# ALTERNATIVE FUELS – WHAT DOES THE FUTURE HOLD FOR SHIPPING?

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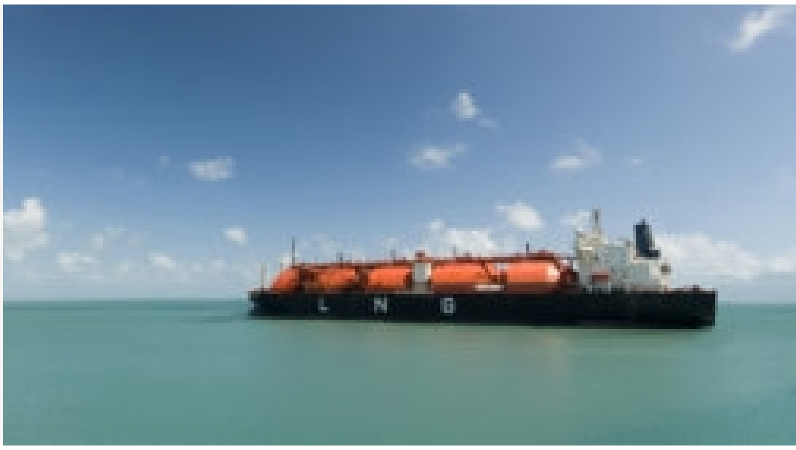
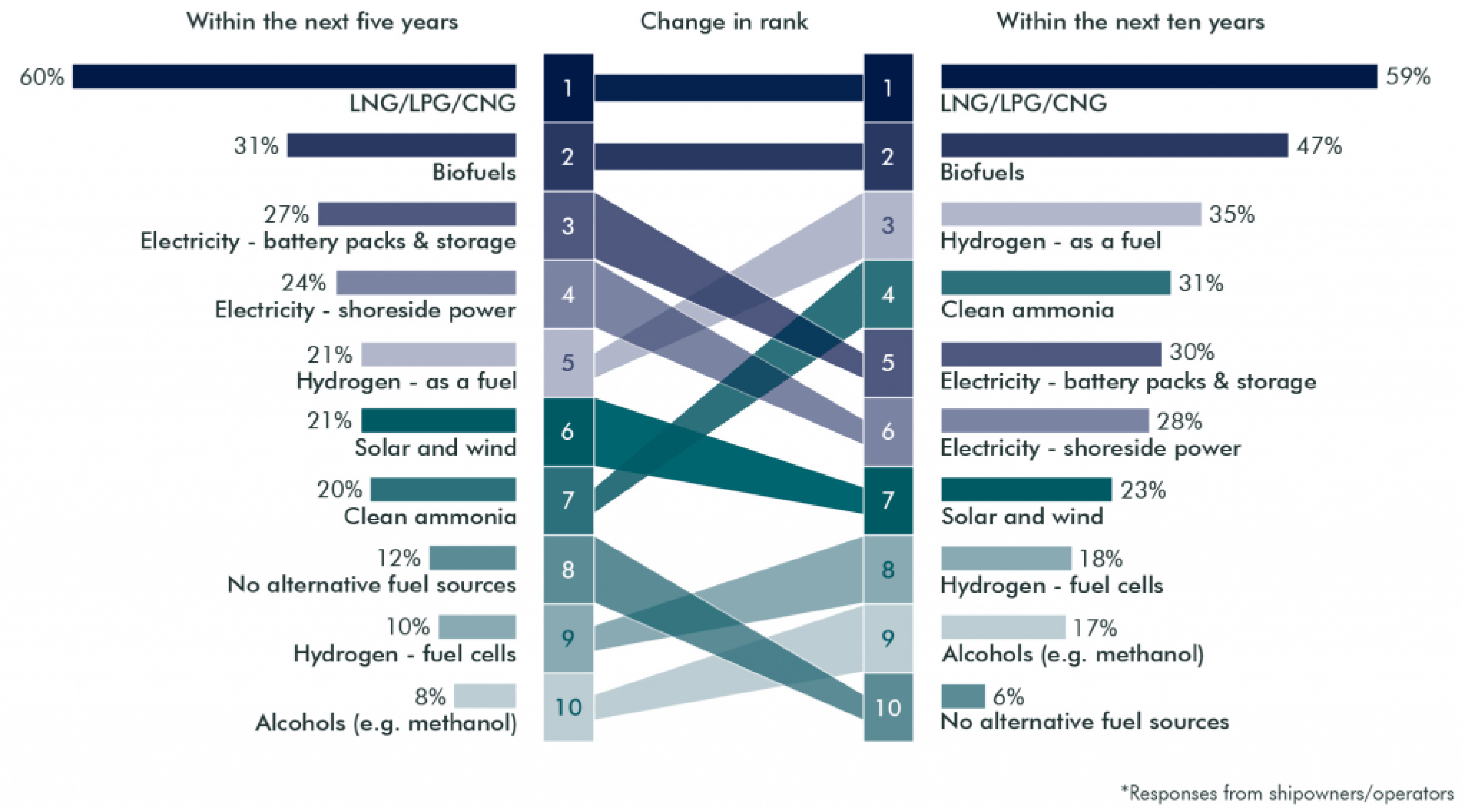


**The shipping industry has a vital role in a net zero carbon future. In response to the Paris Climate Accord, the International Maritime Organisation has set ambitious goals of halving greenhouse gas ("GHG") emissions by 2050, compared to 2008, while at the same time reducing carbon dioxide emissions intensity by 40% by 2030 and 70% by 2050.**

> "Fewer than a third of shipping operators plan to use any alternative to traditional bunker fuel or liquefied gas such as LNG or LPG in the next five years."

