How will bio-LNG stack against other marine fuels in shipping's race towards sustainability

Hit the (bio)gas

by Steve Esau, *COO, SEA-LNG*

The bio-version of liquefied natural gas (bio-LNG) can meet a significant proportion of future shipping demand and will be among the cheapest sustainable alternative marine fuels. In its pure form, bio-LNG could cover up to 3% of the total energy demand for shipping fuels in 2030 and 13% two decades later. As a drop-in fuel blended (20%) with fossil LNG, it could cover up to 16% and 63% of the total energy demand in 2030 and 2050, respectively.

That is one of the key predictions made in a new independent report conducted by Nanyang Technological University's Maritime Energy and Sustainable Development Centre of Excellence. The report also forecasts that the average cost for delivered bio-LNG will fall by 30% by mid-century vs today's values, mainly driven by the reduced expense of producing biomethane in large-scale anaerobic digestion plants. This makes bio-LNG one of the cheapest sustainable alternative marine fuels, compared to biomethanol and electro-fuels, including e-ammonia and e-methanol.

The study, commissioned by SEA-LNG, confirms that bio-LNG has considerable potential as a solution for the decarbonisation of the shipping sector thanks to the mature and commercially available technologies for fuel production and use onboard, existing delivery infrastructure, plus its competitive cost compared to other sustainable biofuels and electro-fuels.

Growing demand – and supply

The LNG-fuelled fleet is growing rapidly, with vessels propelled by dual-fuel engines representing some 38% of all tonnage on order. Owners and operators of gas-fuelled ships worldwide (such as CMA CGM, Furetank, Baleària, TT-Line, UECC, Tote, and Harvey Gulf International) have all used bio-LNG bunkers in response to upcoming regulation and customer demand.

We are already seeing a growing number of strategic collaborations driving the development of bio-LNG production forward: Scandinavian Biogas, for example, has just signed a multi-year agreement worth approximately three hundred million Swedish crowns for the supply of liquid biogas to the transport sector in the Nordic region. Energy company St1 has made an investment decision to construct a biogas upgrading & liquefaction refinery in Sweden after securing long-term off-take contracts, while Latvia's Agrofirma Tervete to supply equipment for a bio-LNG production plant in the Latvian Tervete. Meanwhile, Gasum's network already counts 17 biogas plants across Finland and Sweden, with the company regularly supplying bio-LNG bunker to regional players.

Sustainable sources

Bio-LNG is derived from the liquefaction of biomethane. This gas is produced from the degradation of second-generation biomass, including non-food energy crops, agricultural residues, manure, biowaste, and wood and forestry waste. As a second-generation fuel – unlike most biodiesel – its production will not interfere with food, fodder or fibre supply chains, and its production avoids land use changes.

Importantly, when manure is used as a feedstock, biomethane production avoids releasing methane emissions into the atmosphere. Current management practices involve using manure as a fertiliser on crop fields, where it decomposes, venting methane into the atmosphere.

In general, bio-LNG can reduce greenhouse gas emissions by up to 80% vs marine diesel – if methane leakage in the production process and onboard methane slip are minimised. In the case of bio-LNG produced from anaerobic digestion of manure, if avoided emissions are considered, then bio-LNG can achieve negative emissions ranging from -121% to -188% compared with diesel.

Cost comparison

Although the cost of bunker bio-LNG is relatively high compared to fossil fuels, it is cheaper than most other alternative fuels. In the best-case scenarios, where biomethane is produced from manure and agricultural residues in Asia and delivered to major eastern ports, the cost of bio-LNG could fall to $20/GJ by 2030 and $15/GJ by 2050. Sustainable biofuels such as UCOME made from waste cooking oil are generally cheaper. Still, feedstock availability is low. Biomethanol and bio-LNG have similar costs per unit of energy, with the former being slightly more expensive due to the gasification technology required in its production.

Electro-fuels will be significantly more expensive than biomass-derived fuels. Among these e-fuels, liquid e-hydrogen has the lowest production costs; however, its high transport and delivery costs make it the most expensive bunker fuel. The production costs of e-methanol and e-LNG are similar and have comparable costs for transport and bunkering per unit of energy. It should also be remembered that while a gallon of methanol is cheaper to store and transport compared to an equivalent volume of LNG, it carries far less energy due to its lower energy density.

