INTERNATIONAL
MARITIME
ORGANIZATION

MARINE ENVIRONMENT PROTECTION COMMITTEE
71ST session
Agenda item 16

MEPC 71/16/X
31 March 2017
Original: ENGLISH

ANY OTHER BUSINESS

Current and projected vessel traffic in the Arctic: Heavy fuel oil use and its alternatives

Submitted by the Clean Shipping Coalition, Friends of the Earth International, Pacific Environment, and WWF[1]

SUMMARY

Executive summary:	This paper highlights recent developments regarding the future of Arctic shipping and the comparative costs of using heavy fuel oil versus alternative fuels.
Strategic direction:	7.1, 7.3
High-level action:	7.1.2, 7.3.1
Output:	
Action to be taken:	Paragraph 25
Related documents:	MEPC 69/20/1, MEPC 69/21; MEPC 70/17/4, MEPC 70/17/9, MEPC 70/17/10, MEPC 70/17/11 and MEPC 70/18.

Introduction

1 During MEPC 69, the Committee considered MEPC 69/20/1, which identified the hazards and risks posed by heavy fuel oil (HFO) use to the Arctic environment, and invited interested Member Governments and international organizations to submit proposals for a relevant new output to address this matter at a future session.[2] Subsequently, at MEPC 70, the Committee considered four submissions relevant to the continued use of HFO in Arctic waters, including: (1) MEPC 70/17/4, submitted by the co-sponsors; (2) MEPC 70/17/10, submitted by FOEI, WWF and Pacific Environment; (3) MEPC 70/17/9, submitted by the Russian Federation; and (4) MEPC 70/17/11, submitted by Canada and United States. In the ensuing discussion at MEPC 70, several delegations stressed the importance of the issue of

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[1] The preparation of this document was assisted by the International Council on Clean Transportation, Ocean Conservancy, the Environmental Investigation Agency, and the Iceland Nature Conservation Association.

[2] MEPC 69/21 Report of the Marine Environment Protection Committee on its Sixty-Ninth Session. Paragraph 20.3 – 20.4.

HFO use in the Arctic and the need for further discussion of the issue at future sessions. As a result, the Committee invited Member States and other stakeholders to submit relevant information to future sessions.

2 The threats posed to the Arctic by the use of HFO as marine fuel have been elaborated in MEPC 69/20/1 and MEPC 70/17/4. For example, HFO is virtually impossible to clean up in the event of a spill and its combustion results in higher emissions of black carbon (BC) than alternative fuels, such as distillates and liquefied natural gas (LNG). While the risks posed by the use of HFO are summarized in these submissions, some additional information is worth highlighting.

3 The following example illustrates the long-term environmental consequences of an HFO spill. In 2003, the bulk storage tanker Nefterudovoz-57 collided with another vessel amidst heavy storms in Onega Bay, White Sea.[3] The collision tore several holes in the ship's hull, spilling at least 54 tonnes of mazut-100 HFO into the prime calving habitat of the local beluga population.[4] Only nine tonnes, or 16 percent, of the oil was recovered.[5] Clean up was further complicated by a lack of qualified onsite personnel and equipment.[6] In the immediate aftermath of the spill, more than 74 kilometers of coastline were covered with spilled HFO, and more than 700 oiled bird carcasses were collected and burnt.[7] Some water tests conducted in 2013, a decade after the spill, recorded hydrocarbon pollution levels more than 22 times the Russian Maximum Permissible Contamination (MPC) level.[8]

4 Research conducted in 2013 in the area of the Onega Bay spill confirms the persistent nature of the spilled HFO, which impacted every level of the ecosystem. Bottom benthic invertebrates, such as bivalve molluscs, continued to contain more than ten times the normal level of hydrocarbons in their wet tissue in 2013.[9] Formerly common fish species, such as flatfish and whitefish, either abandoned the area entirely or exhibited signs of a major population collapse.[10] The spill also placed a significant level of environmental stress on the Bay's resident population of beluga whales. As larger predators of opportunity, belugas can be exposed to HFO pollution by either swimming in oiled waters or through bioaccumulation caused by consuming contaminated prey.[11] Scientists observed multiple adult beluga carcasses near the spill site with no obvious injuries, and the population effectively

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[3] Greenpeace International, *Oil and gas development in the Arctic: At What Cost*? (2012) Available at: http://www.greenpeace.org/russia/Global/russia/report/Arctic-oil/Oil-and-gas-devo-in-Russian-Arctic%20.pdf.

