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FURTHER CONSIDERATION OF CONCRETE PROPOSALS ON THE REVISION OF THE INITIAL STRATEGY AND INITIATION OF THE DEVELOPMENT OF A REVISED STRATEGY

Understanding 'net-zero', 'near-zero', 'absolute zero', and 'zero'

Submitted by WSC

SUMMARY

Executive summary:	This document discusses four terms: 'net-zero', 'near-zero', 'zero', and 'absolute zero'; frequently used in GHG-related discussions in the IMO and other fora. This document is submitted to promote greater clarity in the use of these terms and a better understanding of what GHG emission reductions can be expected with the use of certain fuels (many of which are commonly referenced as potential fuels to be used in the maritime sector) when produced using 100% renewable energy. This document also highlights the important role of renewable energy in the production of certain fuels and why this is critical to achieving a major energy transition with minimal GHG emissions.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 13
Related documents:	MEPC 78/7 and ISWG-GHG 12/3

Introduction

1 The Organization is currently engaged in an effort to identify mid- and long-term measures that will be critical to implement the Initial IMO GHG Strategy. Discussions within MEPC and outside IMO often refer to zero-GHG emissions and zero-GHG ships. To facilitate effective deliberation of these important topics, WSC believes it is useful to have a clear and common understanding of the technical potential of a given fuel to reach zero-GHG emissions based on known technologies and a full Well-to-Wake lifecycle analysis (LCA) of the fuel in question. In this context, it is important to understand the difference between 'net-zero' and 'absolute zero'. Given the practical realities and limits of known fuel production technologies, it is also important to understand the concept of 'near-zero' GHG emissions because many of the fuels offering the greatest reduction in GHG emissions do not achieve 'absolute zero', but rather achieve a GHG footprint (again using Well-to-Wake LCA) that achieves 'near-zero' emissions, but results in a GHG footprint that while small, is not 'absolute zero'.

Understanding net-zero, near-zero, absolute zero, and zero

2 Climate discussions within IMO, UNFCCC, and others often include different references to zero emissions. These include ‘net-zero’, ‘near-zero’, ‘absolute zero’, and ‘zero’. Not surprisingly, the understanding of each of these terms may not be common to all stakeholders, and there are circumstances where some terms are used interchangeably which understandably adds confusion to what is already a complicated discussion.

3 In the interest of facilitating greater clarity and understanding, we examine each of the terms concerning zero emissions and attempt to provide a practical, plain-English, distinction that is based on accepted definitions and current state-of-the-art modelling of GHG emissions. Where established definitions are lacking, we offer an informal explanation and practical description. A very brief explanation follows for each of the terms relating to zero emissions.

Net-zero

4 The term ‘net-zero’ is used to describe a neutral or zero effect on the climate system by balancing GHG emissions with removals that may or may not be within the marine fuel lifecycle. For reference purposes the IPCC has defined net-zero GHG emissions as follows: "Net-zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period. Where multiple greenhouse gas emissions are involved, the quantification of net-zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon)."

Near-zero

5 For purposes of this document, the term ‘near-zero’ refers to the GHG emissions associated with the use of fuels produced using best available technology and 100% renewable energy that achieve overall GHG gas reductions equal to or greater than 80%, but less than 100% when compared to Low-Sulphur Fuel Oil (LSFO) produced through conventional refining methods. The range of performance (e.g., >80% reduction) is not presented as a precisely defined threshold or definition, but is based on an objective survey of lifecycle models developed independently by experts. Examples illustrating ‘near-zero’ emissions include combustion of renewable marine fuels in dual-fueled engines using a hydrocarbon pilot fuel. Additional discussion of ‘near-zero’ GHG fuels follows in paragraphs 10 to 12.

Absolute zero

7 The term ‘absolute zero’ is used to describe an energy source that produces no direct or indirect GHG emissions across the full Well-to-Wake lifecycle. To be more specific, ‘absolute zero’ describes where there are no emissions of carbon dioxide (CO_2) or other greenhouse gases (GHG) across all scopes, i.e., where there are no direct emissions from fuel consumption or indirect emissions from energy purchased or any GHG emissions from production to end use.

