WHITE PAPER 4

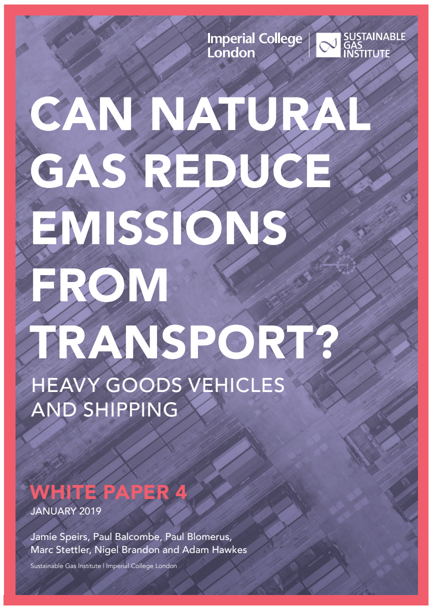
CAN NATURAL GAS REDUCE EMISSIONS FROM TRANSPORT?

HEAVY GOODS VEHICLES AND SHIPPING | 28TH JANUARY 2019

The aim of the white paper is to examine the evidence on the use of natural gas as a transport fuel in reducing greenhouse gas and air pollution emissions in trucks and ships.

Progress on reducing greenhouse gas emissions (GHG) from transport has been relatively slow, with goods transportation and shipping emissions being particularly difficult to address. Local air pollutants arising such as nitrogen oxides (NO_X), sulphur oxides (SO_X), and particulate matter (PM), are also a significant concern for human health. Natural gas is an alternative transport fuel which may help reduce both GHG emissions and air pollutants but there is still some disagreement as to its potential in providing significant improvements relative to current transport systems and fuel options.

Global traffic of trucks and ships represents a significant proportion of global transport greenhouse gas emissions, with road freight in 2015 contributing to 7% of global energy related CO_2 emissions and shipping accounting for 2.6%. These emissions are also expected to grow, with estimates of road freight emission increasing by a third, and shipping emissions by between 50% and 250% by 2050, due to greater demand for goods transportation. Trucks and ships also contribute significantly to air pollution. Road freight contributes approximately 17% of global NO_X emissions, and shipping contributes approximately 13% of global NO_X emissions and 12% of global SO_X emissions.



KEY FINDINGS:

1 Natural gas as a transport fuel has the potential to reduce greenhouse gas emissions in trucks and ships by ~16% and ~10%, respectively, comparing lowest estimates.

- Greenhouse gas emissions from trucks or ships vary due to differences in engine efficiency, methane slip through the exhaust, engine and fuel system methane emissions and supply chain emissions.
- For **trucks**, estimates of lifecycle emissions show a potential to reduce emissions from natural gas fuelled trucks by ~16% against lowest estimates of diesel truck emissions. For **ships**, the equivalent potential for lifecycle emissions reduction is around 10% relative to heavy fuel oil ships.
- However, natural gas fuelled trucks and ships at worst may have lifecycle emissions exceeding current incumbent diesel trucks and heavy fuel oil ships. Dual fuel trucks in urban driving cycles or ships using low pressure dual fuel or lean burn engines are most likely to exhibit these high emissions.

2 Air pollution emissions can be reduced significantly in shipping by switching to natural gas. Air pollution benefits in trucks are reduced given improvements in modern diesel engines.

- In **trucks**, NO_X emissions from spark ignited natural gas engines may be reduced by up to 80%, but emissions from dual fuel engines may be higher than diesel vehicles. PM may be reduced by 18% relative to diesel trucks, but there is likely to be an increase for dual fuel engines. The benefits are typically achieved on motorway driving cycles, with urban driving cycles leading to higher emissions for natural gas vehicles.
- In **ships**, NO_X emissions may be reduced by ~90%, SO_X emissions by ~90% and particulates by up to 98% against the average heavy fuel oil ships. However, there is likely to be a trade-off between NO_X emissions and methane slip with high pressure direct injection engines providing the lowest methane slip but also the highest NO_X emissions (~15% reduction). After-treatment technologies may be used to address this trade-off.

3 Global greenhouse gas (GHG) emissions reductions from natural gas trucks and ships may not be sufficient to meet global emissions goals alone.

