



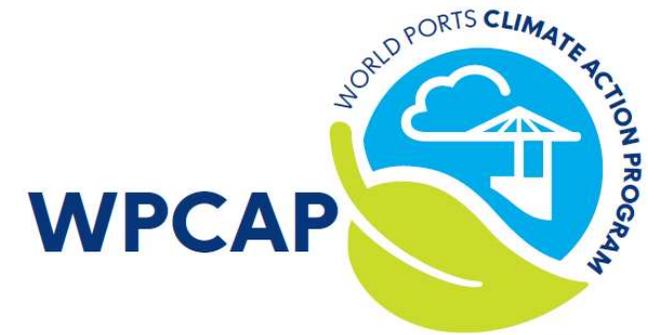
## Work Group #4: Sustainable Marine Fuels

### Deliverable 3.1 Report Review Template

1. Report title	<b>Availability and costs of liquefied bio- and synthetic methane : The maritime shipping perspective</b>
2. Publication date	March 2020
3. Author	CE Delft
4. Client (organization and type of organization, specifying private/commercial/public; research institute/interest group etc.)	SEA\LNG Ltd  SEA\LNG Ltd is a 'multi-sector industry coalition whose members work together to demonstrate the benefits of LNG as a marine fuel throughout the entire value chain'.
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)	100
7. Link (or where to get if not available online)	<a href="https://sustainableworldports.org/wp-content/uploads/CE_Delft_2020_Availability-and-costs-of-LBM-and-LSM-report.pdf">https://sustainableworldports.org/wp-content/uploads/CE_Delft_2020_Availability-and-costs-of-LBM-and-LSM-report.pdf</a>
8. Sector coverage	Maritime shipping
9. Main aim of the study	Main aims of the study are to <ul style="list-style-type: none"> <li>• assess the global maximum conceivable sustainable supply of liquefied biomethane (LBM) and liquefied synthetic methane (LSM) for maritime shipping in relation to the global demand of this sector.</li> </ul>

	<ul style="list-style-type: none"> <li>• assess the cost price of LBM and LSM and to compare it with the cost price of other existing and potential marine bunker fuels.</li> <li>• make recommendations as to how industry and policy makers could address barriers to scaling up of LBM and LSM as a marine fuel.</li> <li>• <i>Scope: global; 2030 and 2050</i></li> </ul>
10. Methodology	Desk research (using both academic and non-academic literature)
<p>11. Topic(s) and indication of the level of detail</p> <p>For example:</p> <ul style="list-style-type: none"> <li>• System Description - <i>A description of the full marine energy system.</i></li> <li>• System Components - <i>A description of all the components.</i></li> <li>• Infrastructure requirements for new fuels</li> <li>• Applicability - <i>which of the new fuels are expected to replace existing fuels?</i></li> </ul>	<ul style="list-style-type: none"> <li>• Availability and cost price of LBM – <i>Extensive assessment</i></li> <li>• Availability and cost price of LSM – <i>Extensive assessment</i></li> <li>• Comparison of prices of marine bunker fuels – <i>Elaborate assessment, but less extensive than former topics</i></li> <li>• Availability of LBM and LSM for and demand of maritime shipping sector – <i>Short discussion that builds on previous assessments</i></li> <li>• Barriers to scaling up of LBM and LSM supply – <i>Qualitative discussion in separate chapter</i></li> </ul>
12. What are the main conclusions from the report?	<ul style="list-style-type: none"> <li>• The future maximum conceivable sustainable supply of LBM and LSM exceeds the energy demand from the shipping sector, provided that biomass will be used to produce methane and sufficient investments are made in renewable electricity production.</li> <li>• The production costs of LBM and LSM could be comparable to other low- and zero-carbon fuels. If the costs of bunkering infrastructure and ships are comparable as well, LSM and LBM would be viable candidate fuels for a decarbonised shipping sector.</li> <li>• A carbon price of USD 50–100 per tonne CO<sub>2</sub> will not be sufficient to make either biomethane or synthetic methane cost-competitive with fossil marine fuels in 2030.</li> </ul>
13. What fuel/energy type(s) are discussed in the report and in what level of detail?	<ul style="list-style-type: none"> <li>• Liquefied biomethane (LBM) – <i>extensive analysis of availability and production costs</i></li> </ul>

