Work Group #4: Sustainable Marine Fuels

Deliverable 3.1 Report Review Template

1. Report title	**Public final report – Methanol as an alternative fuel for vessels**
2. Publication date	2018-01-15
3. Author	Maritime Knowledge Centre (Dutch Foundation) TNO (Dutch public research organization aiming to make knowledge applicable for companies and public entities) Technical University (TU) Delft
4. Client (organization and type of organization, specifying private/commercial/public; research institute/interest group etc.)	Nederland Maritiem Land (Netherlands Maritime Land; now known as Maritime by Holland) and the Dutch Ministry of Economic Affairs Maritime by Holland is a joint initiative of major Dutch maritime firms and trade associations that have the aim to connect the different actors of the Dutch maritime industry as well as knowledge institutes and public entities.
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)	24
7. Link (or where to get if not available online)	https://sustainableworldports.org/wp-content/uploads/MKC-TNO-and-TU-Delft_2018_Methanol-as-an-alternative-fuel-for-vessels-report.pdf
8. Sector coverage	Maritime shipping
9. Main aim of the study	The report aims to establish a coherent overview of methanol as an alternative fuel in shipping including its strengths and weaknesses, opportunities and threats.

10. Methodology	The study relies on existing literature as well as the author's own expertise.
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?*	Following items are discussed in the report • Dutch sustainable fuel vision • Necessary fuel mix in the maritime sector • (Bio)methanol - Characteristics - Details about production • International state of the art - with regard to applications/projects, information is provided about the application of methanol in maritime/inland shipping and about (pilot) projects with methanol as fuel: Stena Germanica methanol ferry, Spireth project, Summeth project, Green pilot project, Waterfront methanol tankers, Methanol fuel cell project – MS Innogy, Methanol fuel cell project – Viking Line Mariella. - with regards to the engine technology (available methanol engine technologies, general & combustion related properties) - with regards to the legislation (statutory requirements, classification society requirements, tentative rules for low flash point fuels) • Methanol logistics Methanol pricing
12. What are the main conclusions from the report?	If zero emission of the ship is the main design objective, including a carbon neutral emission performance, all dual fuel options would not hold, as they make use of fossil fuel as a pilot fuel. The remaining options for single fuel application of methanol are Spark Ignited and Direct Injected Methanol engines. It was concluded that direct utilization of methanol in Direct Injected diesel systems is generally not favorable due to its significantly different physicochemical properties. Mainly the low cetane number does not allow for a controllable auto ignition of direct injected methanol. Furthermore it is concluded that for a carbon neutral combustion of methanol as a single fuel, the fuel should be bio-methanol or synthetic methanol produced by renewable energy resources, like solar or wind energy. The implementation of spark ignited

	injection technology is considered to have the highest potential for this specific application. The possibility of an application of spark ignited methanol injection technology can be performed on existing engines without structural modifications to the engine design and structure.
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	• Liquefied Natural Gas (LNG) is very briefly discussed. According the report LNG offers good perspectives for larger vessels. • Methanol as a maritime fuel is discussed in detail in the report. The production pathways and the quantities, the properties, a number of pilot projects, engine technologies, legislation, logistics and pricing of methanol are discussed. • Table 1 (page 12 in the report) shows all relevant combustion engine related physicochemical parameters of popular transport fuels (gasoline, diesel, methanol, LNG).
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)	Air pollutant emissions (SOx, NOx, PM) and greenhouse gas emissions (CO_2) are discussed in the report.
15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?	The report considers both tank-to-wheel as well as well-to-tank emissions.
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 the methanol-fuelled Stena Germanica ferry, the following expected emission reductions compared to HFO are given for a dual fuel engine with diesel as pilot fuel: SOx emissions: 99%, NOx emissions: 60%, CO_2 emissions: 25%, and PM emissions: 95% . No emission factors are specified in the report.
17. Does the report discuss barriers and opportunities for ships to use the fuel(s)/energy? Does the report identify the	The opportunities of using methanol in internal combustion engines are summarized in Table 2 (page 15 of the report) on a high level. The barriers and opportunities are related to engine and on board technology, efficiency, emissions and environment.

maturity level of the fuel on a regional or global scale with respect to use by vessels?	The report identifies the maturity level of the fuel by assessing state of the art engine technologies, legislation and by presenting (pilot) projects.
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?	Regarding handling and storage of methanol, it refers to the SUMMETH project, an ongoing project at the time of publication of the report. The SUMMETH project focused on smaller vessels. It concluded that the infrastructure for methanol fuel storage and distribution at smaller ports would probably be relatively inexpensive. The specific port infrastructure had not been analysed yet, but it was pointed out that methanol was widely used in the chemical industry in Europe with an established transport and distribution infrastructure in place.
19. Does the report include capital and operating cost estimates for the ship and/or land-side?	No estimations of capital and operating costs for ship and/or land-side are presented. Table 4 (on page 17 of the report) however presents a high-level benchmark of different methanol engine concepts, with retrofit costs being one of the criteria.
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)*	• No timeline is provided for the expected commercial availability of methanol as a marine bunker fuel • Methanol is currently in demonstration phase. • Technology readiness: Examples of pilot projects are provided and engine technologies are discussed • On board and external readiness: Statutory requirements, classification society requirements and tentative rules for low flash point fuels (DNG-GL & LR) are provided.
21. Are the fuels suitable for short and/or long (trans-oceanic) voyages?	At the time of publication of the report, methanol pilot projects focused mainly on short voyages. It is mentioned in the report that bigger fuel storage facilities are needed when using methanol instead of diesel due to methanol's lower energy density, but the suitability of methanol for long voyages is not questioned in this context.

22. Does the report identify/discuss potential issues around community acceptance for this fuel, or potential social/community impacts associated with the system?	-