In our recent report "**The Sustainability Imperative – Part 1**" – which drew on a series of in-depth interviews and a global survey of 545 senior industry leaders – the results showed that fewer than a third of shipping operators plan to use any alternative to traditional bunker fuel or liquefied gas such as LNG or LPG in the next five years; possibly out of caution and a desire to avoid making what might turn out to be the wrong choice in a 20 to 30-year investment. That said, the report also indicated that, as one source commented, "other alternative fuels need to come after LNG and the industry needs to keep working on finding those future carbon-neutral fuels". It was also interesting to see from the report which of the alternative fuels are currently being considered by survey respondents as indicated in the diagram below.

## Alternative fuel sources being considered for future use




The following is a brief summary of possible fuels to replace heavy fuel oil ("HFO"). It seems clear that there will be a continuing need for liquid fuels for the deep sea fleet and for long sea passages as no other way to store large quantities of energy has yet presented itself. There are a number of additional solutions focussing on battery or hybrid technology that seem better suited to the short sea fleets as these have to travel less distance between potential recharging/refuelling stations. Those technologies and how they may change the current trading patterns will be the topic of a later article. While some of these fuels (and technologies) may eventually prove to be intermediate solutions, they remain an essential part of the industry's journey to its carbon neutral future.

## Liquified Natural Gas ("LNG")

Chemically, LNG is very close to natural gas, currently being used for domestic and industrial purposes. LNG is virtually sulphur-free as a result of its production process. Using LNG results in the near elimination of the sulphur from the exhaust resulting in better air quality.

LNG is stored in insulated tanks as its boiling point is -162°C at atmospheric pressure. While LNG has a higher energy density than HFO, it has a low volumetric density and this results in storage of LNG fuels taking twice the space of HFO. Due to the tanks' unique construction these can take up to three times the space of HFO storage. This can be an issue when considering a retrofitted LNG system.

Slippage is also a factor. Slippage occurs as a result of not all the fuel being burned in the combustion process of the engine or gas lost during transfer. A great deal of benefit of the lower CO2 release of this fuel when used as a fuel can be lost because of slippage. Methane (the main component of LNG) lasts for a shorter period in the atmosphere than CO2, but its impact as a greenhouse gas is approximately 25 times greater than CO2 over a 100-year period. As a result, there need to be technological advances to prevent slippage up and down the supply/consumption chain.

"LNG is currently not a complete answer to the marine fuels problem, though when combined with advances in carbon capture and other technologies that will inevitably develop in the future it does present itself as a strong contender. "

The infrastructure for LNG bunkering is continuing to rapidly improve and LNG is available worldwide, although, unsurprisingly, not as ubiquitous as HFO.

LNG technology is available today and more and more vessels are being delivered into service operating on LNG. LNG is currently not a complete answer to the marine fuels problem, though when combined with advances in carbon capture and other technologies that will inevitably develop in the future it does present itself as a strong contender. Certainly, at present it does provide a neat solution to some of the more pressing pollution issues and in particular air quality around port areas.

## Liquified Petroleum Gas ("LPG")

The term LPG is any mixture of propane and butane in liquid form. More commonly thought of as a by-product of the production of refining of oil, using it as a fuel provides a 16% reduction in CO2 emissions when compared with HFO on a like for like basis. Similar to LNG, the use of LPG largely eradicates sulphur emissions from fuel burn. LPG can be used in two and four stroke engines and also in gas turbines.

LPG also looks like an attractive alternative to solve the replacement of HFO but, as with LNG, there is the issue of slippage to factor in, although the warming potential of LPG is between three and four times higher than CO2.

Storage of LPG is either pressurised or refrigerated. The simpler and preferred solution is to store the fuel under pressure. Pressurised storage is simpler to install when the LPG plant is being retrofitted. As with LNG, LPG storage requires larger tanks.

There is currently less infrastructure for LPG than for LNG but as this fuel becomes more commonly used, this may change. LPG can be bunkered with shore connections but can also be transferred by ship to ship bunkering.

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## Methanol

Methanol has the lowest carbon content and highest hydrogen content of any liquid fuel and has the benefit of liquid storage at atmospheric pressure. It can also be used in two and four stroke engines. Methanol is also widely available with 88 of the world's largest 100 ports being able to supply.

