available technical and operational options for reducing these emissions, such as alternative fuels, slow steaming and onshore power supply.

Chapter 7 examines energy use in ports, proposing a methodology to measure sustainable performance of container terminals in the areas of energy and emissions. The chapter contributes to building baseline data on sustainability and climate change contributions of port terminals, since primary data on energy consumption, emissions and their associated costs are rare.

Chapter 8 focuses on adaptation to climate change effects such as sea level rise and storm surges rather than mitigation by reducing emissions. It provides an overview of the global issues and emerging responses by ports around the world, and then explores the perceptions of Chinese port organizations in a comparison to previous work in western countries.

Chapter 9 presents indices and incentive schemes that have been developed by different port stakeholders to lower the environmental impact of ships operating at sea. Based on a number of criteria, some indices and indicators are selected for further comparative study. An evaluation of their strengths and weaknesses is performed based on the application process and general construction, data and quality control, possibility of use by ports and their similarities and differences with other indices. The authors then discuss the future of indices in the larger context of the maritime business. The chapter ends with a number of recommendations concerning an ideal index for a port.

Chapter 10 provides a global review of actions by ports to incentivise more environmental practices in the hinterland transport network. Through an international benchmark study, 176 measures were identified, divided into 10 different types. Four specific measures were then selected, one for each identified environmental goal (air emissions, noise, congestion and modal shift) and evaluated by a stakeholder workshop. The key finding is that the truck replacement programme to reduce air emissions was the most sustainable and the most attractive to take forward, noise reduction was the least popular, and congestion measures were considered the most difficult to implement.

Chapter 11 provides another geographically differentiated comparison by exploring the similarities and differences in green port strategies between western countries and China. Results show that the green port strategies applied in the two Chinese ports studied were investment in intermodal transport connections and dry ports in the hinterland, reducing waste, dust and noise in the port, and, to a lesser extent, reducing emissions of port activities. This situation is not dissimilar to ports in developed countries, who also prefer to act on the issues under their control, first actions within the port and second the intermodal connections, but least motivated to take actions that might raise costs for carriers.

Chapter 12 addresses socio-economic sustainability in ports. While not always considered at first glance to be a “green” topic, the importance of embedding the port in its local area and linking economic and social aspects in port operations is an essential component in port sustainability. Recognizing the problems associated with socio-economic indicators through evaluating the building of such a measurement system at the European level, the chapter particularly focuses on socio-economic impact calculation, attempts to develop a top-down harmonized calculation method and a proxy-based methodology to allow seaports to calculate basic socio-economic impacts. The authors then discuss methodological issues for future development of such measurement systems as well as institutional requirements.

Chapter 13 addresses the essential topic of cruise shipping, which has become an increasingly important element in the port portfolio but brings its own unique environmental challenges. The chapter shows that hosting more cruise calls is broadly supported by communities and decision makers. However, the cruise business is also associated with externalities, raising social, economic and environmental challenges for cruise ports and the surrounding areas. The chapter details the key environmental challenges faced by cruise ports, and reviews the issues that they need to address in order to improve the sustainability of their development.

1.6. Identified challenges and future outlook

The reality is that ports are commercial businesses and are not motivated to spend money unless necessary, so it is essential to understand the challenges and constraints as well as potential policy and operational scenarios. These involve both applications of currently known best practice as well as stronger regulation to incentivise faster adoption of new technology and transfer to greener practices. This book aims to deepen knowledge within a strategic framework to enable decision making, but also to take stock of the current situation and consider whether more can and should be done.

