The case for LNG and LPG-fuelled tankers

12 May 2021 • 11:00-11:45 BST

Supporting organisations

Panellist documents

Page 2: Angus Campbell, Schulte Group
Page 9: Nikos Xydas, WLPGA, World LPG Association
Page 21: Kjeld Aabo, MAN Energy Solutions
Page 32: Steve Esau, SEA-LNG
The case for LNG and LPG fuelled tankers

Angus Campbell
The new reality for shipping

Increasing climate concern will force action.

Global industry, (our customer), has committed to decarbonise rapidly.

Shipping is part of the energy transition, but is unlikely to define zero carbon fuel choice……
Global energy supply, updated 4th September 2020

Total about 15 billion toe annually
Shipping consumes about 400 million tons annually

Sector coupling will define destination fuel choice and availability.
This will allow infrastructure costs to be shared across all sectors.
Change will be forced by global governments and market forces. The IMO will have to adapt at pace.
Transition and destination fuels........

Critical decision when ordering an asset with service life spanning decades.

Do you invest in the transition or aim for the zero carbon destination?

Can you use LNG and LPG, (which are both transition fuels), while building a ship that is ready for zero carbon fuel when available?

Yes, but there may be significant design considerations.......
LPG, LNG ➔ green hydrogen or ammonia ready?

- LPG and LNG fuel cost
- LPG and LNG global availability
- LPG and LNG global infrastructure
  - Impact of carbon price?
- Zero carbon design maturity
- Zero carbon risk management
- Automated engine room and fuel system?
Market forces will drive change.

A quote that has been used over the last decade, but this variation is appropriate for shipping’s new reality:

“The Stone Age didn’t end because they ran out of stones—it ended because better technologies were developed to meet humanity’s changing needs. Likewise, the age of fossil fuel won’t end because we run out of oil and coal. Non-renewable energies will be replaced by renewable sources as new technologies make them more cost-effective than non-renewable sources.”*

Thank You
www.linkedin.com/in/angus-campbell-mni-183bb617
LPG
The Marine Fuel of the Future - Today

Nikos Xydas
World LPG Association

Riviera Maritime
Tanker Shipping & Trade Webinar Week
The Case for LNG and LPG Fuelled Tankers

12th May 2021
LPG - The Bunker Fuel for the Next Decades

• Already a long way ahead on the Green Pathway
  • Compared to 2020 compliant fuels
    • 99% less SOx
    • 15% less CO2
    • 10% less NOx
    • 90% less particular matter PM
  • Meets IMO 2020
  • Not a GHG, greatly supports IMO 2050 GHG strategy
Only Advantages
LPG Bunkering - Available Everywhere

Regional LPG Trade Flows

- More than 1000 existing storage facilities and terminals
- More than 700 small carriers for ship to ship bunkering
- All LPG terminals can become supply points

STS operations are possible around the world and can provide LPG impetus
First 4 LPG Powered VLGCs already sailing BW LPG

- 79 the total of retrofit and newbuild orders, more including options
- 44 new orders already in 2021 totaling 1,06 million DWT
MAN Projections

- In 2021, 60% of all new LPG carriers would be LPG powered (100% so far)
- By 2027, all new LPG carriers would be LPG powered
- By 2028, 30% of container vessels could be LPG powered
ABS - The three pathways to the future

Light Gas
- LNG
- Bio-/Electro-Methane
- Hydrogen

Heavy Gas
- LPG, MeOH
- Bio-/Electro-Fuels
- Ammonia

Bio/Synthetic
- Bio-/Renewable Diesel
- Gas-to-Liquid Fuels
- 2nd and 3rd generation biodiesel

Zero carbon future
LPG to Ammonia
Renewable LPG – the alternative bunker fuel for the next decades

- Produced through a variety of technologies, primarily HVO at present
- Feedstock: A mix of wastes, residues, sustainably sourced vegetable oils
Renewable LPG/bioLPG - Already on the Market

A “drop in” fuel replacement, same molecule, no equipment changes

LPG industry targets:

- **World**: 50% at least of 2050 non-chemical demand to be covered by rLPG
- **Europe**: 100% of 2050 non-chemical demand to be covered by rLPG
The Alternative Bunker Fuel for the Next Decades

Up to 80% of carbon emissions can be reduced by switching to (bio)LPG

Why BioLPG is better fuel choice for the environment
In Summary

- LPG, the proven alternative marine fuel for the next decades - a transition fuel forever
- A pathway to net zero carbon future
  - Zero carbon with carbon capture
  - Zero carbon with potential simple transition to ammonia
- Also as renewable – the great cherry on the cake
- LPG is propelling a cleaner – energy future
- WLPGA – the support for all stakeholders
Thank you!

