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EVALUATION AND HARMONIZATION OF RULES AND GUIDANCE ON THE DISCHARGE OF DISCHARGE WATER FROM EGCS INTO THE AQUATIC ENVIRONMENT, INCLUDING CONDITIONS AND AREAS

Air quality and health impacts of using EGCS (scrubbers) in Canadian waters

Submitted by Canada

SUMMARY

Executive summary:	This document presents information on the use of exhaust gas cleaning systems (scrubbers) by ships in Canada and the results of a modelling analysis on the air quality and health impacts of using scrubbers in Canadian waters.
Strategic direction, if applicable:	1
Output:	1.23
Action to be taken:	Paragraph 16
Related documents:	PPR 9/INF.21 and PPR 11/7/3

Introduction

1 Under MARPOL Annex VI, the global 0.50% fuel sulphur limit came into force on 1 January 2020, except in designated Emission Control Areas (ECAs) where the maximum sulphur content was limited to 0.10% after January 2015. As an alternative compliance mechanism to meet the sulphur limit requirement in ECAs, MARPOL Annex VI allows ships to use high-sulphur fuels if they are fitted with an exhaust gas cleaning system (EGCS), also known as a "scrubber". However, the use of scrubbers has been questioned at recent IMO meetings over environmental concerns, including the impacts from air pollution and washwater discharge. Document PPR 9/INF.21 (Canada) reported that ships using scrubbers with heavy fuel oil (HFO) appear to be less effective at reducing air pollution emissions compared to using compliant low-sulphur fuels, and can result in higher amounts of carbon dioxide, particulate matter and Black Carbon emissions. Document PPR 11/7/3 (FOEI et al.) reported findings from aerial surveillance operations to monitor sulphur emissions from ships, which found that, in some cases, there were higher sulphur emissions than expected.[1]

[1] Van Roy, W.; Merveille, J.-B.; Scheldeman, K.; Van Nieuwenhove, A.; Schallier, R.; Van Roozendael, B.; Maes, F. Assessment of the Effect of International Maritime Regulations on Air Quality in the Southern North Sea. Atmosphere 2023, 14, 969.

2 This document provides information on the use of scrubbers by ships in Canadian waters and the associated air quality and health impacts.

Use of scrubbers by ships in Canada

3 From 2015 to 2018, the use of scrubbers in Canadian waters was relatively rare. Since 2018, the number of ships fitted with scrubbers operating in Canadian waters increased dramatically, from 2.4% in 2018 to 20% in 2022 (105 in 2018 compared to 852 in 2022). Table 1 summarizes the number of ships fitted with scrubbers operating in Canadian waters in 2022, based on Canada's Marine Emissions Inventory Tool (MEIT) and Clarksons Research's World Fleet Register. In 2022, there were 6,943 unique ships that voyaged in Canadian waters. Ship classes that have been observed to use scrubbers include cruise, bulk, container, tanker, merchant and special purpose. For the purposes of this analysis, this grouping of ship classes is called "scrubber capable". In 2022, these "scrubber capable" ship classes made up 61% (4,233 unique ships) of all ships operating in Canadian waters. Ship classes that do not use scrubbers in Canadian waters, which constituted the other 39% of ships in 2022, include fishing, tugs, coastguard and other smaller ship types. Therefore, table 1 only presents data on the "scrubber capable" ship classes. While bulkers accounted for the largest number of "scrubber capable ships", representing more than 52%, bulkers had close to 18% of their fleet equipped with scrubbers. However, while cruise ships made up 2% of the "scrubber capable" ships, cruise ships had 63% of their fleet equipped with scrubbers.

Table 1: Scrubber capable vessels operating in Canada in 2022[a]

"Scrubber capable" ship classes	Total number of unique ships (by ship class)[a]	Proportion of unique ships (by ship class)[a]	Number of ships fitted with scrubber	Proportion within each ship class with a scrubber
Cruise	83	2%	52	63%
Merchant bulk	2,213	52%	395	18%
Merchant container	567	13%	168	30%
Tanker	776	18%	164	21%
Merchant other	592	14%	71	12%
Special purpose[b]	2	-	2	-
Total	4,233[c]	100%	852	20%

[a] All data relates to ship classes that are able to fit a scrubber ("scrubber capable").
[b] Special purpose ships are not usually considered a ship class able to fit a scrubber, however, the two listed above are an exception.
[c] 4,233 ships represent 61% of the total ships operating in Canadian waters and only represents the ships that could have scrubbers fitted.
Data from MEIT: Marine Emissions Inventory Tool - Canada.ca

Air quality impacts of scrubbers in Canada

4 In this study, Canada considered impacts on air quality primarily from particulate matter emissions from scrubber-fitted ships. Particulate matter has multiple components including Black (elemental) Carbon, organic carbon, nitrate, sulphate and other forms of particulates.[2] Given Black Carbon is a component of particulate matter, this analysis also considered Black Carbon emissions from scrubber-fitted ships.