Production of methanol is mainly from natural gas or coal but is also from renewable resources like agricultural waste, paper mills and black liquor from pulp. Considering the entire life cycle (well-to-wake) of methanol including the production of the fuel from natural gas, the total carbon dioxide emissions are similar or slightly higher than the corresponding emissions of oil-based fuels – this is much higher for production of methanol from coal. However, methanol is considered a clean-burning fuel that produces low GHG emissions (SOx, NOx and particulate matter) and as maritime fuel is compliant with the requirements of the strictest emission control areas.

Standard fuel tanks used for storing HFO or marine diesel can be used for storing methanol, but they require certain modifications mainly because of its low flashpoint. Around two and a half times the space is required for storing methanol on account of its low energy density.

## Hydrogen

Hydrogen is non-toxic gas and is therefore seen as a real alternative to fossil fuel or carbon-based alternatives. There is some debate in the scientific and engineering communities as to how viable hydrogen is as a clean fuel but it seems one of the solutions with the longest-term future. Hydrogen is also seen as a new technology with fuel cells being the preferred solution to the combustion engine.

When hydrogen is used on ships as fuel it can be stored as a cryogenic liquid, compressed gas or chemically bound as hydrogen's boiling point is very low. Hydrogen produces zero carbon dioxide emissions when used in fuel cells as converter of energy and could eliminate emissions of GHG (NOx, SOx, particulate matter) from ships. The use of hydrogen with internal combustion engines could also eliminate GHG other than NOx as NOx is always a by-product of combustion in a combustion engine.

Hydrogen's energy density is approximately three times that of HFO but the volumetric density significantly lower. Consequently, the liquefied hydrogen when stored takes up approximately five times the space of the same energy stored in HFO. Where hydrogen is stored as compressed gas the same ratio increases to 15 times the volume of HFO. Hydrogen is also the smallest molecule in the universe and can leak through the tiniest of gaps.

Hydrogen is most commonly used in the transportation sector by reforming natural gas. If the CO2 produced from such reform could be captured, hydrogen could provide shipping a zero-emission solution. The same outcome can be achieved if hydrogen is generated using renewable or nuclear produced energy.

> "Currently there is no hydrogen bunkering infrastructure for ships on a global level because of the very low demand."

Currently there is no hydrogen bunkering infrastructure for ships on a global level because of the very low demand. The technology for producing hydrogen from electrolysis is known and readily available and therefore could be applied in ports provided that there is sufficient non-carbon electrical power to sustain the production process.

For more information on hydrogen, please see our hydrogen series **here**.

## Ammonia

Ammonia is also carbon free, though at present it is mainly produced from fossil fuel-based hydrogen. However, advances in the production of ammonia may allow for the production of renewable ammonia sometime in the future. If ammonia could be produced from renewable energy sources, itcould present another renewable fuel solution.  Like Hydrogen, it requires a rethink of current engine technology.

Ammonia's energy density is lower than the carbon-based alternatives. In liquid form and at atmospheric pressure it can be stored at -33.4°C solving some of the storage problems when compared with hydrogen. At a storage temperature of 20°C, the storage pressure would only require 10 bar.  Unfortunately, ammonia is a more difficult substance to store and use, it is highly toxic and corrosive and requires fuel storage and transfer systems constructed from stainless steel and Teflon seals.  This presents a series of challenges not least from a health and safety perspective.

The relatively low energy density of ammonia means higher storage volumes but only around two and a halftimes more than HFO.

One potential solution to the energy density issues is the mixing of ammonia with hydrogen, which has higher energy density. The position in respect of distribution and available technologies relating to ammonia are similar to those of hydrogen.

There is little to no bunkering infrastructure at the moment for ammonia as there is no commercial demand and the shipping industry will need to overcome the storage and transfer challenges where others have failed. However, many sector participants are taking a hard look at ammonia.  As the expression goes, "watch this space"!

## Conclusion

It is clear that no one fuel currently presents a complete solution.  Those listed above that currently have widespread commercial application reduce, but do not eliminate, carbon emissions from their use.  Some critics even go as far as to say they pose a greater risk because of the warming effect of intentional and unintentional escapes of the fuel.  Hydrogen and ammonia which appear to be cleaner alternatives for the future are not yet ready for widespread commercial implementation and that day seems some way into the future.

> "It is clear that no one fuel currently presents a complete solution."

Evidence on climate change means that action to use an alternative fuel source is required immediately. Still in question is who should take the lead in funding research into alternative fuels and other efficiencies for shipping; in our report almost half of survey respondents took the view, which was broadly shared across financiers and operators in all regions, that it falls to governments to take the lead on this. In the absence of a clear single solution and given the range of options (none of which are particularly complementary), the industry would benefit from at least incentivisation and guidance (if not more) as to the choice to make. A swift move towards an interim 'transition' (or 'transitions') whose benefits outweigh the disadvantages, and which did not inhibit the implementation of an ultimate solution would surely be beneficial if it could be achieved

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