SEA-LNG

LNG - THE ONLY VIABLE FUEL

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LNG AND THE PATHWAY TO SHIPPING INDUSTRY DECARBONISATION

The global shipping industry is facing a period of unprecedented change. Only last year ship-owners and operators were struggling with how to respond to the introduction of the IMO's sulphur cap – a "once in a decade" challenge. Having successfully negotiated the SOx hurdle; the industry has scarcely had time to draw a breath as climate change has risen rapidly up the regulatory agenda. This change is both at the IMO, with the ongoing implementation of its Greenhouse Gas (GHG) Strategy, and on the European stage with the introduction of the far-reaching Green Deal. And on top of this, COVID-19 has caused a massive shock to the global economic system with unknown long-term consequences.

Not only is the regulatory landscape changing rapidly, but new technology developments are being announced almost every week. Academics and industry commentators are making claims for different decarbonisation pathways, and new industry coalitions are springing up like mushrooms. Too often the decarbonisation debate seems to descend into "my solution versus your solution". The art of the possible or practical appears to be forgotten, especially in the area of international maritime operations and regulation.

The understandable response of the shipping industry to this confusing situation is to pause and assess.

Waiting for a "utopian solution" risks locking the maritime industry into the highly polluting conventional oil-based marine fuels for years, if not decades, to come.

LNG IS THE ONLY VIABLE SOLUTION TODAY

Today, and for the foreseeable future, LNG is the only viable fuel for deep-sea ocean shipping which improves both air quality and GHG performance.

The global health benefits resulting from the use of LNG as a marine fuel are well known and accepted. LNG-fuelled vessels emit virtually no SOx while dramatically limiting emissions of NOx. It also virtually eliminates particulate matter, including black carbon or soot, which while not yet regulated, is an environmental concern.

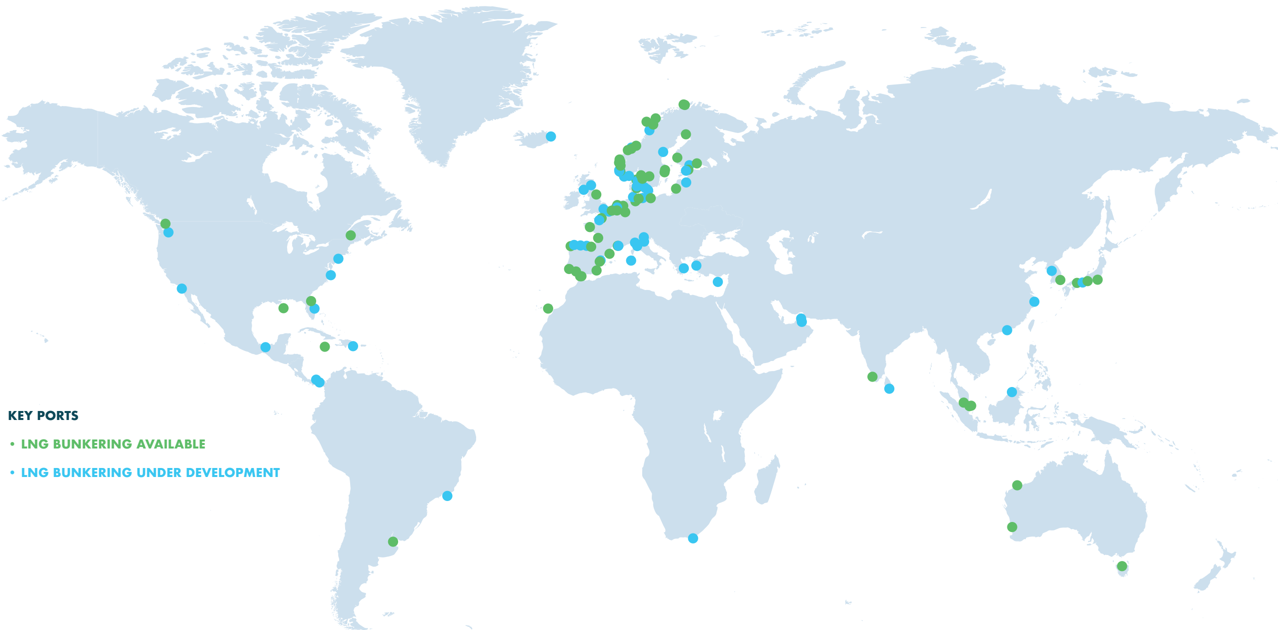
Regarding GHG emissions, the use of LNG in the maritime sector can reduce GHG reductions up to 21% compared with current oil-based marine fuels over the entire life cycle from Well-to-Wake, including methane emissions[1]. This means that when combined with Energy Efficiency Design Index (EEDI) improvements to ship design, LNG will likely meet the IMO 2030 decarbonisation target for new build vessels.