[4] Andrianov, V.V., Lukin, L.R., Lebedev, A, A., Neverova N.V*., Southern local stock of belugas (Delphinapterus leucas) as an indicator of environmental changes caused by oil pollution in the southern Onega Bay of the White Sea*, Marine Mammals of the Holarctic, 8. Vol. 1 (2012); Andrianov, V.V., Lebedev, A.A., Neverozva, N.V., Lukin, L.P., Vorobyeva, T.Ya., Sobko, E.I., Kobelev, E.A., Lisitsina, T.Yu, Samokhina, L.A., Klimov, S.I., *Long-Term Environmental Impact of an Oil Spill in the Southern Part of Onega Bay, the White Sea*, Russian Journal of Marine Biology, 3 Vol. 42 (2016).

[5] Ibid. Andrianov et al. (2016).

[6] Bellona, *Oil and Gas Report: Chapter 4: Oil and gas accidents- prevention and liquidation* (2016). Available at: http://bellona.no/assets/fil_Chapter_4._Oil_and_gas_accidents_prevention_and_liquidation.pdf.

[7] Ibid. Greenpeace International.

[8] Ibid. Andrianov et al. (2016).

[9] Ibid. Andrianov et al. (2016) (up to 38.98 mg/kg of wet mass against a background norm of 1-3 mg/kg of wet mass).

[10] Andrianov, V.V., *Onega Bay. The White Sea. Beluga Whales and the Environment. Russian Academy of Sciences* (2016) Available at: http://arctic.ru/infographics/20160929/446448.html.

[11] Huntington, H, Springer, A., Wilson, B., Yeung, C., Eicken, H., Grebmeier, J., Short, J., Isaacs, J., Stafford, K., Dunton, K., Lowry, L., Spies, R., Hopcroft, R., Weingartner, T., *An Independent Review of USGS Circular 1370: An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas, Alaska*, Prepared for the Pew Environment Group and Ocean Conservancy (2011).

abandoned its former calving grounds.[12]

5 Furthermore, from June 27, 2013 to July 2, 2013, more than 38 kg of mixed oil and sand were collected near the former spill site.[13] While the White Sea is south of the area where the IMO's Polar Code applies, conditions are considered to be a "natural analogue of Arctic seas" by researchers at the Russian Academy of Sciences[14] and the Arctic Council recognizes that environmental conditions in the Arctic and the near-Arctic are often extreme and similar.

6 An oil spill under ice experiment conducted jointly by the Canadian government and the oil industry in the 1970s in the Beaufort Sea also demonstrated the long-term effects of a spill in Arctic waters. Two years after the spill, around one centimetre of oil remained under the ice and the oil caused adverse effects on the entire biological food chain. The spill led to a growth in algae that destroyed the ecosystem and warmed the water and ice. Biologists concluded that the slow rate of degradation of the oil in near-zero temperatures could result in residues from spills in the Arctic Ocean remaining for 50 years and affecting the marine environment.[15]

7 In addition to the environmental consequences of an HFO spill, using HFO as marine fuel produces BC emissions, which are not only linked to human health issues, such as lung cancer, respiratory illness, and cardiopulmonary disease, but also have a potent climate-warming effect when emitted at high latitudes. A recent study found that BC emitted from in-Arctic sources had five times the warming effect than BC emitted at mid-latitudes.[16] In addition, two years of observations in the East Siberian Arctic (Tiksi, Russia) showed that BC contributions from gas flaring (6%), power plants (9%), and open fires (12%) were less substantial than domestic (35%) and transport (38%) sources, including shipping.[17] Furthermore, the shipping industry is expected to account for 10 percent of BC emissions in the Arctic by 2030 and 20 percent by 2050.[18]