Zero

8 The term ‘zero’ is frequently used in articles, conversations, and climate policy documents. Despite the widespread use of the term, this term understandably invites questions as to whether the user really means ‘net-zero’, ‘absolute zero’, or ‘near-zero’. Some speakers clarify that for them ‘zero’ means absolute zero. It is also clear that ‘zero’ is used by different authors and speakers to refer to one or more of the above variants concerning ‘zero’ emissions.

Production of marine fuels using 100% renewable energy is critical to achieving 'near-zero' GHG performance

9 As discussed in documents MEPC 78/7 and ISWG-GHG 12/3 (WSC), renewable energy is critical for production and supply of 'near-zero'-GHG marine fuels. Candidate marine fuels include complex hydrocarbons, like diesel and e-diesel and bio-diesel (e.g., $C_{12}H_{23}$), methanol and e-methanol and bio-methanol (CH_3OH), liquefied natural gas or LNG (CH_4), and hydrogen energy carriers, such as ammonia (NH_3).

10 Producing marine fuels from renewable energy production may follow several pathways, including hydrogen production (e.g., from electrolysis of water to produce e-hydrogen), synthetic production of hydrogen carrying fuels (e.g., e-ammonia, e-methanol, e-methane), or biofuel synthesis (e.g., bio-oils, bio-methane, bio-methanol). Processing these fuels for storage, transport, and consumption in ship systems typically requires additional energy inputs.

'Near-zero' GHG fuels

11 'Near-zero' GHG emissions are reported by current lifecycle models representing state-of-the-art / state-of-practice evaluation of marine fuels derived from renewable energy. Reviewing and comparing lifecycle GHG performance by researchers at MARIN (the Maritime Research Institute of the Netherlands), and at the Maersk Mc-Kinney Møller Center for Zero Carbon Shipping, we can see that these models identify 'near-zero' GHG performance for a number of fuels frequently discussed as possible candidates in the commercial maritime sector. This list of fuels is not intended to be exhaustive, but this work is included to provide examples of currently known fuels and what their LCA GHG footprint can be expected to be if produced through processes using 100% renewable energy. Paragraphs 10.1 through 10.3 and Figure 1 provide further detail:

.1 The MARIN portal[1] prepared for the European Sustainable Shipping Forum (ESSF) sub-group on Sustainable Alternative Power for Shipping (SAPs) provides lifecycle modeling results for a large variety of marine energy pathways. The portal provides "free access to consistent and transparent knowledge and information in order to" foster "awareness of what is possible in terms of sustainable alternative power for ships." WSC selected the following MARIN pathways using internal combustion engines (ICEs) to represent four candidate marine fuels that can be produced with renewable energy:

.1 Ammonia (NH3): eNH_3 95%vol + Diesel 5%vol ICE CI two-stroke;

.2 Methanol: eCH_3OH (flue gas CO_2) ICE SI four-stroke;

.3 LNG: eLNG ICE NG four-stroke; and

.4 Diesel: eDiesel (flue CO_2) ICE four-stroke

[1] "The content of this portal is sustained by ongoing strategic research on zero emission maritime transport conducted at MARIN, the Maritime Research Institute Netherlands, and made possible thanks to the European Commission, by means of its working group on Sustainable Alternative Power for Ships (SAPS), part of the European Sustainable Shipping Forum (ESSF)." https://sustainablepower.application.marin.nl, last accessed September 2022.

.2 *The Industry Transition Strategy*[2] report by the Maersk Mc-Kinney Møller Center for Zero Carbon Shipping, October 2021, provides "a science-based, independent perspective of what it takes to decarbonize the maritime industry by 2050." The analysis is "based on publicly available data, data provided by the Center's partners, and output from NavigaTE – the techno-economic model developed by the Center." The Center presents modeling results for the following renewable fuels when used in an internal combustion engine (ICE):

.1 Fuels from green electricity, including e-Hydrogen, e-Ammonia, and e-Methanol;

.2 Fuels from renewable electricity and carbon capture involving natural gas, so-called blue energy, including blue hydrogen and blue ammonia; and

.3 Fuels from bio-feedstock, including bio-methanol, bio-methane, and bio-oils.