Methane slip in marine engines is receiving much attention in relation to the GHG benefits of LNG as a marine fuel. Slip is often misleadingly characterised as an irremediable design flaw. This is NOT correct. Engine manufacturers recognise slip as an issue for certain types of internal combustion engines but not for all of them. It is important to note that LNG-fuelled engines were originally developed in the 1990s to address local emissions, i.e. NOx and SOx. GHG emissions were not an area of focus at the time. Since then, levels of methane slip, where applicable, have been reduced by a factor of four[2] and engine manufacturers continue to invest in R&D to further reduce the slip in response to both commercial and regulatory pressures. Hence, the LNG-fuelled vessels being built today have much lower levels of methane slip than that which is often cited in academic studies which are based on older engine technologies and outdated data. The 2019 study which SEA-LNG commissioned used the most current data available. The engine manufacturers are on a pathway to continue to reduce methane slip even further[3] by working on more design changes and the implementation of advanced combustion algorithms.

For example, MAN Energy Solutions state they have reduced emissions from their four-stroke engines by half in a decade. In addition, they indicate that engine design changes together with new solutions for post-treatment and the transfer of technology from high-performance two-stroke engines to four-stroke engines has the potential to reduce methane slip by a value greater than 90 percent. Fellow marine engine manufacturer Wärtsilä have said methane slip from their dual-fuel engines has been slashed by 75% over the past 25 years and further advances will drastically reduce it gain over the next three years. WinGD has just announced a technology improvement that will reduce methane slip in their 2-stroke low-pressure internal combustion engine by 50%, a significant breakthrough.

Unfortunately, the recently released IMO 4th Study on GHG Emissions relies in part on 2018 and prior data, therefore it does not fully recognize the aggressive work that has been done in the area of slip.

WORLDWIDE GROWTH IN LNG INFRASTRUCTURE

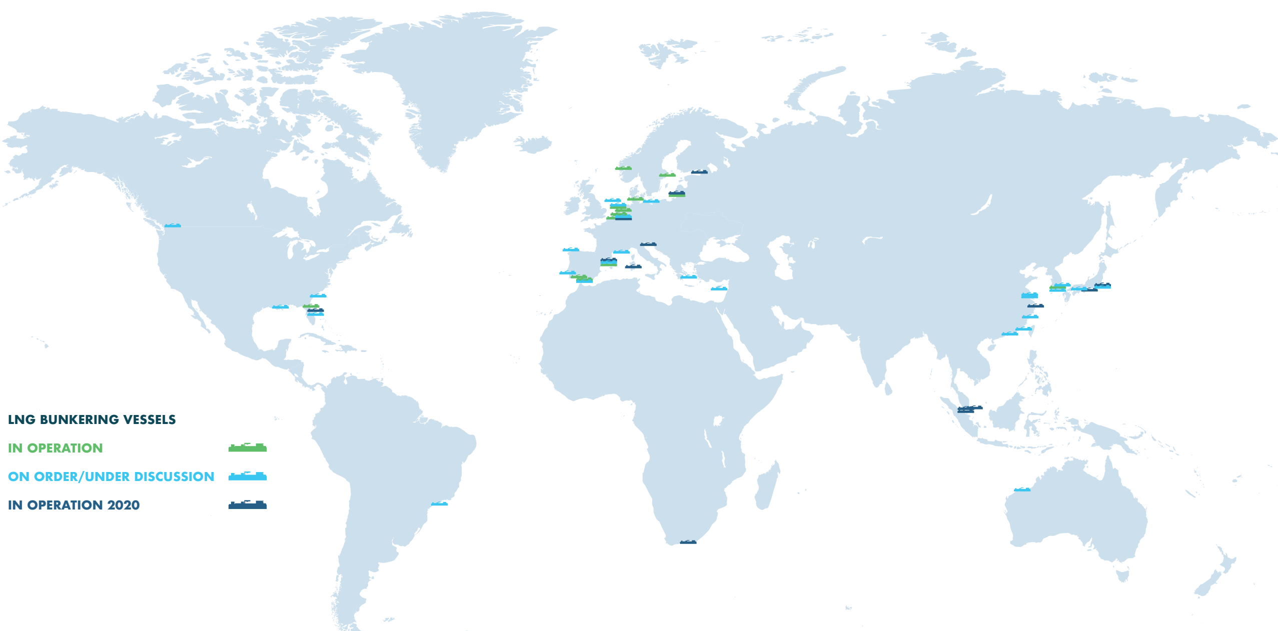


LNG's accelerating adoption as a marine fuel is driven by increasing recognition of its commercial and operational viability. The investment case is robust. It is based upon independent modelling of the economics of LNG-fuelled vessels across a variety of different vessel types and trade routes using publicly available data on CAPEX. The cases show that LNG provides a compelling business case for ship-owners when compared to conventional marine fuels. LNG as a marine fuel currently delivers the best return on investment on a net present value (NPV) basis over a conservative 10-year horizon compared with low sulphur fuel oil, with paybacks varying from less than one year to five years and CAPEX for LNG engines, fuel systems and storage tanks continues to fall[4].

