Summary of Emissions and Performance of Alternative Diesel Fuels on PLA Harbour Service Vessel - *Kew*

The Port of London Authority (PLA) commissioned the University College London to perform an experimental study comparing the engine emissions from Kew, *one of the Harbour Service vessels, when operating on Ultra Low Sulphur Diesel (ULSD), the Gas-To-Liquid (GTL), and Hydrotreated Vegetable Oil (HVO). The emissions results together with the post-trials engine inspection performed by PLA's engineers and greenhouse gas emissions calculation helped the PLA make an informed decision on switching from ULSD to lower emissions fuels across the vessel fleet. The summary of the trials is as follows:*

PLA Harbour Service Vessel - Kew

Emissions monitoring

Exhaust gas samples were collected from operating on neat (100% vol/vol) ULSD, neat GTL, and neat HVO under various engine speeds during the course of dedicated sampling cruises. The concentration of air pollutants and greenhouse gas, including nitrogen oxides (NO_x), particulate matter (PM), total hydrocarbon (THC), carbon monoxide (CO) and carbon dioxide (CO_2), within the exhaust gas samples were then analysed at the university's laboratory.

- CO_2 emitted during the combustion of GTL were 12-49% lower compare to ULSD. However, reduced level of CO_2 during the operation with GTL are suggestive of lower fuel flow rates and reduced engine work out for a given engine sampling speed. For HVO, the CO_2 reduction was 7-44% at engine speed lower than 1500 rpm and a 1% increase at the highest tested engine speed at 2500 rpm.
- NO_x emissions reduced with the use of

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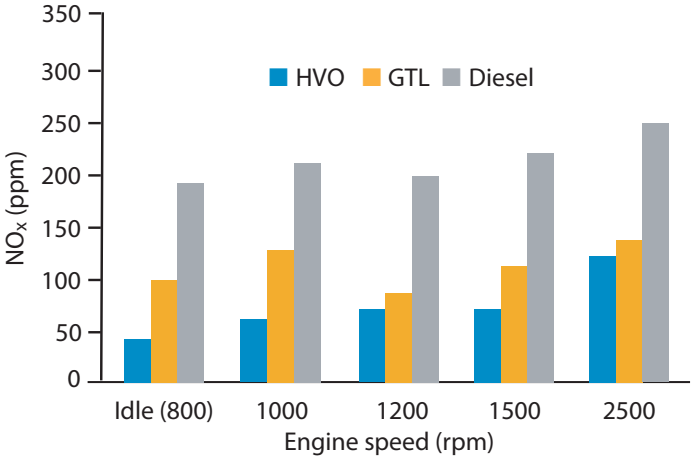
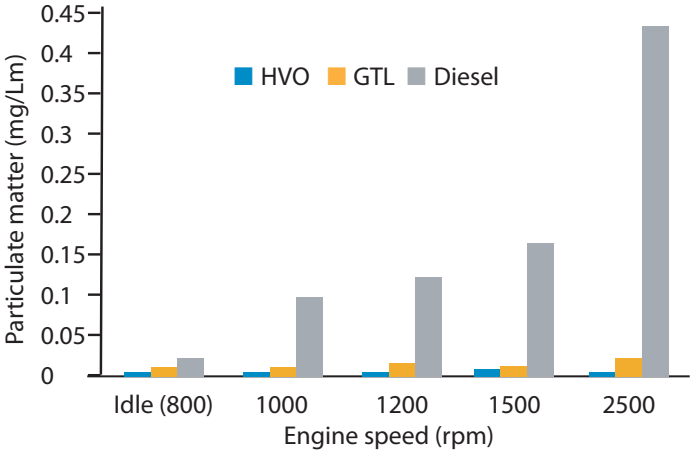




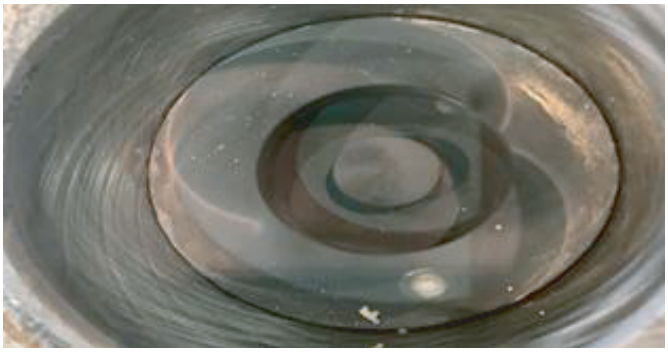
GTL and HVO fuels relative to ULSD. HVO recorded 51-78% reduction while GTL recorded 39-56% reduction in NO_x. However, evidence suggested that the reduced NO_x formation with GTL might be attributed to the reduced rate of fuel delivery, which subsequently resulted lower in-cylinder temperatures for a given engine speed.

- PM emissions reduced significantly with the use of GTL and HVO fuels relative to ULSD. HVO recorded 76-99% reduction while GTL recorded 50-93 % reduction in PM. The reductions are attributable to the paraffinic nature and reduced aromatic content of both fuels.
- CO and THC emissions were both lower with the use of GTL fuels relative to ULSD. However, the emissions of CO and THC were generally higher with the use of HVO relative to GTL, and some conditions ULSD, suggesting a greater degree of incomplete combustion due to fuel over-dilution or insufficient temperatures.
- The effects of tide and weather conditions were not taken into account for analysis, which might affect the engine load and fuel consumption, and hence, the air emissions.

Engine condition

The vessel engine was also lifted out and had a full inspection after the trials by the PLA's engineers. Note that the findings are only based on a trial on a single vessel, see diagrams above.

- No physical or visible operational issues, including no blockages and no signs of fuel breakdown, were experienced during the trials.
- No additional servicing, which is carried for every 400 hours of operation, were required during the trials of GTL and HVO relative to ULSD.
- The fuel consumption rate with ULSD, GTL, and HVO fuels were found not to be significantly different during the trial.



The post-trials engine inspection identified no significant wear and no signs of cylinder glazing, no signs of damage due to changing of combustion timing related to the higher cetane number, and reduced soot deposition on the piston crowns, valves and injector nozzles

Greenhouse gas calculation

The greenhouse gas emissions associated with an organisation's activities based on the average annual usage and UK government conversion factor were estimated.

- The scope 1 CO_2e – the equivalent greenhouse gases emissions were significantly lower with the use of HVO compare to ULSD as the carbon dioxide emitted during combustion is deemed to have been offset by the absorption of carbon dioxide during growth of the biomass that forms the biofuel.
- No comparison was made against GTL as there is no conversion factor available for GTL.

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