Imperial College London

Sustainable Energy Futures Conference 2018

14 September 2018

An Analysis of Liquefied Natural Gas for Heavy Goods Transport in the United Kingdom

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BACKGROUND

Transport is responsible for approximately 25% of greenhouse gas (GHG) emissions in Europe, a quarter of which are attributed to heavy goods vehicles [1]. Without action, growing demand for road freight will be accompanied by rising emissions. As the UK strives to reduce its GHG emissions by 80% in 2050 relative to 1990 [2], it will be necessary to decarbonise heavy goods transport. Due to technical and commercial constraints, there are few potential solutions available in the short term.

RESEARCH AIM

This project aimed to evaluate whether LNG can provide an economically viable solution to decarbonise long-haul distribution for a large food retailer in the UK.

METHODOLOGY

A spark-ignited (SI) LNG truck was assessed relative to a fleet of diesel comparators from a technical, environmental, and economic perspective. Vehicle fuel consumption data was collected and used as an input in economic and environmental models. Uncertainties and risk were addressed by Monte-Carlo based sensitivity analyses and financial indicators.

Figure 1: Components of methodology for key stages in the value chain

Fuel production and procurement

Well-to-tank (WTT) emissions were modelled in GREET for several fuel pathways: current UK diesel mix, LNG from Qatar, and LNG from the US. A hot spot analysis was employed to highlight the main components of WTT emissions.

Vehicle refuelling

Calculated infrastructure costs by fleet size. Evaluated impact of vented methane on life-cycle emissions. Compared refuelling experience using driver surveys.

Vehicle performance

Collected fuel consumption data to compare vehicle efficiencies. Used telematics to investigate the impact of drive cycle on fuel consumption. Carried out driver surveys to gain insight into technology acceptance.

Life-cycle emissions and costs

Combined WTT emissions with tank-to-wheel (TTW) emissions for observed fuel consumption to give well-to-wheel (WTW) emissions. Total cost of ownership (TCO) evaluated for diesel and LNG via Monte-Carlo simulations.

Fleet-wide investment strategy

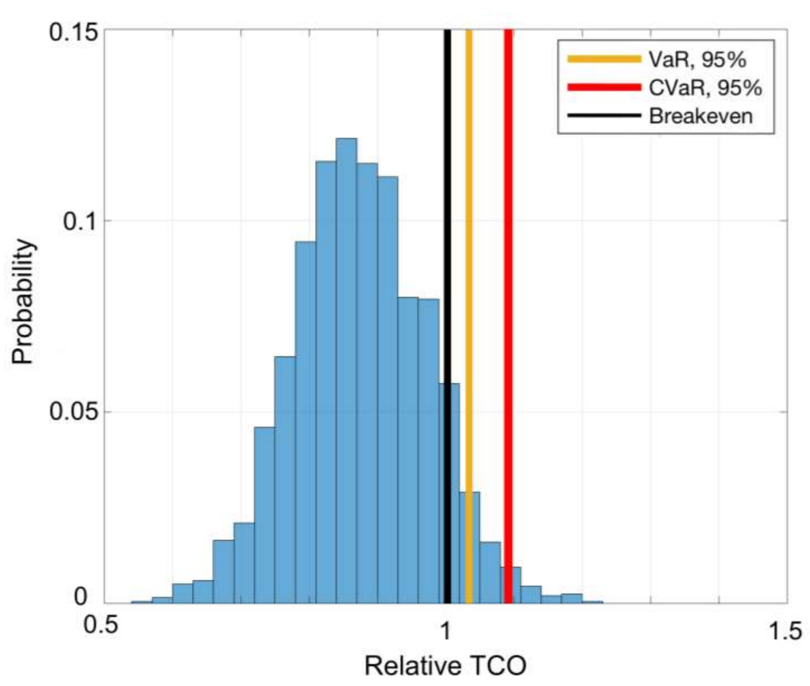
Emissions and costs evaluated at fleet-level for five depots to identify characteristics of sites for optimal LNG investments.

KEY FINDINGS ECONOMIC ANALYSIS

LNG presents a strong business case for long-haul distributors.

