MARINE ENVIRONMENT PROTECTION COMMITTEE
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REDUCTION OF GHG EMISSIONS FROM SHIPS

Vessel shore power installation worldwide

Submitted by FOEI

SUMMARY

Executive summary:	In this document, FOEI outlines the benefits associated with vessel shore power and progress globally with respect to its installation, specifically in the annex
Strategic direction, if applicable:	2 and 3
Output:	Not applicable
Action to be taken:	Paragraph 16
Related documents:	MSC 98/20/7; MEPC 69/5/8; MEPC 68/INF.16; MEPC 59/4/11; MEPC 55/4/13, MEPC 55/4/6; MEPC 54/4/3 and PPR 5/INF.16

Introduction

1 Vessel shore power – otherwise known as cold-ironing, onshore power supply (OPS), shore-side electricity, and alternative maritime power – has seen an upswing in interest and development over the past several years. This document highlights the environmental and public health benefits of shore power with an emphasis on reductions of traditional air pollutants and, to a lesser extent, greenhouse gas emissions, and provides a listing of high-capacity installations worldwide in the annex.

2 Vessel shore power here denotes ships connecting to the land-based electrical grid[1] in order to supply dockside energy requirements.[2] Thus, ships would not need to run auxiliary engines (or, for cruise ships, main diesel generator sets) to produce power for ventilation, pumps, cranes, refrigeration of cargo, communication systems, air conditioning, lighting,

1 Neither the use of alternative fuels in dockside or barge-mounted systems nor Advanced Marine Emission Control Systems are contemplated in this submission.

2 There is a global standard for high-voltage shore connection (HVSC) systems – IEC/ISO/IEEE 80005-1:2012(E).

heating, and other equipment.[3] There are, though, some at-berth emissions from ships that occur before the vessel has "plugged-in" to shore power and in the case of boiler emissions. Nevertheless, a substantial decrease in ship emissions at berth can be achieved through the use of grid-based shore power.

Vessel at-berth emissions

3 Vessel emissions in ports are not insignificant, and their impacts are acutely felt because of their proximity to residential communities – many of which are socioeconomically and politically marginalized – and sensitive coastal ecosystems. In 2011, ships produced 0.4 million tonnes of NO_x, 0.2 million tonnes of SO_x, 0.03 million tonnes of PM_{10}, and 18 million tonnes of CO_2 in port areas.[4,5] The bulk of these emissions, approximately 85 percent, came from tankers and containerships.[6]

> Shipping emissions have considerable external costs in ports: almost EUR 12 billion per year in the 50 largest ports in the OECD for NO_x, SO_x and PM emissions, the emissions most directly relevant to local populations. Approximately 230 million people are directly exposed to the emissions in the top 100 world ports in terms of shipping emissions.
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> Most shipping emissions in ports (CH_4, CO, CO_2 and NO_x) are estimated to grow fourfold up to 2050. This would bring CO_2-emissions from ships in ports to approximately 70 million tonnes in 2050 and NO_x-emissions up to 1.3 million tonnes. Asia and Africa will see the sharpest increases in emissions, due to strong port traffic growth and limited mitigation measures.[7]

4 Most of the emissions within a port area are often attributable to ocean-going vessels.[8] And most of these vessel emissions occur at berth, as opposed to at anchor, in the port basin, or while manoeuvring.[9] Time at berth and attendant emissions can be significant, depending

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3 Energy demands of vessels at berth are substantial. For cruise ships (over 200 meters) and containerships (over 140 meters) peak power demand for 95 percent of these vessels is 9.5 MW and 5 MW, respectively. H. Wang et al. (2015). Costs and benefits of shore power at the port of Shenzhen. Prepared by ICCT for the China Environment Forum at the Woodrow Wilson International Center for Scholars, Dec. 2015.

4 O. Merk (2014). Shipping emissions in ports – Discussion paper no. *2014-20*, at 4, OECD International Transport Forum: Paris, France.