2 United States Environmental Protection Agency. 2024. How does $PM_{2.5}$ relate to PM species such as EC, OC, SO4, NO3, PMFINE, and DIESEL-PM_{25}? https://www.epa.gov/air-emissions-inventories/how-does-pm25-relate-pm-species-such-ec-oc-so4-no3-pmfine-and-diesel-pm25

5 In 2018, the International Council on Clean Transportation (ICCT) organized its fifth Black Carbon workshop in San Francisco, California, with an aim to contribute to IMO's work on Black Carbon. During the workshop, the University of California Riverside made a presentation to an ad hoc expert group on Black Carbon to explain the physical limitation of the current wet scrubber design. This workshop showcased information that suggested scrubbers installed on ships are designed to remove gases and they are not specifically designed to remove solid particles, such as Black Carbon.[3]

6 In 2020, Canada contracted the ICCT to conduct a detailed literature review and recommend emission factors for releases to air and water from ships using EGCS. The resulting study was published in November 2020 by ICCT[4] and included as the annex to a Canadian document to PPR 9 in 2022 (PPR 9/INF.21).

7 For air pollutant emission factors, the ICCT review study evaluated eight published studies, representing 23 samples containing information on the air pollution performance of scrubbers, which were the most comprehensive studies on this topic at the time of the review and this analysis. However, the field of study that assesses the air pollution performance of scrubbers in maritime shipping is rapidly evolving and numerous studies have been conducted since then. Newer, state-of-the-art, real-world emissions studies can further substantiate this study, help reduce existing uncertainties and provide a more comprehensive understanding of the air pollution performance of scrubbers, including their capture of gaseous and non-gaseous pollutants, emissions factors and how they compare relative to using marine gas oil (MGO).

8 Based on the recommended emissions factors for ships using HFO with scrubbers in the 2020 ICCT study, Canada updated its Marine Emissions Inventory Tool (MEIT) (Marine Emissions Inventory Tool - Canada.ca) and analysed air emissions from ships equipped with scrubbers in Canadian waters. The MEIT is a Web-based tool that provides an inventory of shipping activity, energy use, air pollutants and greenhouse gas emissions from commercial marine ships operating in Canadian waters. The MEIT uses actual ship movement data and information on ship engines/machinery to model marine emissions in Canada, assuming compliance with regulations in effect during an inventory year. The analysis identified ships operating in Canada's 200-nm Exclusive Economic Zone using their IMO unique ship number. These ships were cross-referenced with data from Clarksons Research's World Fleet Register to determine which ships were fitted with scrubbers. This analysis allowed Canada to produce a list of scrubber-fitted ships operating in Canadian waters.

9 Utilizing the ICCT study, Canada first assessed emissions from ships that currently have scrubbers for two compliance options with the sulphur regulations in Canada. The emissions from the 852 "scrubber capable" ships (shown in table 1) that were in Canadian waters in 2022 were modelled assuming HFO use with a scrubber. These same 852 "scrubber capable" ships were then modelled as if they used fuel complying with sulphur limits. In both cases, the location of the ship was taken into account since in 2022 Canada had implemented the North American ECA which has different sulphur in fuel limits than the Canadian Arctic waters (outside of the North American ECA). By subtracting the emissions from these two cases, it was determined that the use of scrubbers with HFO contributed to more emissions

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3 Wayne Miller, Fifth ICCT Workshop on Marine Black Carbon Emissions: Brief on Understanding BC Removal by Wet Scrubbers, 19 and 20 September 2018, San Francisco, California. https://theicct.org/event/5th-workshop-on-marine-black-carbon-emissions/

4 Bryan Comer, Elise Georgeff, Liudmila Osipova, Air emissions and water pollution discharges from ships with scrubbers, (ICCT: Washington, D.C., 2020), Air emissions and water pollution discharges from ships with scrubbers - International Council on Clean Transportation (theicct.org).

compared to using sulphur compliant fuel, adding 57% more $PM_{2.5}$ and 104% more Black Carbon from these 852 "scrubber capable" ships in 2022.

10 Canada was also interested in understanding the impacts of the lower and upper bounds of scrubber usage, the associated emissions, the resulting ambient air pollution concentrations, and health impacts. This exercise, although not a forecast, was performed to determine the highest possible impact from scrubbers in Canada. When the North American ECA proposal was being developed, the modelling only included the use of compliant fuels. However, now with the rapid growth of scrubber usage, understanding the maximum potential impact of scrubbers on air pollution and human health is of interest to Canada.