.3 Figure 1 presents a summary comparison of the lifecycle GHG performance for the sets of fuels listed above with a benchmark fossil fuel, reflecting lifecycle performance of low-sulphur fuel oil (LSFO). Noting that varying inputs and assumptions can result in a range in GHG reduction performance, the similarity across model results is more remarkable than their differences. All fuels modeled reduce GHGs by more than 80%, and none of the fuels reduce 100% of GHG emissions across the energy lifecycle.[3]

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2 The Center's "Transition Strategy discuss[es] the development in maritime industry and ways for it to decarbonize." The report presents what current data show and the state of modelling insights. Numbers for the figure are from page 18 of that report. https://www.zerocarbonshipping.com/publications/industry-transition-strategy/, downloaded August 2022.

3 These comparisons are generally valid across a range of traditional marine fuels, which various models show performing between about 85-96 gCO_2e/MJ

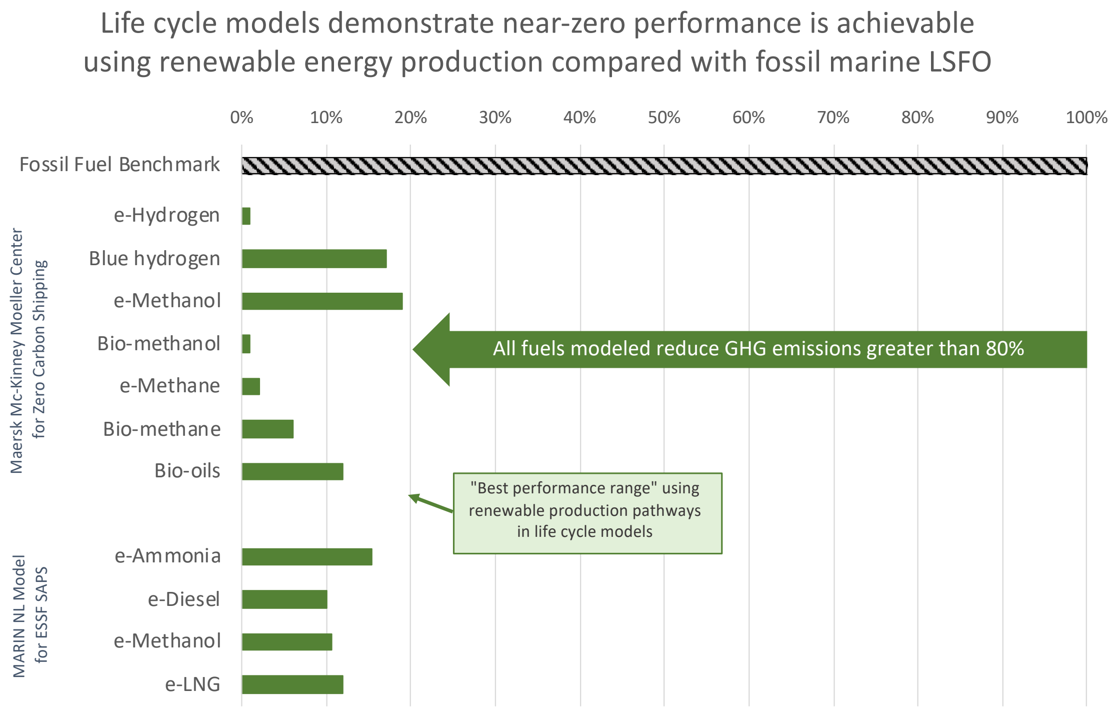

Figure 1: Lifecycle GHG performance of a range of renewably produced marine fuels as percent of current fuels

11 The above information suggests three important insights:

.1 Marine fuels produced from renewable energy and bio-feedstocks have significant potential for deep decarbonization;

.2 All fuels modeled reduce GHGs by greater than 80%, and none of the fuels examined reduce 100% of GHG emissions across the energy lifecycle; and

.3 It should be carefully considered what terms (‘net-zero’, ‘near-zero’, or ‘absolute zero’) best represent what is considered when referencing ‘zero’.

12 GHG reduction targets and schedules depend upon the ability of renewable energy resources and technologies to produce marine fuels with absolute or ‘near-zero’ GHG performance. Significant GHG reductions compared with current fuels can be achieved with renewably produced marine fuels (ISWG-GHG 12/3), including ‘net-zero’ fuels and blends thereof. Current lifecycle models based on the most expert combinations of 100% renewable production with practical best-case conditions do not indicate ‘absolute zero’ GHG emissions.

Action requested of the Working Group

13 The Group is invited to consider the information contained in this document and take action as appropriate.

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