E- ammonia is generally cheaper to produce as, unlike e-methanol and e-LNG, its production does not require CO_2. That said, there are major uncertainties about fuel handling systems and engine technologies, which are only at the research or pilot stage. Further data on onboard conversion system costs and efficiency are needed before e-ammonia's cost competitiveness can be determined.

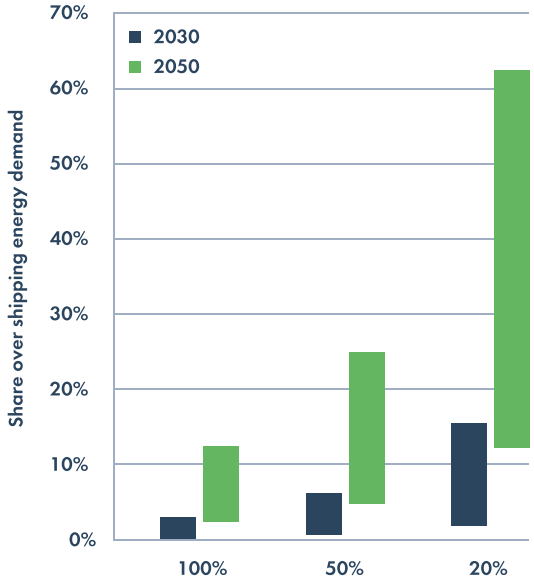
Future availability

The adoption of bio-LNG in shipping will be linked to the widespread use of biomethane across other sectors to grow the overall supply pool. It will require regulation in two key areas. Firstly, national and international standards for biomethane injection into gas grids. Secondly, a commonly accepted, preferably legally binding, certificate of origin scheme to facilitate efficient trading in biomethane in its gaseous and liquefied forms and reduce transportation costs.

Logistics considerations

The upstream production costs of biomethane can be reduced by optimising the size and location of future biomethane plants by reducing the cost of biomass collection and transport. The best-case scenario is represented by medium-sized plants close to farms and biomass waste collection points, such as cities for food waste and slurry, animal farms for manure, and agricultural sites for residues.

Fig. 1. Potential availability of bio-LNG for the shipping sector in 2030 and 2050 over total shipping energy demand, with different blending rates with fossil LNG



Source for all figs.: SEA-LNG

Fig. 2. Scheme for the evaluation of bio-LNG availability for shipping

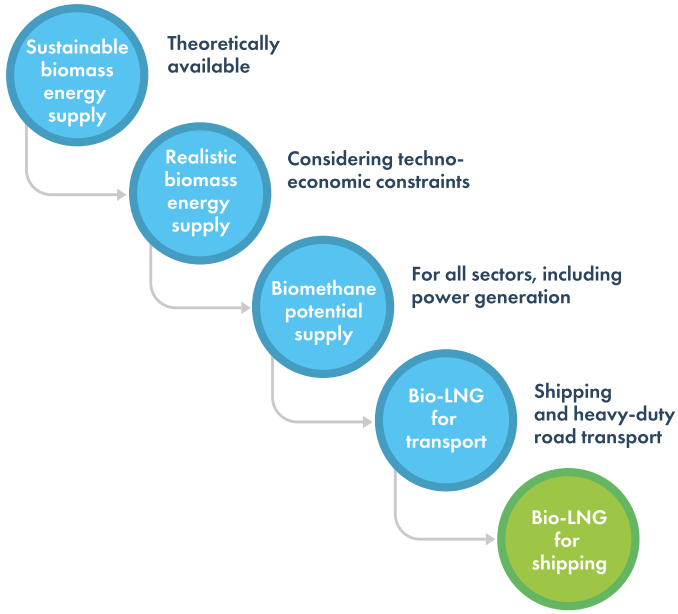


Fig. 3. Bio-LNG from anaerobic digestion total cost range in 2020, 2030 and 2050, compared with fossil LNG bunker price