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The case for LNG and LPG-fuelled tankers

Date: Wednesday 12 May - Time: 11:00-11:45 BST

Kjeld Aabo
Director New technologies
Sales and Promotion Two stroke Marine
Member of WG ISO 8217 & Chairman CIMAC Fuels
# MAN B&W dual fuel portfolio

<table>
<thead>
<tr>
<th>LNG</th>
<th>Ethane</th>
<th>Methanol</th>
<th>LPG</th>
<th>Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME-GI</td>
<td>ME-GA</td>
<td>ME-GIE</td>
<td>ME-LGIM</td>
<td>ME-LGIP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>→ 2024</td>
</tr>
</tbody>
</table>

LNG Ethane Methanol LPG Ammonia

→ 2024
## Alternative fuels

### Properties

<table>
<thead>
<tr>
<th>Energy storage type</th>
<th>Specific Energy MJ/kg</th>
<th>Energy Density MJ/L</th>
<th>Required Tank Volume m³</th>
<th>Supply pressure bar</th>
<th>Estimated PtX efficiency</th>
<th>Injection pressure bar</th>
<th>Emission Reduction Compared To HFO Tier II</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGO</td>
<td>42,7</td>
<td>35,9</td>
<td>1000</td>
<td>7-8</td>
<td></td>
<td>950</td>
<td>SO₂  NO₃  CO₂  PM</td>
</tr>
<tr>
<td>Liquefied natural gas (LNG -162 °C)</td>
<td>50,0</td>
<td>22,4</td>
<td>1602</td>
<td>300</td>
<td>0,56</td>
<td>300</td>
<td>90-99%  20-30%  24%  90%</td>
</tr>
<tr>
<td>Liquid ethane gas (LEG -88 °C)</td>
<td>47,5</td>
<td>17,1</td>
<td>2099</td>
<td>380</td>
<td></td>
<td>380</td>
<td>90-97%  30-50%  15%  90%</td>
</tr>
<tr>
<td>Liquefied petroleum gas (LPG -42,4 °C)</td>
<td>46,4</td>
<td>23,5</td>
<td>1527</td>
<td>50</td>
<td></td>
<td>600-700</td>
<td>90-100%  10-15%  13-18%  90%</td>
</tr>
<tr>
<td>Methanol</td>
<td>19,9</td>
<td>15,8</td>
<td>2272</td>
<td>10</td>
<td>0,54</td>
<td>500</td>
<td>90-97%  30-50%  5%  90%</td>
</tr>
<tr>
<td>Ethanol</td>
<td>26</td>
<td>21,2</td>
<td>1693</td>
<td>10</td>
<td></td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Ammonia (liquid -33 °C)</td>
<td>18,6</td>
<td>11,5</td>
<td>3121</td>
<td>70</td>
<td>0,65</td>
<td>600-700</td>
<td>100% Compliant with regulation &gt;95% &gt;90%</td>
</tr>
<tr>
<td>Hydrogen (liquid -253 °C)</td>
<td>120</td>
<td>8,5</td>
<td>4223</td>
<td></td>
<td></td>
<td>0,68</td>
<td></td>
</tr>
<tr>
<td>Marine battery market leader, Corvus, battery rack</td>
<td>0,29</td>
<td>0,33</td>
<td>108.787</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tesla model 3 battery Cell 2170*</td>
<td>0,8</td>
<td>2,5</td>
<td>14360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1: Given a 1000 m³ tank for MGO. Additional space for insulation is not calculated for in above diagram. All pressure values given a high pressure Diesel injection principle.

2: Values for Tesla battery doesn’t contain energy/mass obtained for cooling/safety/classification.
ME-GI and ME-LGI engines for future fuels
Combustion Principle - diesel cycle

1. From actual footage (colorized)
   - Yellow = pilot oil (0.5 to 5%* @100% load)
   - Blue  = fuel gas
2. Conventional slide fuel valve
3. Gas fuel valve
4. High pressure safety valve
5. Gas distribution channel (yellow)
6. Gas distributor block
7. Gas chain link double-walled pipes

*) based on main fuel selection
Solutions for retrofitting to alternative fuels
- Now adding Ammonia (NH3)

Future-proof engine Technology.
MAN B&W ME-C engines are future-proof and can be retrofitted to use LNG, LPG, Ethane, Methanol and Ammonia as fuel.

