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Decarbonization in the Shipping

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Abstract

International Maritime Organization (IMO) established a Decarbonization policy in 2018, consisting of short-term, mid-term and long-term measures, to reach a full carbon-neutral shipping until 2050. In 2023, the implementation of some technical and operational measures entered in force. Alternative fuels, such as Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG) and Methanol are already used in some vessels, but the development of the plants and optimization of their performance is not yet completed. Huge efforts are made to find solutions in development and implementation of engines, which are driven by Ammonia, Hydrogen and Biofuels. They are expected to substitute the standard fossil fuels beyond 2030. The solar, wind and wave power also are considered as a part of the energy transition since they can contribute to energy efficiency and fuels consumption reduction.

Keywords: IMO; Optimization; Alternative fuels; LNG; LPG; Methanol; Ammonia; Hydrogen; Biofuels; Wind energy; Wave energy; Solar energy

Abbreviations: IMO: International Maritime Organization; LNG: Liquefied Natural Gas; LPG: Liquefied Petroleum Gas; GHG: Greenhouses Gases; SEEMP: Ship Energy Efficiency Management Plan; EEXI Energy Efficiency Existing Ship Index; EEDI: Energy Efficiency Design; CII: Carbon Intensity Indicator rating; ETS: Emissions Trading System; ICEs: Internal Combustion Engines; GTs: Gas Turbines; SOX: Sulfur Oxides

Introduction

The increased energy consumption, tremendous fossil fuel demand and production have a devastating effect on the environment. Control over global warming, caused by greenhouse gases, is possible and achievable only by means of strict measures. The sector emitting huge number of harmful gases is the shipping sector. Now, shipping is accountable for 2.5% of the greenhouse gases, but the expectations are for this number to reach a 250% increase. For that reason, special measures and policies should be established and followed with diligence.

IMO GHG Strategy

The importance of reducing the Greenhouses Gases (GHG) in the atmosphere is a job with huge public interest, in order to cease global warming and reduce air pollution. In the Shipping, the role of International Maritime Organization, in conjunction with ship owners, charterers, operators, classification societies and all other parties concerned, is to establish a strategy, which must be followed strictly in the next years, in order to reduce the greenhouse gases in the atmosphere. As a reference point is established 2008, To achieve it, IMO established a zero-carbon emissions goal in shipping until 2100, but it was revised last year, and the new strategy is to complete the process no longer than 2050. For that reason, IMO adopted the following measures, part of IMO GHG Strategy:

a) Short term measures (2018-2023)

b) Mid-term measures (2023-2030)

c) Long term measures (Beyond 2030)

The Short-term measures include improvement of Ship Energy Efficiency Management Plan (SEEMP), development of technical and operational energy efficiency measures for new and existing ships (EEXI and CII), national actions plan, technical cooperation and capacity-building and life-cycle analysis for fuels. The most important measures for the vessel owners and operators are the EEXI and CII indexing, which have the greatest impact on the vessel performance.

The Energy Efficiency Existing Ship Index (EEXI) is like the already enforced Energy Efficiency Design Index for the New buildings (EEDI), but the target of the new index is the old

vessels. EEXI is calculated once in a lifetime-a design index, not operational and is based on standard reference conditions. Ships need to comply with the EEXI by first IAPP survey after 1 January 2023.

In order to meet the EEXI requirements with technical measures, the vessel owners are facing three possible scenarios:

a) Optimization of Engine/Shaft Power Limits

b) Fuel change with alternative one

c) Replacement of new ships

The Carbon Intensity Indicator rating (CII) impacts all Cargo, Ro-Pax and cruise ships above 5000 GT. Its goal is to divide the vessels in ratings from A to E, and establishes requirements for all vessels to achieve at least rating C. The rating must be calculated every year from 2023, and it is based on Annual fuel consumption, CO_2 factor, Annual distance travelled and Capacity (DWT or GT). Some ambiguities arose with the following index, concerning the vessels which are off hire, but we expect to be cleared soon. The Mid-term measures, which commenced from 2023, include a program for alternative fuels, Operational energy efficiency measures for new and existing ships and Market based measures (MBM), e.g., CO_2 cost and Global Emissions Trading System (ETS) [1-5].

The Long-term measures, which are planned beyond 2030, include zero-carbon or fossil-free fuels, which means full transition to Alternative Fuels, and Emission reduction mechanism.

