11. Liquefied Petroleum Gas (LPG) – HD5

11.1 Background

LPG HD-5 is essentially liquefied propane gas. Most LPG used on the East Coast of Australia is Autogas. Propane as a vehicle fuel is limited to Western Australia. There is very little usage of LPG in Australian heavy vehicles. LPG has particularly low particulate levels, which make it an attractive fuel for urban buses and delivery vehicles. However, as diesel particulate emissions reduce to Euro4 levels this advantage may be lost.

11.2 Results

Because it is relatively rare for LPG to be used in heavy vehicles, there is a lack of published data on its emissions characteristics though there is considerable data in relation to LPG used in cars.

11.2.1 Greenhouse gas emissions

Figure 11.1 depicts the greenhouse gas emissions estimated for gaseous fuels. These are shown as emissions on an energy basis, as emissions on a per tonne-km basis for trucks, and on a per passenger-km basis for buses. We have used data from Apelbaum Consulting Group (1997) for the passenger task and the freight task in Australia and taken the mean energy intensity for the Australian freight task to be 1.2 MJ/tonne-km (Apelbaum Consulting Group, 1997: p.118), and the energy intensity of buses to be 1.06 MJ/passenger-km (Apelbaum Consulting Group, 1997: p.116). Exbodied emissions of greenhouse gases are lower from HD5 than from LSD.

11.2.2 Particulate matter emissions

Figure 11.2 depicts the particulate matter (PM10) emissions estimated for gaseous fuels. These are shown as emissions on an energy basis, as emissions on a per tonne-km basis for trucks, and on a per passenger-km basis for buses using the same energy intensities previously noted. Particulate emissions of HD5 are markedly lower than those of LSD.

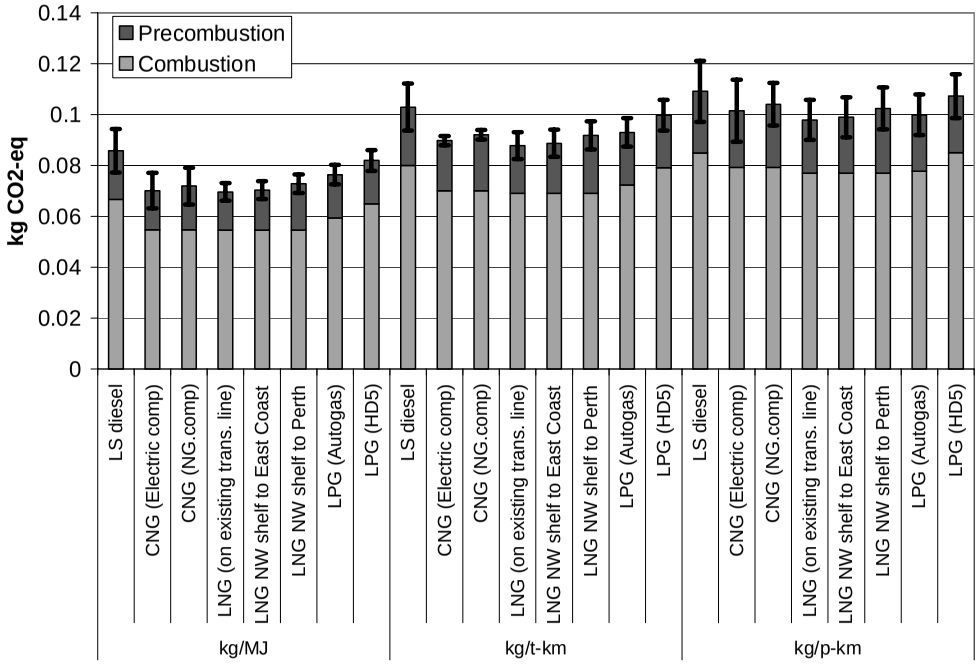

Figure 11.1
Exbodied emissions of greenhouse gases for gaseous fuels.