4 August 2020 launch of MV Ecobunker Tokyo Bay (picture courtesy of YKIP)

LNG is a global commodity with 21 countries exporting to 42 importers. The bunkering infrastructure to support LNG as a marine fuel continues to snowball. LNG bunkering facilities are now established in 118[5] ports and under development in 90. This includes most of the leading oil bunkering locations. Ship-to-ship bunkering is upscaling dramatically. In early 2019 there were just six LNG bunkering vessels in operation; five in Europe and one in North America. As of July 2020, this has grown to 13 with a further 28 on order and/or undergoing commissioning.

WORLDWIDE GROWTH IN LNG BUNKERING VESSELS



Geographies such as Brazil, China, Japan, Malaysia, Singapore, South Korea and South Africa are all developing bunkering solutions, the majority due to come into service within the next two years.

LNG's key attribute is its safety. LNG is easy to transport, poses minimal risk to marine environments, has a low flammability range and is non-toxic. Effective regulations, standards and guidelines for safe operations are widespread, and LNG has been shipped around the world for 50 years without any major incidents at sea or in ports.

ALTERNATIVE FUELS ARE UNLIKELY TO BE READY FOR DECADES

Some "zero-emissions" fuels such as hydrogen and ammonia are actively promoted despite being, at this stage, nothing more than conceptual solutions or early-stage pilots. There are a whole range of safety, environmental and technical issues to be addressed before these, or any other, alternative fuels and technologies are ready for use in the marine environment. There are serious questions and implications for cost, safety and the practical role that alternatives can play in decarbonising the shipping industry in the next few decades.

With respect to safety, hydrogen is highly flammable, and ammonia is extremely toxic and the effects of "ammonia slip" are yet to be considered. These attributes have significant implications for vessel operations, safety aboard vessels and in port communities, and public acceptance.

In terms of technical and environmental challenges, hydrogen and ammonia fuel storage and propulsion systems are at very low technology maturity levels[6] with a variety of extremely challenging issues to be resolved. Liquid hydrogen has a low energy density, needs to be contained at extremely low temperatures (-251 degrees Celsius), requires large storage tanks and specialised materials. As a fuel it can only be purged with helium which creates another level of complexity and costs. Ammonia combustion in an internal combustion engine can produce significant emissions of nitrous oxide (N2O), a greenhouse gas with a global warming potential of 265-298 times greater than CO2 on a 100-year basis. It also produces NOx, a potent local pollutant. Ammonia slip remains an issue to be quantified and addressed. Because of its narrow flammability range when used in an internal combustion engine, Ammonia requires an undetermined percentage of pilot fuel with potential implications for GHG emissions. Finally, there has been no comprehensive Well-to-Wake analysis performed on any of these alternative fuels as there has on LNG. Without these studies, we cannot effectively compare the long-term environmental attributes of these or other alternatives.

An additional challenge, but critical, associated with putting vessels fuelled by hydrogen and/or ammonia on the water by 2030 will be the parallel development of the associated fuel-supply chains and bunkering infrastructure. This will take time and represent a significant cost burden. All previous marine transitions, i.e. wind to coal; coal to oil; and now oil to LNG have leveraged already mature fuel supply chains, which are not available for these new and untested fuels.

This challenge is emphasised by the recent UMAS / Energy Transition Commission study[7], focusing on hydrogen and ammonia pathways.

Estimated that of the $1-1.4 trillion investment needed to reduce the shipping industry's GHG emissions by 50% by 2050, in line with current IMO targets, only 13% relates to ships themselves. 87% of this enormous cost is needed to construct the land-based infrastructure and production facilities for low carbon fuels.

There is little evidence that other industries consider ammonia as a viable future fuel option. For that reason, if shipping were to select ammonia as its dominant fuel, infrastructure costs would likely be borne entirely by the shipping industry.

SEA-LNG supports a mix of alternative future marine fuel systems, but the solutions cannot be prescriptive. We must set goals then develop realistic, affordable and deployable solutions that are viewed on a comprehensive Well-to-Wake basis. Without Well-to-Wake benchmarks and agreed parameters we cannot be sure that we are evaluating all possible solutions on a common and equitable basis. We must be cognizant of the unintended consequences of certain actions which can create long-lasting safety and operational issues.

