

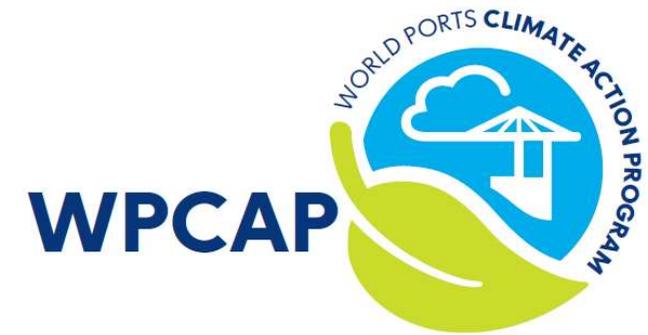


## Work Group #4: Sustainable Marine Fuels

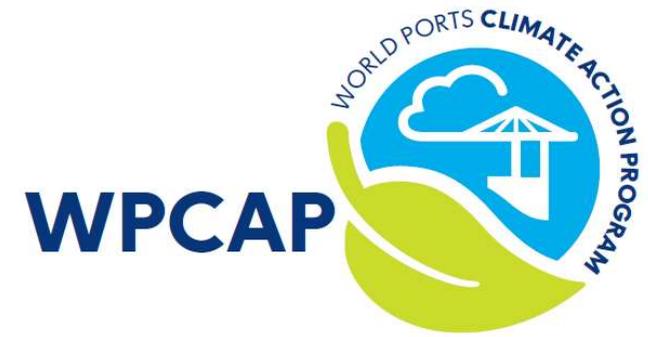
### Deliverable 3.1 Report Review Template

1. Report title	The climate implications of using LNG as a marine fuel
2. Publication date	January 2020
3. Author	Nikita Pavlenko, Bryan Comer, PhD, Yuanrong Zhou, Nigel Clark, PhD, Dan Rutherford, PhD
4. Client (organization and type of organization, specifying private/commercial/public; research institute/interest group etc.)	International Council on Clean Transportation (ICCT)
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)	40
7. Link (or where to get if not available online)	<a href="https://sustainableworldports.org/wp-content/uploads/ICCT_2020-The-climate-implications-of-LNG-as-a-marine-fuel-report.pdf">https://sustainableworldports.org/wp-content/uploads/ICCT_2020-The-climate-implications-of-LNG-as-a-marine-fuel-report.pdf</a>
8. Sector coverage	
9. Main aim of the study	
10. Methodology	
11. Topic(s) and indication of the level of detail For example: <ul style="list-style-type: none"> <li>• System Description - <i>A description of the full marine energy system.</i></li> </ul>	

<ul style="list-style-type: none"> <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>	
<p>12. What are the main conclusions from the report?</p>	<ul style="list-style-type: none"> <li>• LNG contains less carbon per unit of energy than conventional marine fuels</li> <li>• LNG emits more life-cycle GHGs than conventional fuels (due to production &amp; methane slip)</li> <li>• using LNG does not deliver the emission reductions required by the IMO's initial GHG strategy, and that using it could actually worsen shipping's climate impacts.</li> <li>• Continuing to invest in LNG infrastructure on ships and on shore might make it harder to transition to low-carbon and zero-carbon fuels in the future.</li> </ul>
<p>13. What fuel/energy type(s) are discussed in the report and in what level of detail?</p> <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>	<p>life-cycle GHG emissions of LNG, marine gas oil (MGO), very low sulfur fuel oil, and heavy fuel oil when used in engines suitable for international shipping</p>
<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>GHG only Global Warming Potential (GWP)</p>
<p>15. Does the report consider exhaust emissions only, or life-cycle, or both (or some other range of emissions)?</p>	<p>Life-cycle only (upstream emissions, combustion emissions, and unburned methane (methane slip))</p>



<p>16. If determined in the report, what are the emission rates 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>LNG-methane slip emission factor assumptions          Well-to-hull emissions (CH<sub>4</sub>, N<sub>2</sub>O, CO<sub>2</sub>) for LNG and a selection of conventional marine fuels          Hull-to-wake combustion emission factors by fuel (CH<sub>4</sub>, N<sub>2</sub>O, CO<sub>2</sub>)          Upstream (well-to-hull) methane leakage assumptions</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>Depending on the time frame of the global warming potential and engine type used, LNG can either result in little savings of GHG emissions or emit tremendously more emissions compared to engines burning MGO. The maximum life-cycle GHG benefit of LNG was a 15% reduction compared with MGO over a 100-year time frame.          On the other hand, the most popular LNG engine technology—LPDF, four-stroke, medium-speed, which is used on at least 300 ships and is especially popular with LNG-fueled cruise ships—emitted 70% more life-cycle GHGs when it used LNG instead of MGO.          An opportunity could be the price, since it is mentioned as less expensive than MGO and HFO.</p>
<p>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?</p>	<p>Based on limited GHG emission reductions and even higher amounts of emissions, it is questionable, if further investments on ships and on shore are reasonable, since it does not support the decarbonization.</p>
<p>19. Does the report include capital and operating cost estimates for the ship and/or land-side?</p>	<p>LNG price: LNG is less expensive than MGO and in some regions cheaper than HFO</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> </ul>	<p>N/A</p>



<ul style="list-style-type: none"> <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>	
<p>21. Are the fuels amendable for short and/or long (trans-oceanic) voyages?</p>	<p>N/A</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>N/A</p>