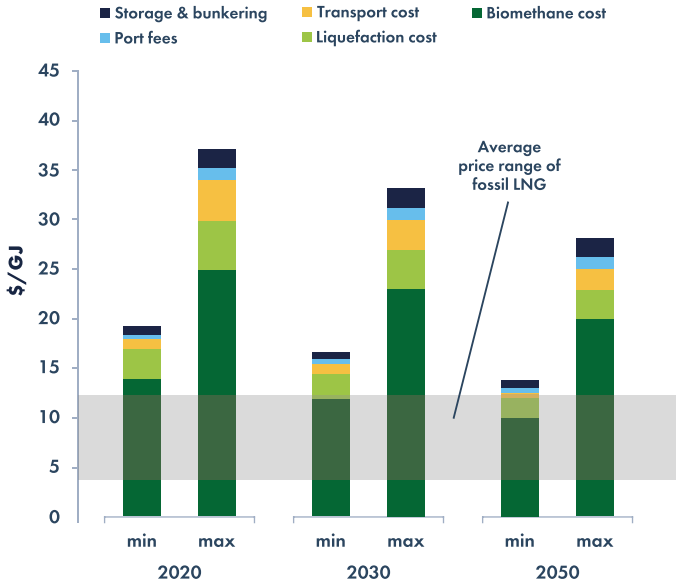
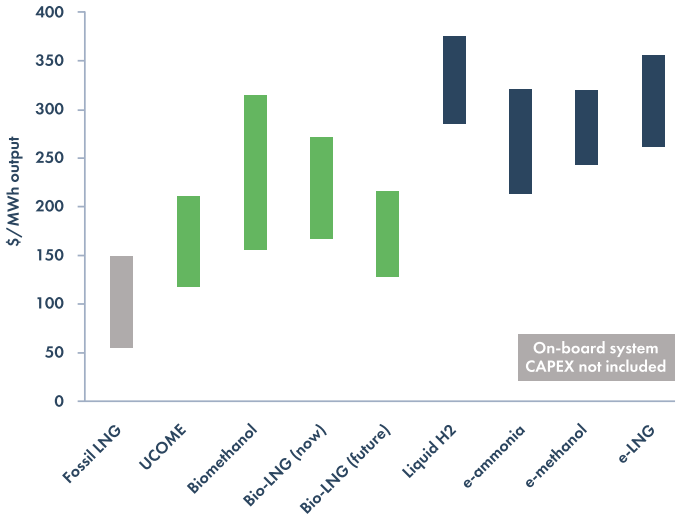


Fig. 4. Alternative fuels energy cost comparison (per unit of output energy from the engine)[1, 2, 3]



[1] *Including transport & bunkering costs (bio-LNG and e-LNG transport cost is based on fossil LNG, thus implying the use of existing infrastructure)*
[2] *Assumed engine conversion efficiency: 45% (50% for liquid hydrogen used in a fuel cell)*
[3] *The higher and lower ends of the spectrum represent 2030 and 2050 costs, respectively*

Dedicated supply chains for shipping involving on-site liquefaction and transport of bio-LNG by trucks and bulk carriers are appropriate for demonstration purposes. Still, they do not make economic sense for large-scale implementation due to very high infrastructure costs. Utilising existing LNG infrastructure and logistics should therefore be incentivised.

The lowest costs are achieved when biomethane is injected into the gas grid and virtually transported to liquefaction plants and LNG terminals using existing infrastructure and instruments such as Green Gas Certificates and Biomethane Guarantees of Origin for trading. This would require an appropriate regulatory framework like that already in place for green electricity in some regions of the world, including Europe.

Part of the mix

The global shipping industry faces unprecedented challenges as the pressure to meet climate targets grows. Over the next couple of decades, alternative fuels and propulsion systems may emerge. However, LNG is, for the moment, the only commercially viable and scalable alternative marine fuel, offering the shipping industry a low-risk and incremental pathway to decarbonisation, starting now and continuing through bio- and e-LNG into the future. ■

SEA-LNG Founded in 2016, with numerous high-profile members including shipping companies, ports, LNG suppliers, bunkering companies, infrastructure providers, original equipment manufacturers, classification societies, banks, and brokers, SEA-LNG is a multi-sector industry coalition whose members work together to demonstrate the benefits of LNG and its variations as a marine fuel throughout the entire value chain. Head to **sea-lng.org** for more info.