LNG as Marine Fuel

Hype or valuable option to reduce air pollutant and greenhouse gas emissions?

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Over the past years the reduction of air pollution and greenhouse gas emissions finally became one of the top priority issues for the shipping community. Although ships today are considered a comparatively climate-friendly mode of transport regarding their carbon dioxide (CO_2) emissions per tonne-kilometre, their overall environmental performance is significantly worse due to the massive release of harmful air pollutants such as sulphur dioxide, nitrogen oxides and particulate matter including black carbon. LNG (liquefied natural gas) is currently discussed as a solution for the sector's air pollution problems. LNG reduces the amount of air pollution significantly and already is in line with future regulation on the horizon – be it the implementation of further Sulphur Emission Control Areas (SECAs) or a global sulphur cap of 0.5 percent from 2020 on. However, vital questions on the environmental performance, life-cycle analysis and infrastructure have not been addressed adequately. This publication reflects a holistic assessment of the technology and its impacts for climate, health and the environment.

Today's predominantly used marine fuels, heavy fuel oil (HFO) and even marine gas oil (MGO) with lower sulphur contents have an enormous environmental impact as they cause lots of exhaust gases while oil spills and illegal oil dump to the ocean lead to severe eco system damages. Therefore, it is crucial to find alternatives to ensure the sustainability of shipping as the central transport mode of the globalized world economy. This challenge has not only been taken by progressive parts of the maritime industry but also put new players on the plan. Since some years numerous stakeholders like ship owners, engine manufacturers, port authorities or gas suppliers seek to establish LNG as an alternative fuel. However, some environmental concerns have not been addressed adequately in the current discussion yet.

NABU acknowledges that the utilisation of LNG bears the potential to significantly reduce health, climate and environmentally harmful emissions from shipping. Sulphur oxides, particulate matter and heavy metal emissions can be avoided almost entirely. Nitrogen oxides and ultrafine particles can be significantly reduced compared to the use of heavy fuel oil or marine diesel. Nevertheless, there are still doubts about the overall ecological performance of LNG. First, the frequently emphasized improvement regarding the greenhouse gas balance is questionable. Depending on the respective supply chain and the ship's engines, it can even turn out negative in the worst case scenario. This is because LNG primarily consists of methane, which has a global warming potential (GWP) that is approximately 30 times higher compared to CO_2. Therefore, it must be ensured that the methane leakage is as limited as possible along the whole process chain of extraction, procession, transport, bunkering and combustion. In addition, LNG is still a fossil fuel and accordingly is not a proper way to limit the transport sector's emissions by around 95 percent until the year 2050 which is required to stay well below the 2 degree target adopted in the Paris Agreement. As a consequence it has to be substituted by renewable energies as soon as possible. Finally natural gas is sometimes gained by the questionable extraction method of fracking, which causes severe environmental damage.

Methane Slip

Escaping methane leakage is called methane slip. Only if this slip can be widely limited, the GHG balance of LNG is advantageous over the use of heavy fuel oil or diesel. Based on the heating value the combustion of methane causes about 28 percent less CO_2 compared to diesel. Unfortunately, this is more a theoretical technology potential than today's standard in place and therefore the average GHG benefit is estimated to be only as good as 8 percent. In some cases it even is slightly negative by about 5 percent compared to MGO and residual oil (ICCT 2013). From NABU's point of view it is consequently inevitable to employ a well to propeller approach in order to evaluate a marine fuel's environmental performance in a fair and useful way. Otherwise it may only result in emission shifts to other elements along the process chain but not actual GHG reductions. Regarding LNG such an approach results in the immediate need to check the fuels sources and to limit methane leakage at any time. Latest reports have shown that especially bunkering operations and the engine's design concept play a crucial role here (MARAD 2015; DLR/IFEU 2014). LNG is highly compressed and cooled to -162° Celsius. It has only about one six-hundredth the volume of gaseous natural gas. The combustion of the gas in conventional or dual-fuel engines always creates some methane slip, which can be minimized by discerning control. Supplementary, catalysts could be used to avoid methane emissions.

The greenhouse gas balance of LNG can be better compared to heavy fuel oil by up to 28%. But it can be even worse, depending on supply chain, fueling technology and engine.

Purposes of LNG

Besides the use in sea-going vessels LNG can be used in trucks, buses, inland shipping and for power generation. Power generation is today's main purpose of LNG, and this especially comes into play when the customer cannot be supplied via pipeline. Consequently, 80 percent of today's LNG production goes to Japan, South Korea and Taiwan. Future LNG world market prices and demand are expected to stay depended on these established markets to a great extend.

For LNG carriers propulsion by gas engines is obvious, as for the cooling of the stored LNG a natural slip from the tank is required anyway. Instead of flaring this methane slip which would mean a complete waste of energy it is used for fuelling the carriers engines. Next to this, LNG is also used in other ship types due to stricter environmental regulation in some regions like northern Europe and Northern America. Today a few hundred ships, in particular in Norway, are using LNG. Further retrofits and new-builds are under construction and ordered. Especially in the field of merchant shipping, the use of LNG faces obstacles because of its advanced space demands following an energy density for LNG that is about half of diesel. This means that considerably larger tanks are required on board. Especially for long-haul transport, such as the important route from East Asia to Europe larger tank volumes would result a severe loss in cargo.

Green LNG

In principle, LNG could be produced from renewable sources such as waste and biomass. Likewise, LNG can be generated by surplus and volatile electric energy and a power to gas conversion. LNG may therefore serve as storage for renewable energy in future. For now, high conversion losses, poor infrastructure and the risk of methane slip stand against favouring LNG as storage for renewable energy. Furthermore, against the background of low oil prices there is hardly a business case to develop and run appropriate systems for now.

Alternatives to LNG

Operating ships on LNG is a continued use of a fossil fuel and consequently not sustainable and in line with global climate agreements. Furthermore a new supply infrastructure needs to be built up. This also applies to methanol and ethanol, which are also discussed as alternative fuels for ships or have already been used sporadically.

Diesel fuelled engines equipped with particulate filter and catalytic systems assure an almost complete reduction of air pollutant emissions. Even ultrafine particles can be almost completely removed from the exhaust gases like it is already been a common standard for cars and trucks, while they still occur from the combustion of LNG. Diesel is available worldwide, the infrastructure for storage and bunkering already exists. Moreover the retrofitting of vessels is possible with no need for new engines and fuel tanks and therefore cheaper.

On top, electric components and wind propulsion, in the near future may contribute substantially to improve the overall eco-performance of ships and mitigate air pollution and greenhouse gas emissions from shipping.

Conclusion

LNG can contribute to a significant reduction of shipping related air pollution. However, it has to be ensured that environmentally harmful trade-offs, especially due to methane slip, are minimized effectively. In this field, further research and development is needed. Under the scenario of a widely decarbonised transport sector in 2050 fossil gas can merely represent a bridge technology – renewable energy sources must be given preference as quick as possible. Low-sulphur fuels in conjunction with particulate filters and catalysts are available, cost-effective and proven technologies for pollutant reduction. Of course, private-sector actors can still decide their path of emission reduction. However, NABU rejects the favouring of LNG versus other, readily available alternatives. In particular, public subsidies for building up an LNG infrastructure are seen critically.

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