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1.Third IMO GHG Study 2014. See: http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx

2.http://www.researchgate.net/publication/38021938_Emissions_of_maritime_transport_A_European_reference_system

European Commission

Science for Environment Policy

Methane emissions from LNG-powered ships higher than current marine fuel oils

Due to regulation on sulphur emissions, liquefied natural gas (LNG) has increased in use as a maritime fuel. This study measured exhaust gases from a ship with dual-fuel engines running on LNG and marine gas oil (MGO). Although NO_X and CO_2 emissions were lower for LNG compared to MGO, hydrocarbon and carbon monoxide emissions were higher. The authors say future work should reconsider the climate impact of LNG.

Exhaust gases from ships are a major source of air pollution. According to estimates[1], international shipping emitted 796 million tonnes of CO_2 in 2012 — approximately 2.2% of global CO_2 emissions for that year. Shipping also accounts for up to 30% of total global NO_X emissions and 9% of SO_X[2].

Growing awareness of the scale and environmental impacts of these emissions spurred the International Maritime Organization (IMO) to implement stricter regulations on emissions. SO_X is regulated by the sulphur content in marine fuel oils or use of alternative compliance methods. The use of alternative fuels, including natural gas (which has been used for years in stationary engines, such as power plants), as propulsion fuel for shipping, use of low-sulphur fuels, and the installation of exhaust gas scrubbers are the main methods for compliance with more stringent air emission requirements. For use in internal combustion engines (as found in vehicles), natural gas can be cooled and liquefied (LNG), massively reducing its volume. LNG mainly consists of methane and significantly reduces emissions of SO_X, as well as NO_X and CO_2.

Development has been slow however and globally there are just 34 ships using LNG (due to numerous factors, including issues with safety and regulations). Before development proceeds further, it is important to assess the emissions from ships running on this type of fuel.

This study is, as far as its authors are aware, the first to measure emissions from a ship running on LNG, aiming to characterise both particle and gaseous emissions. The measurements were made in December 2013 on-board a cruise ferry running on LNG in the Baltic Sea. The ship was equipped with lean-burn dual fuel engines, using MGO as pilot fuel. Emissions were measured under different engine loads and both LNG and MGO were used for propulsion. When using LNG for propulsion a small amount of MGO (1-5% of total energy) was injected to ignite the LNG.

The measurements revealed that emissions of particles (both number and mass), NO_x and CO_2 were all considerably lower for LNG compared to MGO and other marine fuel oils. However, emissions of carbon monoxide and total hydrocarbons were higher. Analysis of the exhaust gases showed that around 85% of hydrocarbon emissions from LNG were methane.

Emissions of unburnt methane (known as the 'methane slip') were around 7g per kg LNG at higher engine loads, rising to 23–36g at lower loads. This increase could be due to slow combustion at lower temperatures, which allows small quantities of gas to avoid the combustion process. These escaped emissions are significant, as methane has a global warming potential which is 28 times higher than that for CO_2 over a 100 year perspective, and 84 times higher over 20 years.

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Methane emissions from LNG-powered ships higher than current marine fuel oils *(continued)*

In order to retain the climate benefits of LNG, it is important to address methane emissions. Possible ways of doing this involve carefully timing of the injection of pilot fuel and use of after-treatment systems, such as oxidation catalysts.

Alongside the gases, emissions also contained particles. Although overall particle emissions were lower from LNG than MGO, LNG particle emissions were dominated by very small (ultrafine) and volatile particles, while combustion with MGO resulted in a smaller fraction of these particle types.

Ultrafine particles can penetrate the respiratory system and be transported to other parts of the body via the blood, where they can cause widespread inflammation. Very small particles may also play a role in atmospheric processes, dictating the amount and lifetime of clouds, which can influence climate.

Volatile particles can also be toxic, as they may contain polycyclic aromatic hydrocarbons, which have carcinogenic properties. They can also generate primary organic aerosols, which go on to form harmful secondary pollutants, including ozone.

This study clearly shows that emissions of particles and some gases are lower when using LNG as the primary energy source as compared to marine fuel oils. However, it also shows that there are issues with LNG requiring further investigation, most clearly emissions of methane and thus the overall impact on the climate compared to conventional fuels. These issues are being addressed by expert forums, including the IMO, the European Sustainable Shipping Forum and the Society for Gas as a Marine Fuel. Already some options to minimise methane slip have been identified, such as methane emissions mitigation plans, optimisation of transport efficiency of LNG-fuelled ships and adequate design of the LNG supply chain.

To read more about this topic, visit www.lngforshipping.eu, a European Commission initiative to share research and information on LNG as a fuel solution for the shipping industry.