ZERO-EMISSIONS SHIPS ARE ON THE WATER NOW

Many organisations are focused on developing commercially viable zero-emissions vessels to operate along deep-sea trade routes by 2030.

Liquefied Bio Methane (LBM) and Liquefied Synthetic Methane (LSM) as fuels in existing LNG vessels the Industry is getting very close to reaching that goal today as witnessed in recent small scale tests.

Our recent study by CE Delft found that large scale LBM supplies could be available in 2030s and we know that they are already available as a fuel in smaller quantities at various global locations.

This pathway to a decarbonised deep-sea shipping industry has already been demonstrated, and it works! In June 2020 in Raahe, Finland, Gasum bunkered ESL Shipping's dry bulk carrier, m/s Viiki, a dry bulk carrier, with 100% renewable LBM to transport iron ore for the Swedish steel company SSAB. Later this year, Wessels Marine will be piloting the use of LSM in its LNG-fuelled container feeder-ship, Wes Amelie. The LSM will be supplied from a new liquefaction plant being built at car manufacturer Audi's power-to-gas factory in Wertle in north Germany.

World's largest liquefied bio-methane LBM plant in Skogn, Norway (picture courtesy of Biokraft)

While still niche products the recent study[8] commissioned by SEA-LNG from CE Delft concludes that LBM and LSM are scalable solutions for the maritime sector. Estimated sustainable global supplies potentially exceed the future energy demand of the global shipping fleet. It also showed that LBM and LSM will likely be commercially competitive relative to other low- and zero-carbon fuels. This analysis is supported by a recent report by the IEA[9] on the outlook for biogas and biomethane. The IEA report concludes that feedstocks available for sustainable production of biogas and biomethane are huge, but only a fraction of this potential is used today. Clearly, future policy will play a key role in allocating biomass resources to the hardest to abate sectors such as shipping, aviation and plastics.

LBM has other advantages when it is produced from domestic and agricultural waste. The process can capture methane that would otherwise be vented into the atmosphere, resulting in a fuel that is not just zero GHG emissions but actually has the potential for negative emissions. By assisting with the reprocessing of waste materials, we can support the circular economy and help abate yet another global concern, waste management.

LNG CAN ACCELERATE DECARBONISATION

The shipping industry needs to shift its perspective on decarbonisation. The recent IMO GHG study reinforces this premise. However, the discussion should be an "and" not an "or" discussion. The scale of the challenge means that all future fuel options need to be on the table and, the pathways towards them must recognise synergies between the different fuel choices. As noted earlier, solutions cannot be prescriptive. Rather, they should set policy guidelines which include clear, well defined scientific parameters and benchmarks for the reporting of progress.

LNG dual-fuel engines can accelerate decarbonisation of the shipping sector. Not only do they enable significant GHG reductions to be achieved now but, they offer the industry a realistic decarbonisation pathway.

This pathway has been proven with little or no modifications through the use of LBM and, in due course, LSM as drop-in fuels. These fuels can be transported, stored and bunkered in ports utilising existing LNG infrastructure.

Dual-fuel internal combustion engines are incredibly flexible and offer ship owners optionality and future fuel choice. In addition to providing a potential pathway to zero emissions via LBM and LSM, the same engines could use a small percentage of hydrogen as a drop-in fuel with minimal, if any, retrofitting. They could also be converted to use other synthetic fuels if they become viable in the future, thereby ensuring the assets are not "stranded."

This pathway is consistent with the analysis that organisations leading the thinking on the way forward for global decarbonisation are developing. For example, the influential Energy Transitions Commission states in its 2018 report[10] on harder to abate sectors, Mission Possible: *"In the shipping sector, economics and technical feasibility argue strongly in favor of 'drop-in' fuels which can be used in existing engines."*

LNG fuel tanks and bunkering infrastructure have the potential for retrofit to future fuels. The current development and roll-out of safety and operational guidelines for LNG as a marine fuel acts as a best practice for the adoption of future alternative marine fuels when and if they become practical. It will also create industry capacity, i.e. a workforce trained in handling more challenging cryogenic and gaseous fuels.

In summary, the industry must act NOW, not wait for untried and theoretical solutions that may or may not be realised in future decades. Waiting is not a plan designed to solve a serious matter.

By investing in LNG dual-fuelled vessels, the shipping industry is beginning the decarbonisation process now, creating a direct pathway to significantly lower carbon emissions and facilitating the introduction of zero-carbon alternative fuels as and when they become commercially and operationally viable.

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