Over 90% of outcomes generated financial savings. CVaR, 95% indicated the worst 5% of LNG investments were expected to be 9% more expensive than diesel. Three key variables influenced variation in TCO: diesel vehicle efficiency, diesel fuel price, and LNG fuel price. Fuel cost savings paid back incremental vehicle cost. Diesel vehicles with highest fuel consumption benefitted most from switching to LNG. Matching fuel duty on a carbon basis nullified possible financial savings. Changes to fuel duty are unlikely for current levels of LNG uptake.

Figure 2: Distribution of TCO outcomes for LNG relative to diesel from a Monte-Carlo based economic analysis

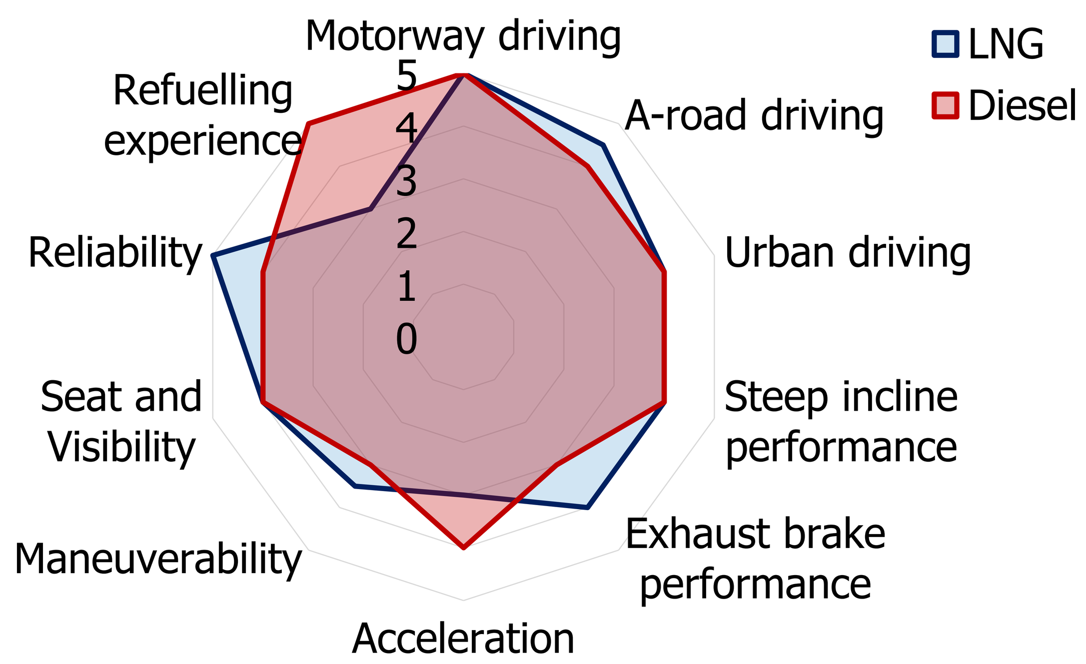


KEY FINDINGS TECHNICAL PERFORMANCE

LNG SI vehicle is 70% to 80% as efficient as a diesel comparator.

Clear efficiency gap observed between spark-ignited LNG and compression-ignition diesel. While opportunities exist to improve LNG engine performance, the gap is likely to narrow rather than disappear.

Figure 3: Median values of 22 driver surveys measuring LNG acceptance



Refuelling infrastructure is central to successful LNG uptake.

