Work Group #4: Sustainable Marine Fuels

Deliverable 3.1 Report Review Template

1. Report title	**Navigating the way to a renewable future: Solutions to decarbonise shipping, Preliminary findings**
2. Publication date	September 2019
3. Author	IRENA (International Renewable Energy Agency)
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)	-
6. Length (pages)	36
7. Link (or where to get if not available online)	https://sustainableworldports.org/wp-content/uploads/IRENA_2019_Navigating-the-way-to-a-renewable-future-report.pdf
8. Sector coverage	Maritime shipping
9. Main aim of the study	The study aims to • explore the impact of maritime shipping on CO_2 emissions, the structure of the shipping sector, and key areas that need to be addressed to reduce the sector's carbon footprint; • review the principal, existing policy frameworks that address GHG and airborne emissions;

	• describe the potential clean fuels and renewable-based means of propulsion for maritime ships.
10. Methodology	Desk research
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?*	• Introduction – *Short description of the current state and challenge of global maritime shipping regarding CO_2 emissions* • Sectoral analysis – *Descriptions of the shipping sector, ports and bunkering, and the policy and regulatory framework* • Renewable fuel pathway analysis – *Detailed description of the features of different renewable fuels/technologies* • Overview and outlook – *Short description of the challenge ahead for maritime shipping to decarbonise the sector*
12. What are the main conclusions from the report?	• Global international bunkering for shipping accounts for 8.9 exajoules (2017), with 82% of these energy needs met by heavy fuel oil and the remaining 18% by marine gas and diesel oil. In 2017, the sector was responsible for emitting 677 megatons of CO_2. • Seven ports are responsible for nearly 60% of the bunker fuel sales around the world, with Singapore delivering as much as 22% of today's total bunkering. Accordingly, any shift towards the use of cleaner fuels should consider the needs for infrastructure adjustments at the main bunkering ports. • Tightening regulations on sulphur oxide (SO_x) reductions are expected to be the key driver impacting the reduction of CO_2 emissions associated with the shipping sector. Yet actions taken to reduce SO_x will not necessarily support the CO_2 reductions necessary to achieve IMO targets. • There are three main routes for reducing the carbon footprint of the shipping sector: improve the design of the vessels themselves to reduce their specific fuel consumption; shift from fossil fuels to other alternative fuels and means of propulsion; and improve practices during docking periods by means of shore power. • Alternative fuel options all have different advantages and disadvantages and there is no consensus on which option is best.

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	CO_2 emissions, air quality emissions, lower heating value, volumetric energy density, storage pressure and storage temperature, flammability, toxicity, technical compatibility, production methods, safety issues, availability of different marine fuels are discussed (mostly qualitatively, as part of the fuel-specific descriptions). The full list of fuels/technologies that are mentioned in the report: • HFO • MGO • MDO • LNG • Biofuels (biodiesels, bio-DME, bio-LNG, bio-alcohols, pyrolysis oil) • Methanol • Hydrogen • Ammonia • Batteries • Use of wind and solar energy on ships Of these, biofuels, methanol, hydrogen, ammonia, batteries and wind and solar energy are described in more detail.
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), air pollutant emissions (SO_x, NO_x) and toxicity to humans are considered.
15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?	The report states that any action focused on the reduction of GHG emissions by cutting down on the use of liquid fossil fuels in the shipping sector must consider the total life cycle emissions of the alternative renewable options.

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.	Only a figure (Figure 11 on page 19; based on another source) is provided, which shows CO_2-eq. emission factors of different marine fuels.
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?	The economics associated with sustainable fuels and means of propulsion are stated as the main barrier to reducing the carbon footprint of the shipping sector. Fuel prices, fuel availability and required on-ship modifications are also discussed. Furthermore, the need for further technological developments is stated. These barriers and opportunities are made more specific in the detailed descriptions of specific fuels/technologies. The maturity level of fuels/technologies is briefly touched upon, by describing their current (limited) use in the shipping sector.
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 report discusses the system components of port infrastructure that need to be adapted to enable the switch to alternative fuels. Also, technical properties of fuel/technology options and their implications for logistics, infrastructure and safety are mentioned as important factors. Furthermore, it is concluded that safety measures must be taken for fuels like ammonia. The maturity level of fuels/technologies with respect to provision by ports is only touched upon indirectly, by noting their current limited use in the sector and the need for further technological development.
19. Does the report include capital and operating cost estimates for the ship and/or land-side?	The report includes capital and operating costs, but gives only a couple of estimates as part of the fuel-specific descriptions. These are mostly estimates relevant for ships.
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*	Readiness levels are not quantified. Generally, it is stated that fuel technologies need to be developed further. For example, the following is mentioned on hydrogen: “As of mid-2019, substantial development was still needed before hydrogen could reach commercial scale.”

• 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)*	
21. Are the fuels suitable for short and/or long (trans-oceanic) voyages?	For two fuels/technologies, a limitation to the use for ship propulsion is mentioned: • Batteries are stated to be viable for short distance applications. • Wind and solar energy production on ships cannot provide the thrust needed to move the full load of a large ship.
22. Does the report identify/discuss potential issues around community acceptance for this fuel, or potential social/community impacts associated with the system?	No community aspects are discussed, but the toxicity of some fuels for humans and the required development of safety measures for fuel handling and use are shortly discussed in the fuel-specific descriptions.