<p>For example:</p> <ul style="list-style-type: none"> <li>Fuel description e.g. type, energy density, specific energy density, flash point, boiling point, fire point, flammability limits, hazards</li> </ul>	<ul style="list-style-type: none"> <li>Liquefied synthetic methane (LSM) – <i>extensive analysis of availability and production costs</i></li> <li>Fossil LNG – <i>short description of bunker fuel price (incl. carbon mark-up)</i></li> <li>Very low sulphur fuel oil (VLSFO) – <i>short description of bunker fuel price (incl. carbon mark-up)</i></li> <li>Liquid renewable hydrogen – <i>short description of production costs and basic properties</i></li> <li>Liquid renewable ammonia – <i>short description of production costs and basic properties</i></li> </ul>
<p>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)</p>	<p>The report shortly mentions that the exhaust emissions of ships using LBM or LSM can be accounted for as zero emissions, that the other exhaust emissions can be expected to be the same as for fossil LNG, and that well-to-hull emissions can be expected to be different from those of fossil LNG. GHG accounting methods for biofuels are described in an appendix. Other than this, environmental aspects are not considered in the report.</p>
<p>15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?</p>	<p>Neither of the two.</p>
<p>16. If determined in the report, what are the emission rates/factors by pollutant? NO<sub>x</sub>, SO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, ultra fine PM, VOC, NH<sub>3</sub>, GHGs, Black carbon, and any others e.g. that may be unique to the fuel/energy.</p>	<p>Not determined.</p>
<p>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?</p>	<p>Yes, the report discusses barriers and opportunities to scaling up of LBM and LSM use in maritime shipping in a separate chapter (chapter 6). These relate to costs, market competition, climate impacts and regulations. (A distinction between barriers/opportunities for use by ships vs. provision by ports is not explicitly made.) The maturity level of LBM/LSM use by vessels is not explicitly discussed. (These fuels are currently not used.)</p>
<p>18. Does the report discuss barriers and opportunities for ports to provide the fuel(s)/energy? Does the report identify the</p>	<p>Yes, the report discusses barriers and opportunities to scaling up of LBM and LSM use in maritime shipping in a separate chapter (chapter 6). These relate to costs, market competition, climate impacts and regulations. (A distinction between barriers/opportunities for use by ships vs. provision by ports is not explicitly made.)</p>



<p>maturity level of the fuel on a regional or global scale with respect to provision by ports?</p>	<p>The maturity level of LBM/LSM provision to ports is not explicitly discussed. (These fuels are currently not used.)</p>
<p>19. Does the report include capital and operating cost estimates for the ship and/or land-side?</p>	<p>In the report the cost price of LBM and LSM are assessed, based on desk research. The cost price includes the capital and operating costs over the entire supply chain: feedstock/energy costs, biomethane production costs (in case of LBM), liquefaction costs, transport costs and bunker infrastructure costs. These cost components are also considered separately. Retrofitting costs for ships are not considered.</p>
<p>20. When are the fuel(s)/energy expected to be at a demonstration stage vs. commercialization? For example:</p> <ul style="list-style-type: none"> <li>• Technology Readiness Level of the system - <i>Estimated maturity of the system technology</i></li> <li>• On Board Safety Readiness Level of the system - <i>Estimated maturity of the risk mitigations on board (on a scale of 1-9)</i></li> <li>• External Safety Readiness Level of the system - <i>Estimated maturity of the risk mitigations for bunker operations (on a scale of 1-9)</i></li> </ul>	<ul style="list-style-type: none"> <li>• LBM using anaerobic digestion for biomethane production – <i>mature/commercial</i></li> <li>• LBM using gasification for biomethane production – <i>needs to be demonstrated commercially</i></li> <li>• LSM using electrolysis and CO2 capture from industrial flue gasses: near-mature to mature</li> <li>• LSM using electrolysis and direct air capture: near-mature to mature</li> </ul>
<p>21. Are the fuels suitable for short and/or long (trans-oceanic) voyages?</p>	<p>The suitability of fuels for short/long voyages is not discussed. The report does mention that LBM and LSM can substitute (fossil) LNG, either as a drop-in fuel or as a fuel that would require retrofits (which are expected to be minor).</p>
<p>22. Does the report identify/discuss potential issues around community acceptance for this fuel, or potential social/community impacts associated with the system?</p>	<p>Social/community issues and impacts are not discussed.</p>