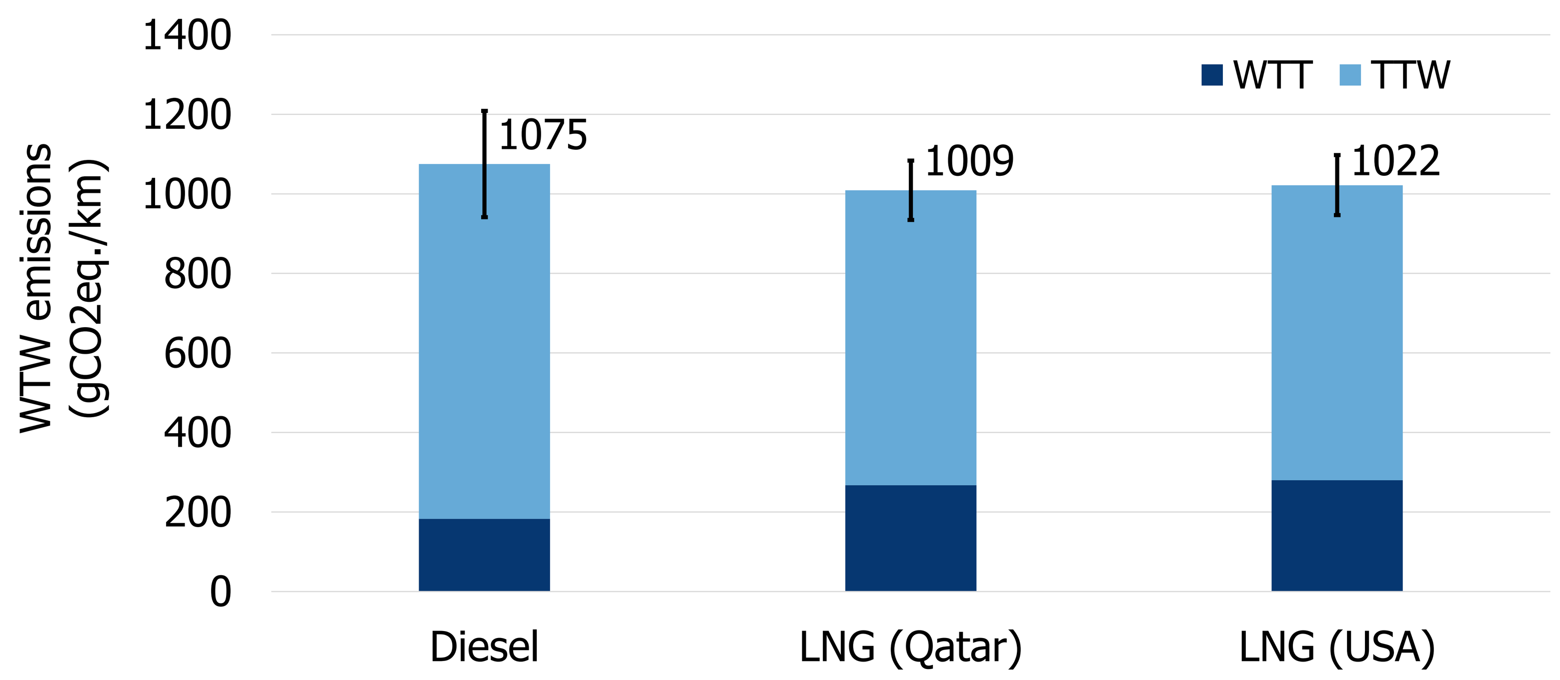
Refuelling strategy (private on-site or public station) dictated the potential for LNG to generate economic returns. Refuelling at public stations delivered TCO savings while private infrastructure investments incurred net costs relative to diesel. Driver surveys highlighted refuelling experience as the major challenge facing LNG acceptance. Boil-off gas management was found critical to minimising emissions.

KEY FINDINGS ENVIRONMENTAL COMPARISON

LNG offers 6% GHG emissions reductions on a WTW basis.

Despite 23% lower WTW emissions per unit energy, LNG was found to reduce WTW emissions by only 6% per unit distance travelled. Vehicle efficiency had greatest influence over emissions for each fuel type. LNG supply chain emissions were dominated by natural gas recovery (36%) and liquefaction (36%), while the contribution from shipping (6%) was small. Venting 0.7% of LNG throughput at the vehicle refuelling stage was found to negate potential GHG emission savings.

Figure 4: Well-to-wheel emissions by fuel pathway



CONCLUSIONS

Liquefied natural gas can offer significant cost savings for distributors when public refuelling stations are within operating range. The LNG-diesel price gap is critical to ensuring economic returns. Without drastic improvements in engine efficiency, spark-ignited vehicles fuelled by conventional LNG offer limited contributions to emissions reductions.

REFERENCES

[1] European Commission, 2018, A European Strategy for Low-Emission Mobility
[2] CENEX, 2016, Low Carbon Truck and Refuelling Infrastructure Demonstration Trial Evaluation

ACKNOWLEDGEMENTS

I would like to thank my supervisors, Dr Salvador Acha and Dr Marc Stettler, for their guidance and motivation throughout this project. Special thanks also to Dr Daniel Ainalis for his support.