5 "NO2 and CO-emissions in ports have been linked to bronchitic symptoms, whereas exposure to SO2-emissions is associated with respiratory issues and premature births." Id. at 5. NO_x is also a chemical precursor of ground level ozone, or smog, which is "a very potent human respiratory irritant and short-term climate forcing gas. Ozone causes inflammation in the respiratory system that leads to coughing, choking, and reduced lung capacity over long periods of exposure. Increased hospital visits for respiratory problems such as asthma especially among children are common in urban areas with high ozone." In addition, "[t]he effect of PM on public health is very direct, causing acute respiratory stress and contributing to a range of chronic illnesses from long-term exposure." (MEPC 68/INF.16).

6 Id. at 4.

7 Id.

8 *E.g.*, EPA (2018). EPA and Port Everglades Partnership: Emission Inventories and Reduction Strategies, EPA-420-R-18-013, June 2018 [hereinafter Port Everglades Inventories]; López-Aparicio et al. (2017). Shipping emissions in a Nordic port: Assessment of mitigation strategies. *Transportation Research Part D: Transport and Environment* 53: 205-216; *see but* OECD's Shipping emissions in port, *supra* note 4, at 10 (asserting that, in developing countries, trucks' emissions can exceed ships' emissions in ports).

9 *E.g.*, H. Winnes et al. (2015). Reducing GHG emissions from ships in port areas. *Research in Transportation Business & Management* 17: 73-82 (regarding the Port of Gothenberg).

on the ship type. For example, cruise ships combust 20 tons of fuel portside during a typical visit,[10] which, even while taking place in an ECA, produces emissions equivalent to nearly 35,000 trucks idling for 10 hours.[11] Ships carrying freight may remain dockside for longer periods. Containerships at U.S. ports have an average hotelling period of about 31 hours;[12] however, larger ones can remain at the dock for up to 63 hours.[13]

5 Global ship-related health impacts, it should be noted, cause approximately 400,000 premature deaths from lung cancer and heart disease and about 14 million childhood asthma cases each year.[14] One of the proven means to curtail these emissions from impacting port-side communities is the use of vessel shore power.

Air emission benefits derived from shore power use

6 Vessel air pollutants such as SO_x, NO_x, PM, and BC (see document PPR 5/INF.16 from CSC et al.) can be reduced significantly at berth via shore power. The degree of benefit is dependent on the types of energy sources utilized by the power plants supplying electricity to the port at issue. If the power source is fundamentally cleaner or the plant has applied advanced pollution control technology, then overall net emission reduction benefits (and zero or minimal at-berth emissions) can be realized.

7 A number of analyses, including in peer-reviewed journals, have shown this to be the case. For example, Corbett and Comer (2013) estimated that shore power use for cruise ships at the Port of Charleston, South Carolina, in 2019, would decrease overall emissions of NO_x by nearly 99 per cent, $PM_{2.5}$ by 71 percent, and SO_2 by 30 percent.[15] Similarly, NO_x levels are expected to be reduced by 98 percent at the Brooklyn's Cruise Terminal due to shore power use, with overall monetized health benefits of nearly 9 million USD annually.[16] Chang and Wang (2012) calculated that shore power would reduce PM emissions by 39 percent in the Port of Kaohsiung, Taiwan Province of China.[17] Finally, a recent U.S. Environmental Protection Agency (EPA) report found that, for certain types of frequently calling ships, shore power on a per-call basis would reduce NO_x emissions by 62.1 to 89.9 percent and $PM_{2.5}$ emissions by 62.0 to 89.4 percent.[18]

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[10] ABB Communications, One ABB approach on shore-to-ship power to help cut emissions, *available at* http://www.abb.com/cawp/seitp202/84051796b5d6f141c1257715004882a3.aspx.

[11] Coastal Conservation League, How do cruise emissions and truck emissions stack up? *available at* https://coastalconservationleague.org/wp-content/uploads/2010/01/trucks-v-cruise-so2-calc_final-for-web_24sep2012.pdf.

[12] NATIONAL PORT STRATEGY ASSESSMENT: Reducing Air Pollution and Greenhouse Gases at U.S. Ports, EPA-420-R-16-011, September 2016, Table 6-48, at 140 [hereinafter EPA Port Strategy].

[13] Port Everglades Inventories, *supra* note 8, Table 4-11, at 4-13.

[14] Sofiev et al. (2018). Cleaner fuels for ships provide public health benefits with climate tradeoffs. *Nature Communications* 9: 406.