8 Although the climate forcing mechanisms of BC are well known,[19] there is some uncertainty regarding the relative BC emissions between marine fuel types. To address this uncertainty, researchers from the University of California - Riverside (UCR), Environment and Climate Change Canada (ECCC), National Research Council Canada (NRC), and Eastern Research Group (ERG) measured marine BC emissions in the lab and on board two container ships, one with a modern Tier II main engine and another with an older Tier 0 engine outfitted with an exhaust gas cleaning system (EGCS).[20] Results suggest that BC emission factors are

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[12] Ibid. Andrianov et al. (2012).

[13] Ibid. Andrianov et al. (2016).

[14] Leonov, A.V., Nemirovskaya, I.A., *Petroleum Hydrocarbons in the Waters of Major Tributaries of the White Sea and its Water Areas: A Review of Available Information*, Water Resources, 3 Vol. 38 (2011).

[15] HFO Project Phase III. Heavy Fuel Oil & Other Fuel Releases from Shipping in the Arctic and Near-Arctic, Submitted to PAME II-2016 by USA, Finland, Russian Federation, Kingdom of Denmark, Norway and Iceland. http://www.pame.is/index.php/projects/arctic-marine-shipping/heavy-fuel-in-the-arctic-phase-i.

[16] Sand, M., Berntsen, T.K., Seland Ø., Kristjánsson, J.E., *Arctic surface temperature change to emissions of black carbon within Arctic or midlatitudes*, Journal of Geophysical Research: Atmospheres, 14 Vol. 118 (2013).

[17] Winiger, P., Andersson, A., Eckhardt, S., Stohl, A., Semiletovc, I.P., Dudarev, O.V. Charkin, A., Shakhovac, N., Klimont, Z., Heyes, K., Gustafssona, Ö., *Siberian Arctic black carbon sources constrained by model and observation,* Proceedings of National Academy of Sciences, 7 Vol. 114 (2017).

[18] AMAP, *Summary for Policy-Makers: Arctic Climate Issues 2015, Short-lived Climate Pollutants*, AMAP Secretariat (2015).

[19] Ibid. AMAP (2015).

[20] Johnson, K., Miller, W., Durbin, T., Jiang, Y., Yang, J., Karavalakis, G., and Cocker D., *Black carbon measurement methods and emission factors from ships*, Prepared for the ICCT. Prepared by the University of California for the International Council on Clean Transportation (2016). Available at: http://www.theicct.org/sites/default/files/publications/Marine-BC-Testing_ICCT-UCR_Consultant-Report_16012017_vF.pdf.

influenced by fuel characteristics, engine type, engine load, and exhaust gas after treatment technology. With regard to fuel type, researchers found that distillate fuel had the lowest BC emission factor compared to HFO (3.2% sulphur) and desulphurized residual fuel (0.0013% sulphur).[21]

Current and Projected Change In Arctic Shipping

9 In a recently published report, the International Council on Clean Transportation (ICCT) demonstrated that although there are fewer ships operating on HFO than distillate in the Arctic, the quantity of fuel on board is dominated by HFO at a ratio of more than 3:1. For example, in 2015, a total of 2,086 ships sailed in Polar Code Arctic waters, carrying over 800,000 metric tonnes of HFO and more than 250,000 metric tonnes of distillate in their main bunker tanks. Although less than half of the IMO Arctic fleet operated on HFO in 2015, these ships accounted for more than 75% of the mass of bunker fuel carried on board. As a class, bulk carriers carried the most HFO as fuel,[22] while cargo ships, fishing vessels, and service vessels account for the majority of HFO fuel on board (metric tonnes) and HFO fuel transport (metric tonne-nautical miles) in Arctic waters.

