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Youngsub Lim

Alternative Fuels for Environmentally-Friendly Ships

Hydrogen, Ammonia, Bio-fuels and E-fuels

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Preface

The shipping and shipbuilding industries are facing an unprecedented period of change. To regulate greenhouse gas (GHG) emissions, the energy efficiency design index (EEDI) has been applied to newbuild ships from 2013 and the energy efficiency existing ship index (EEXI) and carbon intensity index (CII) also have been applied to existing ships from 2023. Now ships that do not comply with the GHG regulations cannot operate.

Furthermore, the International Maritime Organization (IMO) adapted the "2023 IMO Greenhouse Gas Strategy" at the 80th Environmental Protection Committee (MEPC) in 2023, which significantly strengthens the GHG reduction goal to net-zero by or around 2050. In addition, in recognition of the problems in assessing the GHG emission intensity of the conventional Tank-to-Wake (TtW) process, the introduction of a new Well-to-Wake (WtW) GHG emissions intensity based on life-cycle assessment (LCA) is being considered, which has led to a new phase of GHG reduction for ships. This is a shift from the traditional focus on "what fuel is used" to a new paradigm of "how it's produced and used." This decision is also leading to a complete rethink of the traditional fossil fuel-based shipping strategy, and a number of controversies surrounding alternative marine fuels and related technologies have emerged.

Hydrogen is a prominent decarbonized alternative fuel, but most of the hydrogen currently available is gray hydrogen, which is produced by reforming natural gas and therefore has a higher WtW GHG emissions intensity than even fossil fuels. Green hydrogen is not yet economically feasible, and it is not well-understood that liquefaction and transport of hydrogen requires additional energy. Ammonia, which is more economical to transport and use, has been proposed as an alternative solution, but the gray ammonia also has a higher WtW GHG emissions intensity than fossil fuels. Moreover, additional technical considerations, such as toxicity issues and the generation of additional GHGs from nitrous oxide, are rarely mentioned. Biofuels and e-fuels are also considered as alternative fuels, but it is not well-known that quantitative sustainability criteria are currently being proposed and that in the future fuels that do not meet the criteria may not be approved as biofuels or e-fuels, even if they are produced from biomass or green hydrogen. While there is growing interest

in carbon capture, utilization and storage (CCUS) and onboard carbon capture and storage (OCCS) technologies, there are also limitations.

The knowledge required for alternative fuels for environmentally friendly ships is diverse and requires an interdisciplinary understanding. I have tried to summarize in this book the changing international situation and various knowledge, for those interested in environmentally friendly ships and alternative fuels. I hope it will be useful to all those involved in the shipping and shipbuilding industries.

Finally, I would like to thank my lovely wife, Sujin.

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