The breadth and depth of chapters in this book has demonstrated the wealth of knowledge amassed by researchers in recent years on the environmental issues caused by and facing the maritime sector, and the current and potential solutions. While more sharing of best practice and more technological developments are needed, there is already sufficient knowledge to make large advances in the reduction of environmental externalities. The decarbonisation of the shipping sector remains impossible under present conditions without a considerable reduction in the volume of shipping. Switching a proportion of the global fleet to LNG and a wide adoption of slow steaming are realistic significant options at sea, but even these would fall far short of the 50% IMO target. In ports, which are the primary focus of this book, it is possible to take significant actions such as switching in-port activities to electricity (potentially generated onsite through wind turbines and solar panels, especially in countries where the national electricity grid is not currently generated by sustainable sources) and dealing with ship emissions at the port through combinations of slow steaming in the port area, use of LNG and cold ironing. Other port-led incentives such as differentiated port dues and hinterland modal shift targets can also make significant contributions to the reduction of ship and hinterland emissions.

The final question to ask is why is sustainability always the last thing considered? As academics we must face this question ourselves, even as we ask it of industry and policymakers. Is reducing pollution simply a potential add-on to be evaluated and considered or should it be an essential action that must be undertaken and the additional cost internalised? The container revolution has meant that maritime transport costs today represent only a fraction of the total cost of goods. Worldwide, transport costs average only 3% of the goods value, and for many consumer goods the figure is even less, therefore an increase in freight rates due to e.g. a bunker levy to incentivise transition away from HFO could certainly be absorbed. Stopford (2009) discussed the industry outcry that preceded the Plimsoll Act 1876 which was one of the first pieces of maritime regulation, pointing out that, as with most such policies, after it was implemented the industry adapted and life carried on. A similar point could be made with regards to SECAs. This is not to advocate swift regulation as the answer to every emerging issue, but air (and other) pollution from the shipping industry is not a new issue and the wealth of research undertaken and demonstrated in this volume is already sufficient to inform action. The work in this book demonstrates that, at least from the port perspective, we know what needs to be done and how to do it. Port authorities, governments and regulators have the authority to mandate action. Do they have the courage?

References

Acciaro, M., Ghiara, H., Inés Cusano, M., 2014a. Energy management in seaports: A new role for port authorities. Energy Policy, 71: 4-12.

Acciaro, M., Vanelslander, T., Sys, C., Ferrari, C., Roumboutsos, A., Giuliano, G., Lam, J. S. L., 2014b. Environmental sustainability in seaports: a framework for successful innovation. Maritime Policy & Management, 41 (5): 480-500.

Bergqvist, R. and Egels-Zandén, N. 2012. Green port dues - The case of hinterland transport, Research in Transportation Business and Management 5: 85–91.

Bergqvist, R., Macharis, C., Meers, D., Woxenius, J. 2015 Making hinterland transport more sustainable a multi actor multi criteria analysis. Research in Transportation Business and Management, 14: 80-89.

Brandt J., Silver J.D., Christensen J.H., Andersen M.S., Bønløkke J.H., Sigsgaard T., Geels C., Gross A., Ayoe B., Hansen A.B., Hansen K.M., Hedegaard G.B., Kaas E., Frohn L.M., 2011CEEH scientific report No 3: Assessment of health cost externalities of air pollution at the national level using the EVA Model System. Cent. Energy, Environ. Health Rep. Ser, Aarhus Univ., Nat. Environ. Res. Inst, Roskilde, p. 98

Cariou, P., 2011. Is slow steaming a sustainable means of reducing CO2 emissions from container shipping? Transportation Research Part D: Transport and Environment. 16 (3): 260-264.

Cullinane, K., Bergqvist, R. (2014) Emission control areas and their impact on maritime transport, Transport Research Part D, 28: 1-5.

Cullinane, K. P. B., Cullinane, S. L., 2013. Atmospheric Emissions from Shipping: The Need for Regulation and Approaches to Compliance, Transport Reviews, 33 (4): 377-401.

David, M., Gollasch, S. (eds), 2015. Global Maritime Transport and Ballast Water Management – Issues and Solutions. London: Springer

Dooms, M., Haezendonck, E., Verbeke, A., 2015. Towards a meta-analysis and toolkit for port-related socio-economic impacts: a review of socio-economic impact studies conducted for seaports. Maritime Policy & Management. 42 (5): 459-480.