10 The use of HFO as marine fuel in the Arctic is expected to increase as Arctic sea ice coverage declines and shipping routes become more accessible to ships burning HFO. The Arctic is already beginning to see these changes. In fact, studies estimate that overall shipping activity in the Arctic will increase by more than 50 percent between 2012 and 2050.[23] However, this increase will vary depending on the region.

11 For example, destinational cargo vessel traffic (oil and LNG tankers, bulk carriers) is expected to increase considerably with the completion of development projects for Russian hydrocarbon resources, including LNG from the Yamal region, crude oil production from several fields, and coal exports. The Russian Ministry of Economic Development recently presented figures demonstrating that shipments to ports along the Northern Sea Route (NSR) in 2016 reached a high of 6.9 million tonnes.[24] While many projects are currently on hold due to low fuel prices and technological constraints, by 2030, NSR cargo flow could approach 100 million tonnes of goods a year.[25] Additionally, one study focusing on international transit traffic through the NSR estimates that the NSR will be used for “480 transit voyages, or about 8% of the total container trade between Asia and Europe, in 2030 and 850 transits voyages, or about 10% of all container traffic between Asia and Europe, in 2050.”[26] Another recent study estimates that 4.7 percent of world trade and 13.4 percent of Chinese trade will be re-routed through the NSR by 2030.[27] This expected increase in shipping along the NSR is a result of

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[21] Researchers also found that the modern Tier II engine had much lower BC emissions than the older Tier 0 engine. Black carbon emission factors tended to decrease as main engine load increased in the onboard vessel trials. Lastly, the EGCS reduced BC emissions on the order of 30%. Overall, the UCR report demonstrates the substantial progress made by the research community in measuring BC emissions from marine engines.

[22] Comer, B., Olmer, N., and Moa, X., *Heavy Fuel Oil Use in Arctic Shipping in 2015*, International Council of Clean Transportation (2016). Available at: http://www.theicct.org/sites/default/files/publications/HFO%20Arctic%20Shipping_working-paper_vF_21102016.pdf

[23] Winthera, M., Christensena, J.H., Plejdrupa, M.S., Ravnb, E.S., Erikssonb, Ó.F., Kristensenc, H.O., *Emission inventories for ships in the arctic based on satellite sampled AIS data,* Atmospheric Environment, Vol. 91 (2014).

[24] Staalesen, A., *Record High for Nohrtern Sea Route,* The Barent Observer (December 20, 2016). Available at: https://thebarentsobserver.com/en/2016/12/record-high-northern-sea-route.

[25] Gunnarsson, B., *Future Development of the Northern Sea Route*, The Maritime Executive (February 18, 2016). Available at: http://www.maritime-executive.com/editorials/future-development-of-the-northern-sea-route.

[26] Peters, G. P., Nilssen, T. B., Lindholt, L., Eide, M. S., GlomsrÃ¸d, S., Eide, L. I., & Fuglestvedt, J. S., *Future emissions from shipping and petroleum activities in the Arctic*, Atmospheric Chemistry and Physics, *11*, 5305–5320 (2011). Available at: http://doi.org/10.5194/acp-11-5305-2011.

[27] Bekkers, E., Francois, J. F., Rojas-Romagosa, H., *Melting Ice Caps and the Economic Impact of Opening the Northern Sea Route*, The Economic Journal, doi:10.1111/ecoj.12460 (2016). Available at: https://www.cpb.nl/sites/default/files/publicaties/download/cpb-discussion-paper-307-melting-ice-caps-and-economic-impact-opening-northern-sea-route.pdf.

the cost savings offered by the significantly shorter transit time and distance between the Asia and Europe as opposed to the Suez Canal.