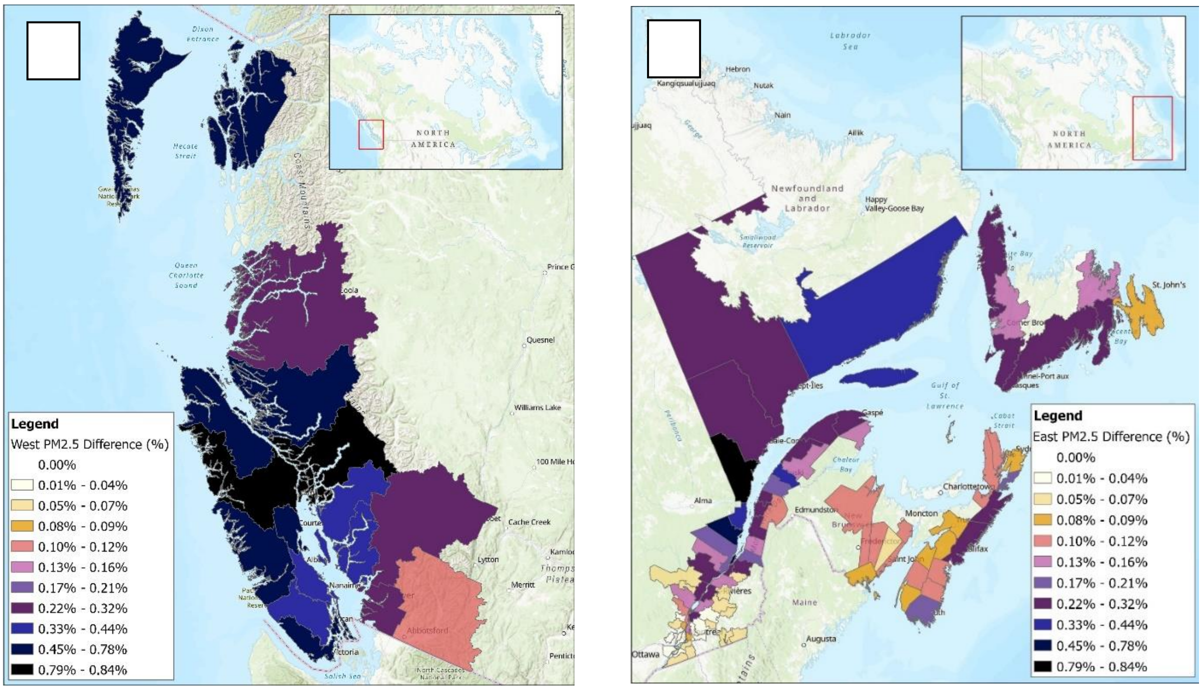
11 To model the impact of emissions on air pollution and forecast air quality, Canada has developed the GEM-MACH (Global Environmental Multi-scale – Modelling Air quality and Chemistry) model. This model uses a large inventory of all emission sources in Canada including all transportation (on- and off-road, rail and marine), industrial, dust, heating and agriculture. Additionally, this model contains a full description of atmospheric chemistry and meteorological processes.[5] At the time of this study, only the 2019 meteorology and 2019 non-marine emissions inventories were available. Therefore, to complete the lower and upper bound scrubber usage exercise, a 2019 ship emission inventory was generated using the MEIT, similar to the 2022 inventory above, to be used with GEM-MACH. The lower bound assumed no ships had scrubbers and all ships used compliant fuel depending on their location (inside the ECA or in the Arctic). The upper bound assumed all ships in the "scrubber capable" ship class (shown in table 1) were fitted with scrubbers and used them with HFO. Table 2 compares the estimated 2019 annual $PM_{2.5}$ and Black Carbon emissions from marine shipping within Canadian waters for the lower and upper bound scenarios. The results presented in this document reflect the information available at the time of the analysis. Noting that a middle-range scenario is more plausible and may be developed at a later date, as more information becomes available. If a linear trend is assumed, a middle-range scenario could result in emissions and results between the lower and upper bound scenarios.

Table 2. Estimates of relative (%) and absolute (tonne) differences of annual total $PM_{2.5}$ and Black Carbon emissions between the lower and upper bound scenarios[6]

Absolute (tonne) & relative (%) differences	$PM_{2.5}$		Black Carbon	
	Tonne	% Difference	Tonne	% Difference
East	242	54	58	146
Great Lakes & St. Lawrence Seaway	151	39	49	118
Pacific	326	54	69	128
Total	720	**50**	176	**130**

5 Government of Canada. 2024. Regional Air Quality Deterministic Prediction System (RAQDPS). https://weather.gc.ca/aqfm/index_e.html

Figure 2: Summer averaged $PM_{2.5}$ per cent difference from upper and lower bound scenarios by census divisions for the (a) Pacific region and (b) Eastern & St. Lawrence Seaway regions