- Global goals for GHG emissions reduction will likely require trucks and ships to adopt a combination of options, including efficiency measures, after-treatment technologies and fuel switching away from fossil fuels to low carbon fuels such as biofuels or hydrogen fuel cells.
- In **shipping**, natural gas engines, in combination with ambitious energy efficiency improvements, may go a long way towards achieving the required GHG reduction, potentially reducing emissions by 36% relative to 2008 fleet emissions. However, even assuming greater rates of efficiency improvements it appears difficult to meet a 50% GHG emissions reduction target by 2050 using natural gas engines and ship efficiency improvements alone. Deeper decarbonisation appears possible if a lower emissions ship technology such as hydrogen fuel cell ships becomes available from 2040 to 2050, potentially leading to

Download the full white paper from: www.**sustainable**gas**institute**.org/**can-natural-gas-reduce-emissions-from-transport**

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The Sustainable Gas Institute at Imperial College London aims to explore the role of natural gas in the world energy mix. Follow us on twitter: @SGI_London a 50% reduction compared to 2008 fleet emissions.

- However, in the meantime, the emissions benefit of natural gas in shipping is notable due to the significant reduction in air pollution. The future role of natural gas in trucks and ships is in part influenced by the future availability of alternative low carbon technologies which are not commercially mature at present.

4 Natural gas is currently a cheaper fuel than diesel or heavy fuel oil, helping to 'pay back' the ~20% greater capital cost of trucks and ships that can use natural gas.

- The additional capital cost relates to the fuel tank, fuel delivery system and the engine. Natural gas fuel costs are currently less than current fuel options. Liquefied natural gas prices have been on average ~50% less than heavy fuel oil prices between 2000 and 2015 and LNG and CNG are ~20% lower than diesel prices, including fuelling costs and duty.
- The extra investment in natural gas trucks and ships is likely to be recovered by operators through reduced fuel costs, with payback periods between 15 months and eight years for trucks and between five and 16 years for ships. However, there is no guarantee that the current price or tax regimes will always favour natural gas transport fuels, and if prices or duties rise, the potential for payback of additional capital expenditure will decrease.

5 A number of policy options could be considered to minimise greenhouse gas emissions and incentivise the other technologies necessary to meet challenging global targets.

i. Policies to help limit supply chain emissions are important. While initiatives are already scrutinising possible action on the well-to-tank supply chain there is likely a need for specific policies to cover monitoring and reducing methane emissions throughout the entire supply chain.

ii. Fuel taxes can also be applied to incentivise emissions reduction. The current tax differential between natural gas and diesel in trucks is an incentive to switch to natural gas. However, fuel tax policies are only useful when they lead to genuine emissions reductions. Therefore, complimentary policy instruments, in conjunction with rigorous and independent in-use testing, should be implemented to ensure that fuel tax benefits applied to natural gas natural are rewarded with genuine reductions in greenhouse gas emissions.

iii. For sufficient CO_2 reduction, a broad suite of options are likely necessary in the truck and ship sectors, including broader fuel switching options, energy efficiency measures and after-treatment. Incentives or mechanisms to support these technologies should therefore be an important aspect of future policy.

iv. Finally, some of the existing policies put in place to help meet emission targets, are insufficient in their current form. Strengthening or extending policies such as the energy efficiency design index in shipping may be a valuable route to meeting long-term emissions targets.

6 Further understanding is needed on a number of open questions in natural gas as a transport fuel in ship and trucks.

Areas that need further understanding include:

i. **Real-world measurement** of the greenhouse gas and air pollution emissions from the latest natural gas trucks and ships and the supply chains that fuel them;

ii. **Improvements in technologies and techniques** to reduce these emissions. This includes engine and truck/ship designs to maximise efficiency and minimise methane emissions, and application and refinement of technologies to deal with methane emissions in the bunkering and refuelling of ships and trucks.

iii. **Improved modelling of the transport system** to better understand the impact of emissions mitigation measures on total fleet emission and costs. This includes more technology richness, better real-world input data and improved understanding of the interactions between different options.

FIGURE ES1 | Breakdown of emissions from the well-to-wheel life cycle of average liquefied natural gas trucks, including the range of emissions estimates.