12 While the Northwest Passage (NWP) has received less interest as a potential transit route than the NSR, destinational traffic, mostly associated with current and future mining developments, is expected to increase substantially in the Canadian Arctic.[28] Baffinland's Mary River mine alone exported roughly 3m tons of ore in 2016, and there are plans to increase this to 12m tons by 2020.[29] This translates into 160 transits of ore carriers in one summer shipping season through narwhal habitat in Mine Inlet and Eclipse Sound (near the entrance of Lancaster Sound and the eastern entrance of the NWP).

13 In the U.S. Arctic, predictions also show anywhere from a 100 percent (low-growth economic scenario) to 500 percent (high-growth economic scenario) increase in vessel traffic.[30] Predictions vary greatly due to uncertainty relating to the expansion of oil and gas in the region, infrastructure development, the numbers of vessels transiting the NSR and NWP, and other variables.[31]

14 Overall, numerous factors including fuel costs, navigation fees, regulatory costs, insurance, security concerns, schedule uncertainty, and the relative costs of the ships themselves will determine the economic viability of the NSR, the NWP and other potential trans-polar routes.[32] The availability of ships with a Polar Certificate may be a further determining factor. While precise predictions of vessel traffic in the Arctic are impossible, some generalizations can be made. Resource extraction projects now in production or under development will result in growth for bulk cargo and hydrocarbons in North America and Russia.[33] In addition, supply operations for communities in the Arctic are likely to grow due to population growth and increases in local economic activity. Finally, tourism-related vessel traffic and research vessels will also increase,[34] and potential fishing grounds are likely to increase in extent and accessibility with changes in ice cover.[35]

15 Overall, increased shipping in the Arctic will place substantial pressure on an already vulnerable ecosystem. However, there are alternative fuels that can reduce the risks posed by the continued use of HFO as marine fuel in the Arctic.

Alternatives to HFO

16 Currently, 56 percent of vessels in the Arctic use alternatives to HFO – some of which have never burned HFO while others have made the affirmative choice to reduce their

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[28] The Mariport Group, *Arctic Shipping Developments for WWF Canada* (2012).

[29] Brigham, L. W., *Alaska and the New Maritime Arctic-Executive Summary: Executive Summary of a Project Report to the State of Alaska Department of Commerce, Community and Economic Development* (2015); and The Mariport Group, *Arctic Shipping Developments for WWF Canada* (2012).

[30] The International Council on Clean Transportation, *A 10-Year Projection Of Maritime Activity in the U.S. Arctic Region* (2015). Available at: http://www.cmts.gov/downloads/CMTS_10-Year_Arctic_Vessel_Projection_Report_1.1.15.pdf.

[31] Ibid. The International Council on Clean Transportation (2015).

[32] Hansen, C., Gronsedt, P., Graversen, C., Hendriksen, C., *Arctic Shipping – Commercial Opportunities and Challenges*; CBS Maritime (2016). Available at: http://climateobserver.org/wp-content/uploads/2016/02/Arctic-Shipping-Commercial-Opportunities-and-Challenges.pdf.

[33] Vard Marine, personal communication (November, 2016).

[34] Det Norske Veritas, *Specially Designated Marine Areas in the Arctic High Seas*, Prepared for the Arctic Council (2013). Available at: https://oaarchive.arctic-council.org/bitstream/handle/11374/1341/WG_PAME_AMSA_Doc04_Specially_Designated_Marine_Areas_in_the_Arctic_final_report_AC_SAO_CA02.pdf?sequence=1&isAllowed=y.

[35] Environment Coastal & Offshore, *Ten Nations Meet to Discuss High Seas Fisheries in the Central Arctic Ocean* (December 5, 2016). Available at: https://www.ecomagazine.com/news/regulation/ten-nations-meet-to-discuss-high-seas-fisheries-in-the-central-arctic-ocean?utm_source=ECO+Newsletter&utm_campaign=c7e2def62f-EMAIL_CAMPAIGN_2016_12_06&utm_medium=email&utm_term=0_efee101587-c7e2def62f-139523841.

emissions by using cleaner fuels.[36] In addition, regulation of the sulphur content permitted in marine fuels, to be implemented in 2020, and ship nitrogen oxide emission standards will likely result in a reduction in the number of vessels burning HFO with a shift to higher-quality distillate fuels or liquefied natural gas (LNG). However, the anticipated continued use of low-sulphur residual fuels or fuel blends accompanied by the installation of exhaust gas cleaning systems (or scrubbers) will mean that HFO will continue to be burned in the Arctic.