12 As mentioned in paragraph 11, the air quality model used a large emissions inventory that included all emission sources in Canada. The emissions inventory showed that in the Pacific region, marine transportation contributed 2% of the total $PM_{2.5}$ emissions across the sectors and emission sources. However, for the diesel combustion sectors specifically, which include all sectors (e.g. on-road and off-road sectors), marine transportation $PM_{2.5}$ contributed 32% of the diesel emissions. To assess the impact of scrubbers on air quality, the model compared simulated ambient concentrations of $PM_{2.5}$ from all sources in Canada in the upper bound scenario to the lower bound scenario. Figure 2 shows the relative (%) differences in the summer (June, July and August) mean concentrations (µg/m^3) for the upper bound scenario compared to the lower bound scenario in Canada's census divisions near coastal areas. The upper bound scenario was found to have a local to regional impact on $PM_{2.5}$ concentrations where the census divisions saw increases of up to 0.84%. Even though marine transport made up 2% of all $PM_{2.5}$ emissions modelled, and 61% of that transport was assumed to have a scrubber in the upper bound scenario, there was still a demonstrated increase in modelled ambient $PM_{2.5}$ concentrations as a result. The upper bound scenario also had an impact on Black Carbon with increases ranging from 0.1% to 4.55%. The modelled impact of scrubbers was even more pronounced in the summer when shipping routes are more active. A similar analysis was conducted for acute exposure to $PM_{2.5}$ (1-hour and 24-hour maximum concentrations) and resulted in a similar increase as the summer averaged $PM_{2.5}$-concentrations.

Health impacts of scrubbers in Canada

13 Canada also analysed the potential health impacts associated with the upper and lower bound changes in overall air quality from the use of scrubbers by ships in Canadian waters based on the air pollution modelling study above. Canada uses the Air Quality Benefits Assessments Tool (AQBAT) to estimate the change in health burden, expressed as annual counts of adverse health outcomes or total welfare impact (in dollar terms), associated with a given change in air pollutant concentrations. Overall, the results showed that compared to the

use of ECA-compliant fuels, the upper bound scenario would result in a population health burden equivalent to $41.2 million (2024 CAD) annually, with 58% of the burden experienced in British Columbia and 36% in Quebec. The additional risk associated with the use of scrubbers in the upper bound scenario corresponded annually to two additional $PM_{2.5}$-attributable deaths in British Columbia and one additional $PM_{2.5}$-attributable death in Quebec. As stated above, the results presented in this document reflect the information available at the time of the analysis. Noting that a middle-range scenario is more plausible and if a linear trend is assumed, a middle-range scenario could result in health outcomes in between the lower and upper bound scenarios.

14 The emissions associated with the combustion of diesel fuels (diesel exhaust), including HFO and MGO, are important contributors to ambient $PM_{2.5}$ pollution and are recognized as a carcinogen to humans by Canada[7] and internationally[8]. The evidence supports a causal or likely causal relationship between exposure to diesel exhaust and adverse respiratory or cardiovascular effects in humans. Diesel exhaust is also an important contributor to ambient fine $PM_{2.5}$ pollution. Exposure to $PM_{2.5}$ is associated with several adverse health outcomes, including premature deaths, non-fatal respiratory and cardiovascular effects, and emergency room visits, with no clear evidence of a threshold at very low ambient concentrations.[9] Similarly, the current $PM_{2.5}$ air pollution health evidence suggests short-term exposure (acute) to $PM_{2.5}$ is associated with adverse respiratory and cardiovascular effects, including an elevated risk of death. The modelling results indicate that increased scrubber usage could lead to higher particulate matter emission levels compared to cleaner fuels, as scrubbers enable continued HFO consumption. This would undermine the air quality and health benefits of the North American ECA.

Conclusion

15 Since 2018, the number of ships fitted with scrubbers has increased dramatically in Canada. The results of the lower and upper bound modelling analysis have indicated that scrubber use has the potential to erode the air quality benefits of the North American ECA by increasing ambient $PM_{2.5}$ concentrations in coastal populated areas, which could result in adverse health impacts for Canadians.

Action requested of the Sub-Committee

16 The Sub-Committee is invited to note the information provided in this document.

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[7] Health Canada. 2016. Human Health Risk Assessment for Diesel Exhaust. Cat. H129-60/2016E-PDF. https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

[8] IARC (2013). Diesel and Gasoline Engine Exhausts and Some Nitroarenes. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 105. International Agency for Research on Cancer, Lyon, France. Available online at: monographs.iarc.fr/ENG/Monographs/vol105/index.php

[9] Health Canada. 2022. Canadian Health Science Assessment for Fine Particulate Matter ($PM_{2.5}$). Cat. H144-100/2022E-PDF. https://publications.gc.ca/collections/collection_2022/sc-hc/H144-100-2022-eng.pdf