EIA, 2018. Short-term energy outlook. https://www.eia.gov/outlooks/steo/data.php?type=tables. Accessed 20th April, 2018.

EMSA, 2016. Annual overview of marine casualties and incidents 2016. http://www.emsa.europa.eu/news-a-press-centre/external-news/item/2903-annual-overview-of-marine-casualties-and-incidents-2016.html. Accessed 2018-04-12

European Commission, 2011. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Brussels: European Commission.

European Commission, 2014. Directive 2014/94/EU of the European parliament and of the council of 22 October 2014 on the deployment of alternative fuels infrastructure. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0094 Accessed 31st Oct 2017.

European Commission, 2017. Reducing emissions from transport. Available at: https://ec.europa.eu/clima/policies/transport_en Accessed 22nd September 2017.

Franc, P., Sutto, L., 2013. Impact analysis on shipping lines and European ports of a cap-and-trade system on CO_2 emissions in maritime transport, Maritime Policy & Management, 41 (1): 61-78, DOI: 10.1080/03088839.2013.782440

Gibbs, D., Rigot-Muller, P., Mangan, J., Lalwani, C., 2014. The role of sea ports in end-to-end maritime transport chain emissions. Energy Policy, 64: 337-348.

Giuliano G., O'Brien, T. 2008. Extended gate operations at the ports of Los Angeles and Long Beach: a preliminary assessment. Maritime Policy & Management. 35 (2): 215-235.

Gonzalez-Aregall, M., Bergqvist, R. and Monios, J., 2018, A Global Review of the Hinterland Dimension of Green Port Strategies. Transportation Research Part D, 59, 23-34.

International Maritime Organisation, 2017. *International Maritime Organisation.* [Online] Available at: http://www.imo.org/ Accessed 26th May 2017.

IMO. 2018. Market-Based Measures. http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Market-Based-Measures.aspx. Accessed 20th April 2018.

InfluenceMap, 2017. Corporate capture of the International Maritime Organization How the shipping sector lobbies to stay out of the Paris Agreement. https://influencemap.org/report/Corporate-capture-of-the-IMO-902bf81c05a0591c551f965020623fda. Accessed 2017-11-03.

Innes, A., Monios, J., 2018. Identifying the unique challenges of installing cold ironing at small and medium ports – the case of Aberdeen. Transportation Research Part D: Transport and Environment. 62: 298–313.

Kosmas, V., Acciaro, M., 2017. Bunker levy schemes for greenhouse gas (GHG) emission reduction in international shipping. Transportation Research Part D: Transport and Environment. 57: 195-206.

Lam, J. S. L., Notteboom, T., 2014. The greening of ports: a comparison of port management tools used by leading ports in Asia and Europe. Transport Reviews. 34 (2): 169-189.

Lindstad, H., Eskeland, G., 2015. Low carbon maritime transport: how speed, size and slenderness amounts to substantial capital energy substitution. Transportation Research Part D: Transport and Environment, 41: 244-256.

Lindstad, H., Eskeland, G., Rialland, A., 2017. Batteries in offshore support vessels – Pollution, climate impact and economics. Transportation Research Part D: Transport and Environment, 50: 409-417.

Lister, J., Taudal Poulsen, R., Ponte, S., 2015. Orchestrating transnational environmental governance in maritime shipping. Global Environmental Change, 34: 185-195.

Ng, A. K. Y., Becker, A., Cahoon, S., Chen, S. L., Earl, P., Yang, Z., (Eds) 2016. Climate Change and Adaptation Planning for Ports, Abingdon: Routledge

Ng, A. K. Y., Song, S., 2010. The environmental impacts of pollutants generated by routine shipping operations on ports. Ocean & Coastal Management, 53: 301–311.

Nicholls, R. J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Chateau, J., Muir-Wood, R., 2008. Ranking port cities with high exposure and vulnerability to climate extremes. OECD Environment Working Paper No. 1. Organisation for Economic Co-operation and Development, Paris.