17 While concerns have been raised that the transition to low-sulphur fuels, distillates and LNG will be more costly than HFO, a recent report published by the International Council on Clean Transportation (ICCT) compares the economic and environmental trade-offs of switching from HFO to two alternative fuels, including distillate fuel and LNG, in the Arctic.[37] With the implementation of the 0.5% fuel sulphur cap in 2020, most ships that currently operate on HFO are expected to use desulphurized residual fuel or residual fuel blends that comply with the standard (referred to as <0.5% S residual fuel in the report) instead of switching to more expensive distillate fuel or installing scrubbers. However, some ships will continue to use HFO in concert with an exhaust gas cleaning system (i.e., a scrubber) in 2020 and beyond. The study projects that switching all the ships in the IMO Arctic fleet from HFO or <0.5% S residual fuel to distillate in 2020 or 2025 would increase fleet-wide fuel costs by approximately $9 million to $11 million per year in $US2015,[38] which is less than a 4 percent increase in fleet-wide fuel costs.

18 With respect to LNG, the ICCT report determined that the price of LNG is expected to be less than both HFO and <0.5% S residual fuel in 2020 and 2025. However, because most ships would need to be converted to operate on LNG, additional costs need to be considered. If the price of LNG remains low relative to other bunker fuels and shipowners accept the payback period, more Arctic ships may operate on LNG in the future. Overall, interest in transitioning to LNG has increased since the IMO agreed to reduce the sulphur limit for marine fuels to 0.5% in 2020. In Russia, for example, there has been success in converting land-based vehicles to natural gas propulsion and work is in progress to use LNG for water-based transport. For example, gas tankers built for the Yamal LNG project will be powered by the natural gas that they transport. Additionally, Russian LNG is used to power a large Estonian ferry that operates between Tallinn and Helsinki in the Baltic, and two LNG bunkering projects are being actively implemented in the Russian portion of the Gulf of Finland.[39]

19 Another study conducted by Vard Marine Inc. analysed the potential economic impact to the Canadian Arctic Sealift (community re-supply) as a result of transitioning away from HFO or residual fuel oils.[40] Using data from 2012, the study estimates that once the 2020 global sulphur fuel cap is in place, the cost of derived totals for dry cargo shipped through the Arctic Sealift operations would increase by as little as 1%. It is also important to highlight that many communities in the Canadian Arctic only receive Sealift goods (non-perishable goods) once a year. Perishable goods are typically flown in to stores or homes and would not be subject to this price increase.

20 The economic benefits of continuing to operate on HFO or <0.5% sulphur residual fuel rather than alternative fuels are even less apparent when the clean-up costs of residual fuel

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[36] Roy, B. and Comer, B., *Alternatives to heavy fuel oil in the Arctic: Economic and environmental tradeoffs. International Council for Clean Transportation* (2017). Available at: http://www.theicct.org/alternatives-to-Arctic-HFO-use-economic-and-environmental-tradeoffs.

[37] Ibid. Roy et al. (2017).

[38] The approximate sum of switching all the Arctic ships that operate on HFO and all the ships that operate on <0.5% residual fuel to distillate fuel in 2020 or 2025.

[39] Personal Communication, Alexey Knizhnikov, WWF Russia (March 2017).