[15] J. Corbett & B. Comer (2013). Clearing the Air: Would Shoreside Power Reduce Air Pollution Emissions from Cruise Ships calling on the Port of Charleston, SC?, prepared for the Southern Environmental Law Center.

[16] Port Authority of NY & NJ letter to Public Service Commission regarding appropriate shore power electrical rate, 29 January 2010 (on file with sponsor).

[17] C. Chang & C. Wang (2012). Evaluating the effects of green port policy: Case study of Kaohsiung harbor in Taiwan. *Transportation Research Part D: Transport and Environment* 17: 185-189.

[18] U.S. EPA Port Strategy, *supra* note 12.

8 The monetized health benefits of shore power utilization are substantial. Winkel et al. (2016) determined that the potential health benefits of a transition to shore power in Europe would be valued at 2.94 billion euros in 2020.[19]

9 In addition to these priority air pollutants, greenhouse gas reductions from vessels can also be attained through the use of grid-based shore power. Again, the resulting benefits are a function of the energy sources that are powering the relevant plants. For example, if coal is relied upon heavily for landside power generation, then reductions in CO_2 emissions via vessel shore power will not be realized – despite decreases in emission levels of other harmful pollutants (e.g. NO_x).

10 However, if renewable sources[20] are a sizeable portion of the applicable energy portfolio, the corresponding CO_2 reductions can be significant. For instance, shore-side electricity implementation throughout Europe has the potential to reduce 800,000 tonnes of CO_2 per year, a 39 percent diminution.[21] Furthermore, the California Air Resources Board has determined that its shore power rule, enacted in 2008 – which applies to container, reefer, and cruise ships at many public ports statewide – would result in 122,000 to 242,000 fewer tonnes of CO_2 emissions released in 2020.[22] In addition, the U.S. EPA has calculated that domestic shore power installation can result in well-to-propeller CO_2 emission reductions of 22.4 to 37.6 percent.[23] Moreover, other estimates have indicated that shore power implementation can reduce CO_2 emissions by 57 per cent in Helsinki, Finland; 99 percent in Oslo, Norway; 71 percent in Cartegena, Colombia; 54 percent in Cristóbal, Panama; and 96 percent in Limón, Costa Rica.[24]

Other environmental benefits of shore power use

11 Vessel shore power use can also decrease in-port noise and vibrations, to the benefit of ship passengers and crew, dockside workers, and near-port community residents.[25]

12 As battery usage by shipowners and operators increases for ferries and tugboats as well as larger ships, having ports that are shore-power equipped will facilitate battery charging and enable optimized energy use from an economic and environmental perspective.[26]

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[19] R. Winkel et al. (2016). Shore Side Electricity in Europe: Potential and environmental benefits. *Energy Policy* 88: 584−593.

[20] The Initial IMO Strategy on Reduction of GHG Emissions from Ships (resolution MEPC.304(72)) references on-shore power provisioned with renewable resources as a candidate short-term measure.

[21] Winkel et al., *supra* note 19.

[22] CARB (2007). Staff Report: Regulations to Reduce Emissions from Diesel Auxiliary Engines on Ocean-Going Vessels While At-Berth at a California Port, Oct. 2007.

[23] EPA Port Strategy, *supra* note 12.

[24] W. Hall (2010). Assessment of CO_2 and priority pollutant reduction by installation of shoreside power. *Resources, Conservation and Recycling* 54: 462-467.

[25] *See* A. Santander et al. (2018). OPS Master Plan for Spanish Ports Project. Study of potential acoustic benefits of on-shore power supply at berth, Euronoise 2018 Crete, 2887-2894, *available at* http://www.euronoise2018.eu/docs/papers/477_Euronoise2018.pdf.

[26] *See* Sciberras et al. (2017). Reducing shipboard emissions – Assessment of the role of electrical technologies, *Transportation Research Part D* 51: 227-239.

There are 185 battery-powered vessels in operation or slated to be delivered in 2018, mostly in France and Norway, and a number of initiatives are underway to push those figures higher.[27]

Legislative and regulatory initiatives are driving shore power proliferation

13 Shore power adoption has been propelled in large measure, though not exclusively, by governmental dictates, such as in California and in the European Union (e.g. Directive 2014/94/EU).[28] The expansion of shore power operations will broaden investment in advanced environmental technologies. It will also serve to mainstream shore power use and improve the economics around ship-side retrofits for "plug-in" capability.