Notteboom, T., Delhaye, E., Vanherle, K., 2010. Analysis of the Consequences of Low Sulphur Fuel Requirements, Report commissioned by European Community Shipowners' Associations (ECSA), 1-83.

Schipper, C. A., Vreugdenhil, H., de Jong, M. P. C., 2017. A sustainability assessment of ports and port-city plans: Comparing ambitions with achievements. Transportation Research Part D: Transport and Environment. 57: 84-111.

Sciberras, E. A., Zahawi, B., Atkinson, D. J., 2015. Electrical characteristics of cold ironing energy supply for berthed ships. Transportation Research Part D: Transport and Environment, 39: 31-43.

Sciberras, E. A., Zahawi, B., Atkinson, D. K., 2017. Reducing shipboard emissions – Assessment of the role of electrical technologies. Transportation Research Part D: Transport and Environment, 51: 227-239.

Smith, T.W.P., Jalkanen, J.P., Anderson, B.A., Corbett, J.J., Faber, J., Hanayama, S., O'Keeffe, E., Parker, S., Johansson, L., Aldous, L., Raucci, C., Traut, M., Ettinger, S., Nelissen, D., Lee, D.S., Ng, S., Agrawal, A., Winebrake, J.J., Hoen, M., Chesworth, S., Pandey, A., 2014. Third IMO GHG Study 2014. International Maritime Organization (IMO), London, UK.

Stopford, M. (2009). Maritime Economics. Abingdon: Routledge.

Styhre, L., Winnes, H., Black, J., Lee, J., Le-Griffin, H., 2017. Greenhouse gas emissions from ships in ports – Case studies in four continents. Transportation Research Part D: Transport and Environment. 54: 212-224.

Vaishnav, P., Fischbeck, P. S., Morgan, M. & Granger Corbett, J. J., 2016. Shore Power for Vessels Calling at U.S. Ports: Benefits and Costs. *Environmental Science and Technology,* 50 (3): 1102-1110.

Van den Berg, R., De Langen, P.W. 2014. An exploratory analysis of the effects of modal split obligations in terminal concession contracts, International Journal of Shipping and Transport Logistics, 6 (6): 571-592.

Wang, S., Notteboom, T., 2014. The Adoption of Liquefied Natural Gas as a Ship Fuel: A Systematic Review of Perspectives and Challenges, Transport Reviews, 34 (6): 749-774.

WCPI, 2018. Existing fleet and current orderbooks. http://lngbunkering.org/lng/vessels/existing-fleet-orderbooks. Accessed 2018-04-13

Wilmsmeier, G., Spengler, T., 2016. Energy consumption and container terminal efficiency. FAL bulletin, Santiago: CEPAL. Available at: http://repositorio.cepal.org/bitstream/handle/11362/40928/1/S1601301_en.pdf. Accessed 2017-09-22.

Winkel, R., Weddige, U., Johnsen, D., Hoen, V., Papaefthimiou, S., 2016. Shore Side Electricity in Europe: Potential and environmental benefits. Energy Policy. 88: 584-593.

Winnes, H., Styhre, L., Fridell, E., 2015. Reducing GHG emissions from ships in port areas. Research in Transportation Business & Management. 17: 73-82.

World Health Organisation, 2016. [Online] Available at: http://www.who.int/mediacentre/factsheets/fs313/en/ Accessed 29th May 2017.

Yang, Z. L., Zhang, D., Caglayan, O., Jenkinson, I. D., Bonsall, S., Wang, J., Huang, M., Yan, X. P., 2012. Selection of techniques for reducing shipping NOx and SOx emissions. Transportation Research Part D: Transport and Environment. 17 (6): 478-486.

Zis, T., Angeloudis, P., Bell, M. G. H., Psaraftis, H. N., 2016. Payback Period for Emissions Abatement Alternatives. Transportation Research Record: Journal of the Transportation Research Board, 2549: 37-44.