[40] Vard, Marine Inc., *Arctic Fuel Switching Impact Study* (2016). Available at: http://www.hfofreearctic.org/wp-content/uploads/2016/10/Arctic-fuel-switching-impact-study.pdf.

versus distillate fuel spills are taken into account.[41] In fact, the clean-up costs of residual fuel oil spills are more than seven times those of a diesel spill, and even a relatively small spill of HFO or <0.5% sulphur residual fuel, measuring less than 1% of the amount of these fuels carried on ships in the Arctic, outweighs the fuel cost savings of continuing to operate on these fuels in a given year. Moreover, the cost of cleaning up an HFO or residual fuel blend spill has exceeded $100 million per incident in recent decades, which exceeds the expected increased fuel costs associated with prohibiting HFO, desulphurized residual fuel, or residual fuel blends ($9-11 million in $US2015).[42]

21 In addition, a comprehensive assessment of the net economic benefits associated with shipping through the Arctic estimated that the climate feedback from the increased use of the NSR, driven primarily by emissions of short-lived pollutants produced by using HFO, could add an extra $2.15 trillion (NPV) to the underlying costs of climate change globally over the period until 2200.[43] This is enough to offset up to a third of the expected long-term economic gains from NSR shipping in Europe and East Asia. These global long-term numbers do not account for the more immediate ecological and societal benefits of switching from HFO or residual fuel blends to alternative fuels in the Arctic region itself which include improved air quality with positive impacts both on local communities and wildlife.

22 In a study conducted by Vard Marine Inc., researchers found that the risks of using HFO for shipping operations could be greatly reduced by switching to distillates and liquefied natural gas.[44] The study assessed the environmental impacts of HFO, diesel, and LNG, while comparing ship design, fuel consumption, and the economic aspects of each marine fuel option. Notably, the study found burning LNG resulted in a 97 percent reduction in particulate matter emissions. A switch from HFO to distillate fuel would also result in a 30 percent to 50 percent reduction in BC emissions.[45]

23 While there are a number of potential policy alternatives to addressing the risks set forth above, prohibiting the use (and carriage for use) of HFO or residual blends offers a short-term solution that would immediately reduce the risks associated with the use of HFO as marine fuel.[46] Even with the additional initial costs, companies around the globe have built and operated vessels using alternatives fuels. In recent years, dry cargo, tankers, cruisers, dredgers and towing vessels have all been designed and built to use LNG. Last year, Finland constructed and launched the first icebreaker powered by LNG, while shore-side, some of the world's largest ports including Rotterdam and Singapore are actively building LNG bunkering facilities.[47]

24 It is likely that future fuel sources for Arctic shipping will consist of a mix of fuel types and power sources. Ultimately it is critical that the Arctic shipping sector transition away from HFO and residual fuel blends. Both distillate fuels and LNG offer an economically viable short-term solution, but the shipping sector must set its ambitions high and constantly strive to be a cleaner industry.

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[41] Yumashev, D., van Hussen, K., Gille, J., Whiteman, G., *Towards a balanced view of Arctic shipping: Estimating economic impacts of emissions from increased traffic on the Northern Sea Route*, Under revision at Climate Change (2017).

[42] Ibid. Roy et al. (2017).

[43] Ibid. Yumashev et al. (2017).

[44] Vard, Marine Inc., *Fuel Alternatives for Arctic Shipping* (2015). Available at: http://awsassets.wwf.ca/downloads/vard_313_000_01_fuel_alternatives_letter_final.pdf?_ga=1.44012389.1558178095.1469629046.

[45] Daniel Lack, *The Impacts of an Arctic Shipping HFO Ban on Emissions of Black Carbon* (2016). Available at: http://www.hfofreearctic.org/wp-content/uploads/2016/10/The-Impacts-of-an-Arctic-Shipping-HFO-Ban-on-Emissions-of-Black-Carbon.pdf.

[46] Ibid. Roy et al. (2017).

[47] Personal Communication, Alexey Knizhnikov, WWF Russia (March 2017).

Action requested of the Committee

25 The Committee is invited to consider the issues and possible future scenarios regarding the development of Arctic shipping.

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