LNG as Marine Fuel

Sufficient solution to reduce air pollutant and greenhouse gas emissions in the shipping sector?

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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 Emission Control Areas 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 yet. 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 dumping to the ocean lead to severe eco system damages. Therefore, it is crucial to identify and promote alternatives which will ensure the sustainability of shipping as the central transport mode of the globalized world economy in the future.

NABU acknowledges that the utilisation of LNG bears the potential to reduce health and environmentally harmful emissions significantly and to lower the climate impact of shipping to some extend at the same time. 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 and only a life-cycle analysis can deliver a fair eco impact assessment. First, the frequently emphasized improvement regarding the greenhouse gas balance is questionable in its scale. 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 25 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 not a proper means to limit the transport sector's emissions entirely by 2050 – which is required to stay well below the 2 degree target adopted in the Paris Agreement. As a consequence the fossil gas 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 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 technological potential than today's standard in place and therefore today's average GHG benefit of LNG as marine fuel is estimated to be only around 8 percent. In some cases the overall balance can even be slightly negative by about 5 percent compared to MGO and residual oil. 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. Regarding LNG such an approach results in the 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. The combustion of the gas in conventional or dual-fuel engines always creates some methane slip, which can be minimized by discerning control. Supplementary in the future, catalysts can be developed to totally 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.

Applications for LNG

Besides the use in sea-going vessels, LNG e.g. can be used in trucks, buses, inland shipping and for power generation. Power generation is today's main application 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 the propulsion by gas is obvious, as for the cooling of the stored LNG some boil of from the tank is required anyway. Instead of flaring this methane which would result in 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.

In the field of merchant shipping, the use of LNG faces obstacles because of its higher space demands. LNG is cooled to -162° Celsius. It has only about one six-hundredth the volume of gaseous natural gas, but energy density for LNG is still 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 come at the price of some loss in cargo.

Future role in a decarbonised transport industry

As heavy fuel oil or marine diesel, LNG is a fossil fuel and therefore not in line with the aim of a completely decarbonised transport sector by 2050 as agreed on under the Paris Agreement. Accordingly, the shipping sector still has to develop a pathway towards a greenhouse gas-neutral and air pollution-free operation. Against this background, a gradually or even complete switch to LNG as marine fuel can only be regarded an intermediate stage on the way to a post-fossil era.

In principle, LNG could be produced from renewable sources such as waste and biomass. Moreover, liquid gas can be generated by surplus and volatile electric energy by 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. Further research and development is needed to enable a future pathway for this technology respectively the fuel itself.

Alternatives to LNG

Apart from LNG also Diesel fuelled engines equipped with particulate filter and catalytic systems assure an almost complete reduction of air pollutant emissions. This is already a common standard for cars and trucks but can almost nowhere be found on board of ships today. 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. But positive effects regarding the GHG balance cannot be achieved and the same need to decarbonise the fuel is also valid here.

Also electric propulsion 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. Further research and development is required to foster the deployment of these zero emission technologies and fuels.

Conclusion

LNG can contribute to a significant reduction of shipping related air pollution. Moreover the GHG balance compared to diesel and HFO can be improved to some extent. However, it has to be ensured that destructive 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. LNG has the principle potential to work as a source of energy which is able to provide renewable energies to those transport modes where a direct use of electric power is impossible (at least today). For the existing fleet low-sulphur marine diesel in conjunction with particulate filters and SCR catalysts may be an adequate means to reduce air pollution effectively. However, additional CO_2 benefits cannot be achieved here.

DLR/IFEU 2014: "LNG als Alternativkraftstoff für den Antrieb von Schiffen und schweren Nutzfahrzeugen" www.bmvi.de/SharedDocs/DE/Anlage/UI-MKS/mks-kurzstudie-lng.pdf?__blob=publicationFile

ICCT 2013: "Assessment of fuel-cycle impact of LNG in international shipping" www.theicct.org/assessment-fuel-cycle-impact-lng-international-shipping

US Maritime Administration (MARAD) 2015: Methane Emissions from Natural Gas Bunkering Operations in the Marine Sector: A Total Fuel Cycle Approach. www.marad.dot.gov/newsroom/news_release/2016/maritime-administration-releases-lng-vessel-operations-emission-report/

Anderson et al 2015: Particle- and Gaseous Emissions from an LNG Powered Ship. Environ. Sci. Technol. 2015 (49) p. 12568–12575.

ICCT 2015: Needs and opportunities to reduce black carbon emissions from maritime shipping. http://www.theicct.org/needs-and-opportunities-reduce-black-carbon-emissions-maritime-shipping