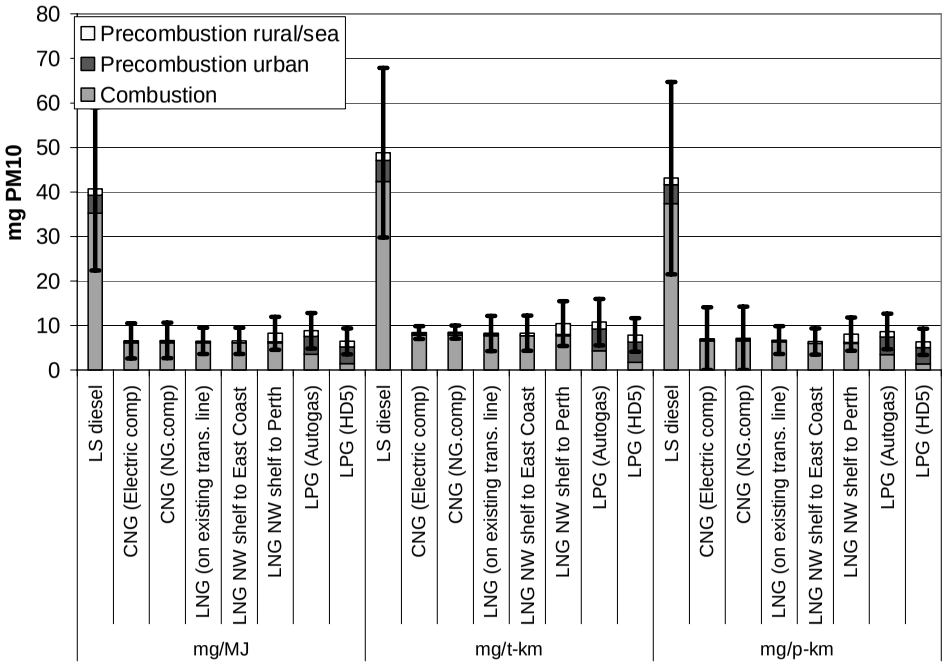

Figure 11.2
Exbodied emissions of particulate matter for gaseous fuels.

11.2.3 Emissions of oxides of nitrogen

Figure 11.3 depicts the oxides of nitrogen (NOx) emissions estimated for gaseous fuels. These are shown as emissions on an energy basis, as emissions on a per tonne-km basis for trucks, and on a per passenger-km basis for buses using the same energy intensities previously noted. Emissions of NOx from HD5 are lower than those of LSD.

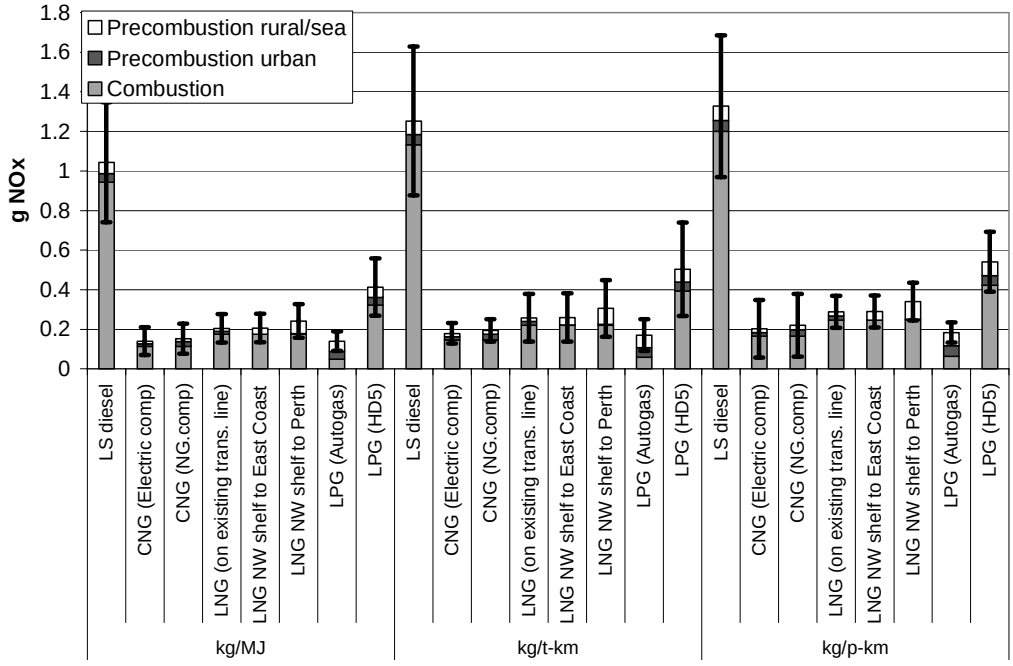

Figure 11.3
Exbodied emissions of oxides of nitrogen for gaseous fuels.