Proven track record of engine conversions.
In Service
- ME-GIE: 1
- ME-GI: 3
- ME-LGIP: 4

In process and on order
- ME-LGIP: 11

*Pictures courtesy of BW Gas. 15 VLGCs will be retrofitted to LPG propulsion with MAN B&W engines.
## Orders Including Options

<table>
<thead>
<tr>
<th>No. of engines</th>
<th>Engine type</th>
<th>Engine type</th>
<th>Mk.</th>
<th>Gensets</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>G 95</td>
<td>ME-C-GI</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>S 90</td>
<td>ME-C-GI</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>G 90</td>
<td>ME-C-GI</td>
<td>9.5, 10.5</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>G 80</td>
<td>ME-C-GI</td>
<td>9.5, 10.5</td>
<td>12 X 7L28/32 DF</td>
</tr>
<tr>
<td>2</td>
<td>S 80</td>
<td>ME-C-GI</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>S 70</td>
<td>ME-C-GI</td>
<td>7, 8.2, 10.5</td>
<td>6 x 9L28/32 DF</td>
</tr>
<tr>
<td>151</td>
<td>G 70</td>
<td>ME-C-GI</td>
<td>9.2, 9.5, 10.5</td>
<td>8 x 7L35/44 DF</td>
</tr>
<tr>
<td>2</td>
<td>L 70</td>
<td>ME-C-GI</td>
<td>8.2</td>
<td>15 x 9L28/32 DF</td>
</tr>
<tr>
<td>8</td>
<td>G 60</td>
<td>ME-C-GI</td>
<td>9.5, 10.5</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>S 60</td>
<td>ME-C-GI</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>S 50</td>
<td>ME-C-GI</td>
<td>8.2,8.5, 9.5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>G 50</td>
<td>ME-C-GI</td>
<td>9.5</td>
<td>8 x 7L28/32 DF / 4 x 5L28/32 DF</td>
</tr>
<tr>
<td>2</td>
<td>G 45</td>
<td>ME-C-GI</td>
<td>9.5</td>
<td>4 X 5L23/30 DF / 8 x 8L23/30 DF</td>
</tr>
<tr>
<td>23</td>
<td>G 50</td>
<td>ME-B/ME-C –LGIM</td>
<td>9.3, 9.5, 9.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>S 50</td>
<td>ME-B-LGIM</td>
<td>9.3</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>G 60</td>
<td>ME-C-GIE</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>G 50</td>
<td>ME-C-GIE</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>S 50</td>
<td>ME-C-GIE</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>G 60</td>
<td>ME-C-LGIP</td>
<td>10.5, 9.5, 9.2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>S 60</td>
<td>ME-C-LGIP</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>G 50</td>
<td>ME-C-LGIP</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>S 35</td>
<td>ME-C-LGIP</td>
<td>9.7</td>
<td></td>
</tr>
</tbody>
</table>

**Total dual fuel engines including options**: 374 engines

**Total power main engine**: 8.9 GW

**Total dual fuel 2-Stroke in service**: 158 engines
LPG as marine fuel

Fast uptake in LPG carrier sector

The industry standard

- Applied to almost 100% of Very Large Gas Carriers (VLGCs) ordered in 2020.
- Several references within handy-size and mid-size LPG carriers as well, however slightly slower transition compared to VLGCs.
How to reach TIER III

Available methods

<table>
<thead>
<tr>
<th>After-treatment</th>
<th>SCR, HP or LP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary method</td>
<td>EGR, HP</td>
</tr>
<tr>
<td></td>
<td>Water in methanol</td>
</tr>
<tr>
<td></td>
<td>ME-GA engines</td>
</tr>
<tr>
<td></td>
<td>Emulsion fuel</td>
</tr>
<tr>
<td></td>
<td>Water injection</td>
</tr>
<tr>
<td></td>
<td>Engine tuning</td>
</tr>
</tbody>
</table>

Possible NOx emission levels

Tier II

Tier III

SCR: selective catalytic reduction; EGR: exhaust gas recirculation
HP: high pressure; LP: low pressure
All data provided in this document is non-binding. This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.
Thank you very much
SEA-LNG
The commercial case for LNG

Tanker Shipping & Trade Webinar Week: The case for LNG and LPG fuelled tankers
11th May, 2021
Investment case for LNG is compelling
Modelled 300 K DWT VLCC

- Best ROI on NPV basis over conservative 10 year time horizon
- 3 to 5 years payback
- Diminishing CAPEX hurdle
- Competitive energy costs
- Enables incremental decarbonization, avoiding stranded assets
- Continuously expanding bunkering infrastructure

LNG can offer competitive finance advantage
Average of +7 years compliance with Poseidon Principle loan requirements

Source: LNG AVERAGES 7 EXTRA YEARS ADDITIONAL COMPETITIVE ADVANTAGE FOR POSEIDON PRINCIPLE LOANS, https://sea-lng.org/news-views/
LNG uptake as a marine fuel is accelerating

Tanker segment in the vanguard


KEY PORTS
- LNG BUNKERING AVAILABLE
- LNG BUNKERING UNDER DEVELOPMENT