Work Group #4: Sustainable Marine Fuels

Deliverable 3.1 Report Review Template

1. Report title	**Assessment of selected alternative fuels and technologies**
2. Publication date	June 2018
3. Author	DNV GL - Maritime DNV GL is a marine classification society.
4. Client (organization and type of organization, specifying private/commercial/public; research institute/interest group etc.)	No third party client is mentioned.
5. Context of study (e.g. project in the context of which report is published or titles of other reports if part of a series)	n/a
6. Length (pages)	44
7. Link (or where to get if not available online)	https://sustainableworldports.org/wp-content/uploads/DNV-GL_2018_Assessment-of-selected-alternative-fuels-and-tech-report.pdf
8. Sector coverage	Maritime shipping
9. Main aim of the study	The aim of the guidance paper is to provide decision support for investments in ships over the coming 5 to 10-year period by providing information on alternative fuels and technology solutions for ships.
10. Methodology	Desk research, expert judgement

11. Topic(s) and indication of the level of detail For example: • System Description - *A description of the full marine energy system.* • System Components - *A description of all the components.* • Infrastructure requirements for new fuels • Applicability - *which of the new fuels are expected to replace existing fuels?*	• Background – *Short description* • Introduction to alternative fuels and technologies – *Elaborate description of fuels, emissions, fuel pricing, fuel availability, technologies* • International regulations and rules for classification of ships – *Short description* • Overview of alternative fuels and technologies – *Long description of technological, financial and regulatory aspects of different fuels and technologies for ships* • Advisory services of DNV GL – *Short description* • Class services of DNV GL – *Short description* • Engines for gas-fuelled ships – *Short description*
12. What are the main conclusions from the report?	According to DNV GL, • LNG, LPG, methanol, biofuel and hydrogen are the most promising sustainable fuels for shipping. LNG has already overcome the hurdles related to international legislation, and methanol and biofuels will follow suit very soon. • All fuel alternatives discussed could meet the foreseeable volume requirements for shipping over the coming years, provided that the production capacity is scaled up. LNG is already available in sufficient quantities today to meet the potential requirement of the shipping industry for many years. • Battery systems, fuel cell systems and wind-assisted propulsion have a reasonable potential for ship applications. • The major challenges for alternative fuels are related to environmental benefits, fuel availability in the quantities needed for shipping, fuel costs and the international rules within the IGF Code.
13. What fuel/energy type(s) are discussed in the report and in what level of detail? For example: • Fuel description e.g. type, energy density, specific energy density, flash point, boiling point, fire point, flammability limits, hazards	Fuel prices, infrastructure, regulations, availability, environmental impacts, technologies, CAPEX and OPEX are shortly discussed for each of the following fuels/technologies: • HFO • MGO • Fossil LNG • Fossil LPG

	• Methanol (fossil, bio-methanol) • Biofuels (biodiesel, biogas) • Hydrogen (fossil, green) • Wind-assisted propulsion • Batteries • Fuel cells
14. What environmental aspects does the report consider? E.g. Air quality emissions, climate change emissions (GHG + BC), other (for example terrestrial or underwater noise, water quality, emergency releases, fugitive emissions, odour, water resources, mining)	Greenhouse gas emissions (CO_2-equivalent emissions), air quality emissions (NO_x, SO_x, particulate matter).
15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?	Exhaust emissions and life-cycle emissions are considered.
16. If determined in the report, what are the emission rates/factors by pollutant? NOx, SOx, PM10, PM2.5, ultra fine PM, VOC, NH3, GHGs, Black carbon, and any others e.g. that may be unique to the fuel/energy.	For HFO, MGO, LNG (from Qatar/used in Europe; from Qatar/used in Qatar), methanol (from CH_4; from black liquor), biodiesel, liquefied biogas, liquefied hydrogen (from CH_4; from water) well-to-tank and tank-to-propeller GHG emission factors (g CO_2-eq/MJ) are presented. And the tank-to-propeller NOx emissions reduction potential of the different fuels compared to HGO is given too (see Figure 4)
17. Does the report discuss barriers and opportunities for ships to use the fuel(s)/energy? Does the report identify the maturity level of the fuel on a regional or global scale with respect to use by vessels?	Barriers and opportunities for ships are discussed. Mentioned challenges (barriers) are related to environmental benefits, fuel compatibility, fuel availability, fuel costs, on-board modifications, and international rule setting. All alternative fuel options have specific technical, financial and regulatory benefits and challenges, which are discussed in the paper. The maturity level of the different fuels and technologies for ships is also discussed (on a global scale).

18. Does the report discuss barriers and opportunities for ports to provide the fuel(s)/energy? Does the report identify the maturity level of the fuel on a regional or global scale with respect to provision by ports?	The availability of sufficient production and distribution facilities and adequate bunkering infrastructure are mentioned as general prerequisites. For each of the fuels/technologies, barriers and opportunities related to infrastructure are shortly discussed. The availability of each fuel/technology are shortly described as well, including the maturity level of fuel provision by ports.
19. Does the report include capital and operating cost estimates for the ship and/or land-side?	CAPEX (engines, storage, processing, retrofitting) and OPEX (exhaust cleaning, scrubber, additional costs for fuel change) for ships are discussed for the different fuel types, as well as current and future fuel prices. This is a qualitative discussion; few cost estimates are given.
20. When are the fuel(s)/energy expected to be at a demonstration stage vs. commercialization? For example: • Technology Readiness Level of the system - *Estimated maturity of the system technology* • On Board Safety Readiness Level of the system - *Estimated maturity of the risk mitigations on board (on a scale of 1-9)* • External Safety Readiness Level of the system - *Estimated maturity of the risk mitigations for bunker operations (on a scale of 1-9)*	This is not discussed in the report.
21. Are the fuels suitable for short and/or long (trans-oceanic) voyages?	LNG, biofuels, methanol and LPG are mentioned as choices for deep-sea shipping, whereas batteries are assessed to be impractical for ocean-going vessels in the near future.
22. Does the report identify/discuss potential issues around community acceptance for this fuel, or potential social/community impacts associated with the system?	The environmental impacts of the different fuels/technologies are discussed, but these are not directly coupled to community aspects.