14 Nevertheless, shore power uptake is also happening in certain parts of the world absent legislative or regulatory mandates, due to financial incentives, governmental funding and direction, public/private partnerships, and/or public pressure. Some companies, too, within the freight and tourism sectors have progressed shore power implementation, including TOTE Maritime and Princess Cruise Lines. Yet, only modest numbers of ships are shore-power equipped – although that number is growing.[29] Obstacles in the form of port-side electricity costs, for instance, have hindered the spread of shore power development. However, these are not insuperable barriers and have often been hurdled by cost-sharing agreements among public and private entities (e.g. Juneau, AK; Brooklyn, NY). Academics have identified the broad societal benefits of shore power use if barriers to implementation can be overcome.[30]

15 Shore power proliferation can often be improved when approached regionally, as shipping lines can use shore power not just at one isolated port but within a constellation of proximate ports, thereby leading to greater economic efficiencies.

Action requested of the Committee

16 The Committee is invited to take note of the information provided.

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[27] *See* M. Holter & J. Hodges (2018). The next ship you board might be run on batteries, Bloomberg, March 13, 2018, *available at* https://www.bloomberg.com/news/features/2018-03-13/the-next-ship-you-board-might-run-on-batteries; Norway Adopts Zero-Emissions Regulations in World Heritage Fjords, Greenport, May 15, 2018, *available at* http://www.greenport.com/news101/Regulation-and-Policy/norway-adopts-zero-emissions-regulations-in-world-heritage-fjords.

[28] Shore-side electricity is mandated to be established as a priority for ports in the TEN-T core network, and in other ports, by the end of 2025, unless there is no demand or the costs are disproportionate to the benefits.

[29] For example, by 2015, 500 vessels (from ferries to containerships) were expected to be fitted with Cavotec's Alternative Marine Power system. *See* http://www.portstrategy.com/news101/port-operations/planning-and-design/breaking-boundaries-in-shoreside-power.

[30] *See* Paishnav et al. (2016). Shore Power for Vessels Calling at U.S. Ports: Costs and Benefits. *Environ. Sci. Technol.* 50: 1102-1110 (concluding that "an air quality benefit of $70−150 million per year could be achieved by retrofitting a quarter to two-thirds of all vessels that call at U.S. ports. Such a benefit could be produced at no net cost to society (health and environmental benefits would be balanced by the cost of ship and port retrofit) but would require many ships to be equipped to receive shore power, even if doing so would result in a private loss for the operator.").