11.2.4 Emissions of hydrocarbons

Emissions of hydrocarbons for the gaseous fuels are shown in Figure 11.4. In every case, the gaseous fuels have lower exbodied hydrocarbon emissions than LSD, though we estimate large pre-combustion emissions of hydrocarbons from propane primarily from leakage.

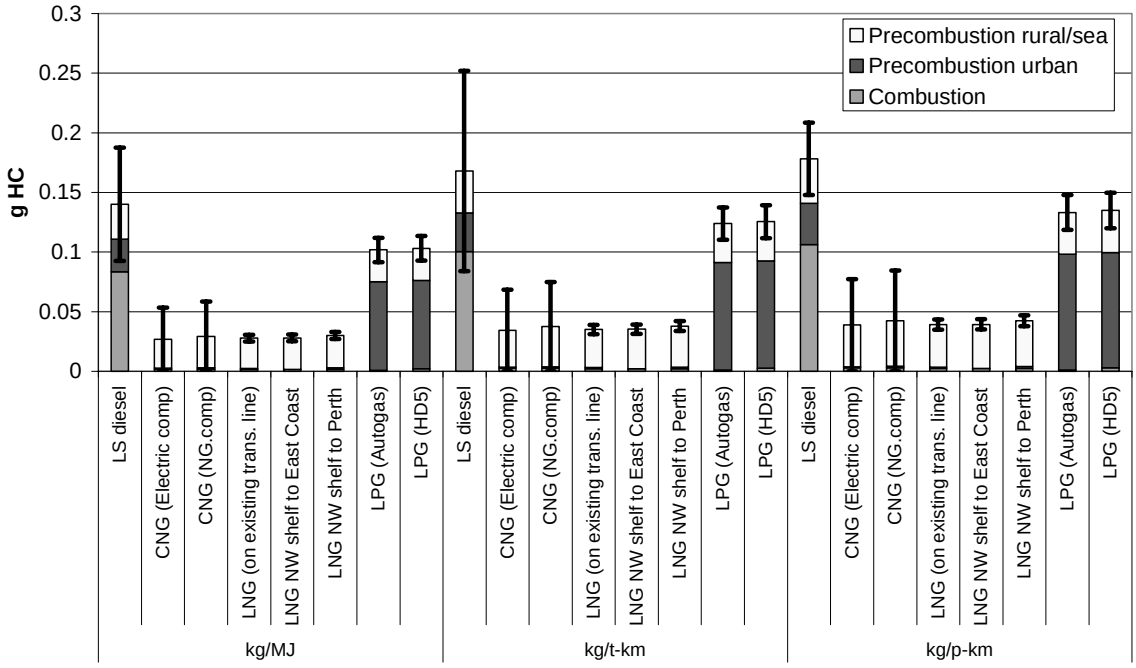

Figure 11.4
Exbodied emissions of hydrocarbons for gaseous fuels

11.3 Viability and Functionality

Propane (HD5) viability and functionality issues are identical to those of Autogas. The main benefit of propane is that the vehicle compression ratio can be adjusted to make use of the higher octane fuel and thus improve fuel economy.

Stakeholder input from Cummins noted that when comparing diesel, propane and natural gas in the same engine then the engine performance ratings are highest for diesel, then CNG, then propane.

Kleenheat Gas recently developed a diesel/LPG fuel substitution conversion kit that was used in a trial of an articulated Volvo B10M MkIII LPG bus in Darwin. Was Diesel Now Gas offers conversion to a dedicated HD-5 vehicle. From the very limited data available, vehicles converted to LPG appear to be less successful at reducing emissions than newly purchased LPG vehicles. Converted vehicles appear to have higher tailpipe emission of hydrocarbons than diesel vehicles, though particulate matter emissions are lower. Other emissions affecting air quality appear to be similar to those of diesel while emissions of carbon dioxide are similar to, or slightly less than, those of similar diesel vehicles. However, it should be reiterated that these conclusions are based on the testing of one converted dual fuel vehicle and one vehicle converted from diesel to dedicated LPG-HD5. The Australian LPG conversion industry for heavy vehicles is at an early stage in its development and the data from such test may not reflect the emissions performance of converted vehicles in the longer term.

