Work Group #4: Sustainable Marine Fuels

Deliverable 3.1 Report Review Template

1. Report title	**Refueling assessment of a zero-emission container corridor between China and the United States: Could hydrogen replace fossil fuels?**
2. Publication date	03-03-2020
3. Author	The International Council on Clean Transportation (ICCT) ICCT is a research organization mainly funded by private foundations.
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)	13
7. Link (or where to get if not available online)	https://sustainableworldports.org/wp-content/uploads/ICCT_2020_Refueling-assessment-of-a-ZE-container-corridor-report.pdf
8. Sector coverage	Maritime shipping with focus on container ships.
9. Main aim of the study	The paper analyses the energy demand and refueling needs of a fleet of container ships servicing a shipping corridor between China and the United States in order to examine the feasibility of powering the ships with hydrogen fuel cells.
10. Methodology	Modelling (using ICCT's SAVE model).

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?*	Main topic: • Hydrogen refueling demand for container ships in the China-US corridor Sections in paper: • Introduction and background – *Description of context and content of paper* • Data and methodology – *Elaborate description of analysis steps* • Results and discussion – *Elaborate presentation of analysis results* • Conclusions and future work – *Short description*
12. What are the main conclusions from the report?	• 99% of the voyages made along the considered China-United States corridor can be powered by hydrogen instead of fossil fuels, with only minor changes to ships' fuel capacity or operations. This could be achieved by replacing 5% of certain ships' cargo space with hydrogen fuel, or by adding one additional port call to refuel hydrogen en route. For 43% of all voyages, no additional fuel capacity or extra port calls are needed. • Medium-sized container ships are more capable of servicing the China-US corridor when powered by hydrogen than small or large container ships, because they have enough space for large enough fuel tanks to complete long-distance legs.
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	(Liquid) hydrogen is discussed, in the context of refueling demand. Mentioned properties: density, volumetric energy density, specific energy. Briefly mentioned: methanol, ammonia (volumetric energy density).
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	GHG emissions (CO_2 emissions).

quality, emergency releases, fugitive emissions, odour, water resources, mining)	
15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?	Emissions are not explicitly discussed, but the context of the analysis is exhaust emissions (zero-emission fuels).
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.	Not determined.
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?	Main barrier analysed: higher refueling needs of hydrogen-powered container ships. Other barrier mentioned: higher hydrogen costs relative to conventional fossil bunker fuels. Maturity level: Hydrogen has never been used to power a large container ship and a planned hydrogen cruise ship has not been realised yet.
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?	Barriers mentioned related to hydrogen: limited supply, limited fueling infrastructure. A hydrogen-power fleet would require a distributed hydrogen production and delivery network, servicing more ports than in the current situation. No further discussion of barriers and opportunities. Maturity level: there is currently no hydrogen refueling infrastructure along the shipping corridor between China and the U.S.
19. Does the report include capital and operating cost estimates for the ship and/or land-side?	No.
20. When are the fuel(s)/energy expected to be at a demonstration stage vs. commercialization? For example:	Not discussed.

• 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)*	
21. Are the fuels suitable for short and/or long (trans-oceanic) voyages?	The main finding of the paper is that although it is challenging to complete long deep-sea routes with zero-emission fuels, due to their lower energy density compared to HFO, hydrogen is a suitable fuel for long voyages with container ships, although an additional port call or (limited) reduction of cargo space might be required. Short remark in the report: batteries could become viable in shorter shipping corridors.
22. Does the report identify/discuss potential issues around community acceptance for this fuel, or potential social/community impacts associated with the system?	Not discussed.