ANNEX

HIGH-CAPACITY SHORE POWER INSTALLATIONS WORLDWIDE

OPS started	City/Port name	Country	Capacity (MVA)	Avg. Use (MWh)	Frequency (Hz)	Voltage (kV)	Vessel types using OPS	# OPS berths
2000	Zeebrugge	Belgium	1.25	-	50	6.6	RoRo	1
2000-10	Gothenburg	Sweden	1.25 - 2.5	-	50 & 60	6.6 & 11	RoRo, RoPax	6
2000-11	Long Beach	U.S.A.	16	-	60	6.6 & 11	Tanker, Cruise, Container	17
2001	Juneau	U.S.A.	11	4,107	60	6.6 & 11	Cruise	2
2004	Los Angeles	U.S.A.	40	19,560	60	6.6	Container, Cruise	25
2005-06	Seattle	U.S.A.	12.8	-	60	6.6 & 11	Cruise	2
2006	Kemi	Finland	-	-	50	6.6	RoPax	-
2006	Kotka	Finland	-	-	50	6.6	RoPax	-
2006	Oulu	Finland	-	-	50	6.6	RoPax	-
2008	Antwerp	Belgium	0.8	-	50 & 60	6.6	Container	-
2008	Lübeck	Germany	2.2	-	50	6	RoPax	-
2009	Vancouver	Canada	16	-	60	6.6 & 11	Cruise	3
2009	Tacoma	U.S.A.	-	-	60	6.6	Container, RoRo	1
2010	Karlskrona	Sweden	2.5	-	50	-	Cruise	-
2010	San Diego	U.S.A.	16	8,004-12,871	60	6.6 & 11	Cruise, Reefer	2
2010	San Francisco	U.S.A.	12	7,182 (2014)	60	6.6 & 11	Cruise	2
2010	Lianyungang (in Jiangsu)	China	3	-	50	-	RoPax, Container	-
2011	Prince Rupert	Canada	7.5	-	60	6.6	Container	1
2011	Oslo	Norway	4.5	-	50	11	Cruise	1
2012	Rotterdam	Holland	2.8	-	60	11	RoRo, RoPax	2
2012	Ystad	Sweden	6.25 - 10	-	50 & 60	11	Cruise, RoPax	-
2012	Shenzhen	China	8	-	-	6.6	Container, Cruise	15
2012-13	Oakland	U.S.A.	8	2	60	6.6	Container	14
2013	Trelleborg	Sweden	3.5 - 4.6	-	50	11	RoPax	6
2014	Halifax	Canada	6 - 14	-	-	-	Cruise	3
2014	Hueneme	U.S.A.	-	2,411 (2013)	60	6.6	Reefer	3
2015	Quebec	Canada	-	-	-	-	Cruise	-
2015	Hamburg	Germany	12	-	50 & 60	6.6 & 11	Cruise	4 (3 LNG)
2015	Livorno[a]	Italy	12	-	-	-	Cruise	1
2015	Brooklyn[b]	U.S.A.	20	-	60	6.6 & 11	Cruise	1
2015	Shanghai	China	16	-	50 & 60	6.6 & 11	Container, Cruise, RoRo	-
2016	Ningbo-Zhoushan	China	2 - 3	-	-	-	Bulk, Container	-
2016	Tuticorin	India	-	-	50 & 60	-	Cargo	2
2016-17	Montreal	Canada	-	-	-	-	Cruise, Wintering	5
2016-17	Guangzhou	China	3	-	60	6.6	Container	-
2017	Bergen	Norway	-	-	-	-	Cruise, Ferry, RoPax	-
2017-18	Kapellskär	Sweden	-	-	-	-	-	-
2017-18	Värtahamnen	Sweden	8(?)	-	60	6.6	Cargo	4
2018	Vancouver	Canada	7.5	-	60	-	Container	2
2018	Cuxhaven	Germany	0.63	-	50 & 60(?)	-	RoRo	-
2018	Kristiansand	Norway	16	-	50 & 60	-	Cruise	1
2018(?)	Qingdao (in Shangdong)	China	-	-	-	-	Cruise	-
Planned 2018[31]	Inland	China	-	-	-	-	Other	615

[31] Planned shore power installation figures in China for 2018 and 2020 were presented by the China Waterborne Transport Research Institute at a March 2017 ICCT workshop in Shenzhen. China's *Specialized Action Plan of Ship and Port Pollution and Control from 2015 to 2020* calls for 90 percent of China's major ports to use at-berth shore power by 2020. Cameron Hickert, Greener Ports for Bluer Skies in China, New Security Beat (blog of the Wilson Center's Environmental Change and Security Program), Oct. 24, 2016, *available at* https://www.newsecuritybeat.org/2016/10/greener-ports-achieve-bluer-skies-china/.

Planned 2018	Coastal	China	-	-	-	-	RoRo	311
Planned 2020	Inland	China	-	-	-	-	Container, Bulk, RoRo, Other	1024
Planned 2020	Coastal	China	-	-	-	-	Container, Cruise, Bulk, Roro	519
Planned 2020	Stockholm (Norvik Port)	Sweden	-	-	50	11	Ferry, RoPax, Cruise(?)	-
Planned 2023	Auckland	New Zealand	-	-	-	6.6 & 11	Cruise	-
TBD	Genoa	Italy	12	-	-	-	Cruise(?)	-
?	Kaohsiung	Taiwan Province of China	-	-	-	-	Container	8 Terms.
?	ShenHua Group[c]	China	2.5	-	-	6.6	Bulk	8 Terms.
?	Osaka	Japan	-	-	-	-	RoPax	-
?	Kalibaru	Indonesia	5	-	-	-	Container	9 (1st phase)
?	Riga	Latvia	-	-	-	-	-	-

a = shore power is apparently not being used/underutilized
b = shore power is being underutilized
c = specific location unknown

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