DAF, the Dutch vehicle maker, has developed a dedicated LPG fuelled bus using the stoichiometric process rather than lean burn. This process reduces the emission rate of particulate matter to one twentieth of Euro2, whereas lean burn only comes to half of Euro2.

Some ullage space must be left in an LPG tank because the liquid volume expands significantly if the tank encounters increasing ambient temperatures. Gaseous fuelled engines are generally considered easier to start than petrol or diesel engines in cold weather, because the fuel is vaporized before injection into the engine. Hot starting may, however, produce difficulties.

Australian LPG, being primarily sourced from natural gas, is vulnerable to disruption in the gas supply. This was most evident with the Longford incident in 1998 when gas supplied to Melbourne, and much of the rest of Victoria were halted following the disaster at the Longford plant. During the period of gas shortage, LPG was sourced from interstate and there was no disruption to the LPG supply. The NSW cavern LPG storage facility at Port Botany provides added security.

11.4 Health Effects

Emissions of PAH and aldehydes are much lower than those of diesel-fuelled vehicles. LPG in liquid form can cause cold-burns to the skin in case of inappropriate use. In general, the health effects of Autogas and HD5 are the same.

LPGHD5 upstream emissions of particles are similar to LSD. LPGHD5 upstream emissions of air toxics are greater than LSD. LPGHD5 tailpipe emissions of particles are substantially less than LSD. LPGHD5 tailpipe emission of benzene, 1,3 butadiene, formaldehyde and acetaldehyde are less than LSD.

11.5 Environmental Issues

Air pollutants are reduced when compared to LSD. Dedicated LPG vehicles have lower emissions than dual-fuelled vehicles. When compared to Autogas, HD5 produces more NOx but less particulate matter.

ESD principles

Noise levels from dedicated LPG buses are less than those of diesel buses. LPG buses produce less air pollutants and greenhouse gases than diesel buses. The potential for water and soil pollution is effectively eliminated by the use of LPG.

Sustainability

LPG is an indigenous fuel that could replace imported, expensive crude oil.

Groundwater

Being a gaseous fuel, LPG does not impact groundwater.

11.6 ADR Compliance

LPG can be expected to meet all future Australian Design Rules for all pollutants.

11.7 Summary

11.7.1 Advantages

- Propane has low cold-start emissions due to its gaseous state.
- Propane has lower peak pressure during combustion than conventional fuels, which generally reduces noise and improves durability.
- LPG fuel systems are sealed and evaporative losses are negligible.
- Propane is easily transportable and offers ‘stand-alone’ storage capability with simple and self-contained LPG dispensing facilities, with minimum support infrastructure.
- LPG vehicles do not require special catalysts.
- Propane contains negligible toxic components.
- LPG has lower particulate emissions and lower noise levels relative to diesel, making propane attractive for urban areas. Noise levels can be less than 50% of equivalent engines using diesel.
- Propane’s emissions are low in greenhouse gases and low in NOx, thus they are low in ozone precursors.
- Increases in future demand for LPG can be easily satisfied from both natural gas fields and oil refinery sources.
- Emissions of PAH and aldehydes are much lower than those of diesel-fuelled vehicles.

11.7.2 Disadvantages

- Although LPG has a relatively high energy content per unit mass, its energy content per unit volume is low which explains why LPG tanks take more space than diesel fuel tanks of the same energy storage capacity.
- Propane tanks are pressure vessels and thus weigh more than the equivalent diesel tank.
- Propane is heavier than air, which requires appropriate handling.
- Propane vapour flammability limits in air are wider than those of petrol, which makes LPG ignite more easily.
- Propane has a high expansion coefficient so that tanks can only be filled to 80% of capacity.
- Propane in liquid form can cause cold burns to the skin in case of inappropriate use.