Work Group #4: Sustainable Marine Fuels

Deliverable 3.1 Report Review Template

1. Report title	**Zero emission vessels, what needs to be done?**
2. Publication date	May 2018
3. Author	Lloyd's Register and UMAS Lloyd's Register is a marine classification society and private entity. UMAS is a consultancy and set up as a partnership between the University College London (UCL) Energy Institute and MATRANS Ltd. and thus a private/public entity.
4. Client (organization and type of organization, specifying private/commercial/public; research institute/interest group etc.)	Sustainable Shipping Initiative (SSI) The SSI was founded by Forum for the Future in conjunction with WWF (both NGOs) and a number of shipping industry companies.
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)	20
7. Link (or where to get if not available online)	https://sustainableworldports.org/wp-content/uploads/Lloyds-Register-and-UMAS_2018_ZESs_What-needs-to-be-done-report.pdf
8. Sector coverage	Maritime shipping
9. Main aim of the study	The report states to have the following four objectives:

	1. Understand technology options that represent viable routes towards zero-emission vessels (ZEVs) for SSI members 2. Understand the economic implications of adopting ZEV enabling technologies for SSI members 3. Explore modelling sensitivities with SSI members 4. Identify and support the enabling drivers toward ZEVs
10. Methodology	A survey was conducted under SSI members. Based on the outcome of the survey, scenarios were defined which were used to model cost estimates of the different pathways.
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?*	The following topics are discussed in the report in some detail: • Technological maturity – *a short paragraph about the assumptions on technological maturity* • Availability – *assumptions about the availability of the fuels* • Carbon pricing – *a sensitivity study for different carbon prices* • Upstream emissions – *comparison of upstream emissions* • Profitability ranking – *ranking of the profitability of different fuels*
12. What are the main conclusions from the report?	Advanced biofuels may represent the most economically feasible zero-emission alternative for the shipping industry. Biofuels, however, may not be the answer to the question of decarbonisation, due to potential sustainability issues and availability. For the ships with trans-oceanic operating profiles, batteries remain uncompetitive under the assumptions used. For hydrogen fuel cell options, the associated costs of the technology on board weighs significantly on the overall profitability, however, given certain projections used in this report, these costs may not be prohibitive, particularly if the development of the technology and its efficiency is encouraged through other industries or through policy changes. The voyage costs, however, remain the largest contributory factor to the poor competitiveness of hydrogen fuel cells. Even with significant carbon pricing, the costs of all zero emission alternatives considered are higher than the reference (HFO) The technological maturity of the considered ZEV options remains a concern.

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	The fuel/energy types that are considered in the report are: • Hydrogen (in combination with fuel cell) • Biofuel • Electricity For each these fuel/energy types the following details are given: • technological readiness • availability • costs • upstream emissions
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)	The report considers greenhouse gas emissions only.
15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?	The report presents the ZEV's CO_2 upstream emissions as a percentage of the operational and upstream CO2 emissions of a reference ship (see Figure 9).
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.	The report presents the ZEV's CO_2 upstream emissions as a percentage of the operational and upstream CO2 emissions of a reference ship (see Figure 9). CO_2 emission factors for the production of electricity and hydrogen are presented in Table 2.
17. Does the report discuss barriers and opportunities for ships to use the fuel(s)/energy? Does the report identify the	The following economic barriers are discussed: • revenue loss

maturity level of the fuel on a regional or global scale with respect to use by vessels?	• extra capital costs • extra voyage costs Assumptions about the maturity level of the fuels on a global scale with respect to ships are presented in Table 2.
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 does not consider ports specifically.
19. Does the report include capital and operating cost estimates for the ship and/or land-side?	Costs for biofuels, electricity and hydrogen are presented in Table 2 under 'Alternative fuels' availability/economy'. Capital costs for fuel cells, batteries and hydrogen storage are presented in Table 2 under 'Technology Developments.
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)*	Two different scenarios are defined with assumptions about: • technological readiness • availability The detailed assumptions are presented in Table 2 of the report.
21. Are the fuels suitable for short and/or long (trans-oceanic) voyages?	For batteries as an energy source, concerns about its amenability for long distances are stated.

22. Does the report identify/discuss potential issues around community acceptance for this fuel, or potential social/community impacts associated with the system?	The report does not mention issues about community acceptance for this fuel.