Alternative Fuels as Part of Decarbonization

Is discussed the scenario, concerning the Fuel change and transition to Alternative Fuels, but there are still many technical challenges in front of the marine engineers, in order to construct and put in operation a reliable and effective engine. As Alternative Fuels in the Marine Industry can be assumed LNG, LPG, Methanol, Ammonia, Hydrogen and Biofuels.

As LNG, LPG and Methanol are used long time ago in all industries, their application in shipping is not a big challenge. There are vessels, which engines and generators are already running on those fuels. Their impact on the environment and their emitted CO_2 emissions are less in comparison with the most used fossil fuels, e.g., HFO and MGO. However, LNG is assumed as a transit fuel, since the reduction of CO_2 emissions compared to HFO is only 20%, which cannot meet the zero-carbon emission strategy in long term. For that reason, LNG can support the transition to zero-carbon and carbon-neutral fuels that are required to meet the 2050 target such as Ammonia and Hydrogen. LNG remains the clear choice today because of its cleanliness, availability and technological readiness among low carbon and low-emission fuels.

Advantage of methanol over LNG or other gas fuels is its liquid state and ability to repurpose existing infrastructure to include engines and vessels with efficient retrofits. Methanol is significantly easier and more economical to store on board than LNG. Existing methanol trade infrastructure can also be an important factor for the cost and availability of methanol over other alternative fueling options. Other positives of methanol plants is the chemical and physical characteristics of this kind of marine fuel, as it remains liquid at ambient temperature and pressure. It is capable of being produced from renewable sources and supported with carbon capture. Provides about 10% emission reduction compared to MGO. However, Methanol is currently more expensive than MGO. It possesses lower energy density compared to fuel oil. It requires 2.5 times more volume. The Design challenges including tank location and fuel supply system should also be put in consideration. Still, there is lack of marine fuel quality standards and other regulations regarding Methanol.

Hydrogen is extracted from fossil fuels and biomass, or from water, or from a combination of the two. Currently, the total energy used worldwide for the production of hydrogen is about 275 Mtoe (mega tonnes of oil equivalent). This corresponds to two percent of the world's energy demand. Natural gas is currently the primary source of hydrogen production (gray hydrogen, 75%). Most interesting option of the future, is the production of green hydrogen through electrolysis of water. Until this moment, only a 4-stroke engine has been developed, using hydrogen, which efficiency is similar to a diesel engine.

Ammonia is one of the two zero-carbon fuels considered for use in the marine sector and its production pathway. The key benefits of Ammonia stem from its higher density than hydrogen and the fact that it can stored as a liquid at - 33°C. This factor make ammonia a more volumetrically effective energy carrier than hydrogen, and offer easier distribution, storage and bunkering. It's high energy density enables sufficient capacity for long ship voyages without refueling for weeks. Different modifications can enable the use of Ammonia in Internal Combustion Engines (ICEs) and Gas Turbines (GTs) in the short term. It possesses the potential to be used in the future directly in fuel cell. Offers lower risk compared to hydrogen due to the higher ignition temperature and narrower flammability range. It Have zero contribution to CO_2 and Sulfur Oxides (SOX) emissions during utilization. Biofuels are liquid hydrocarbon fuels that are produced from renewable sources such as vegetable and animal oils or agricultural and forestry waste.Their composition is similar to that of petroleum diesel. Thus, they do not offer any carbon emissions reduction, although the current IMO proposals doprovide reduction.

Solar and Wind/Wave Technologies in Shipping Industry

Solar and wind technologies are also considered to assist in energy transition, but they can act only as auxiliary energy saving devices. Various sail arrangements, kites, fixed wing and flatter rotors have been tested on merchant vessels over the years.

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Savings can typically range between 3-15% for the main engine consumption. More than 10 ships with sails are in operation. Waves can also be an energy source for ships. The fuel saving is reported to be typically in the range 3-10%, but higher savings are also reported. Installing solar panels (e.g., on hatches) will allow for electricity production both at sea and in port. However, power production is limited to daylight hours.

Conclusion

The Decarbonization in shipping is a long process, commenced in 2018, and expected to be completed in 2050, when we should transit to carbon-neutral shipping. The proper implementation of all measures should be followed with extreme diligence since negligence can cause a devastating effect on the environment. All parties concerned should apply all recommendations and regulations, issued by IMO, and be in touch with the upcoming updates, since it is not a completed process, and many amendments are expected.

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