

## Part 1 Summary of Fuels

### 10. Liquefied Petroleum Gas (LPG) - Autogas

#### 10.1 Background

Liquefied petroleum gas (LPG) a petroleum industry by-product, consists mainly of propane, propylene, butane, and butylene in various proportions according to its State of origin. Autogas grade LPG is a mixture of propane and butane in approximately equal ratios. The Australian industry has prepared a set of performance-based specifications that are widely seen as a de facto standard. 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. A national standard for LPG is being developed under the *Fuel Quality Standards Act 2000*.

#### 10.2 Full Fuel Cycle 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. The AGO also has some data on dual fuel vehicles as a result of the Alternative Fuels Conversion Program.

##### 10.2.1 Greenhouse gas emissions

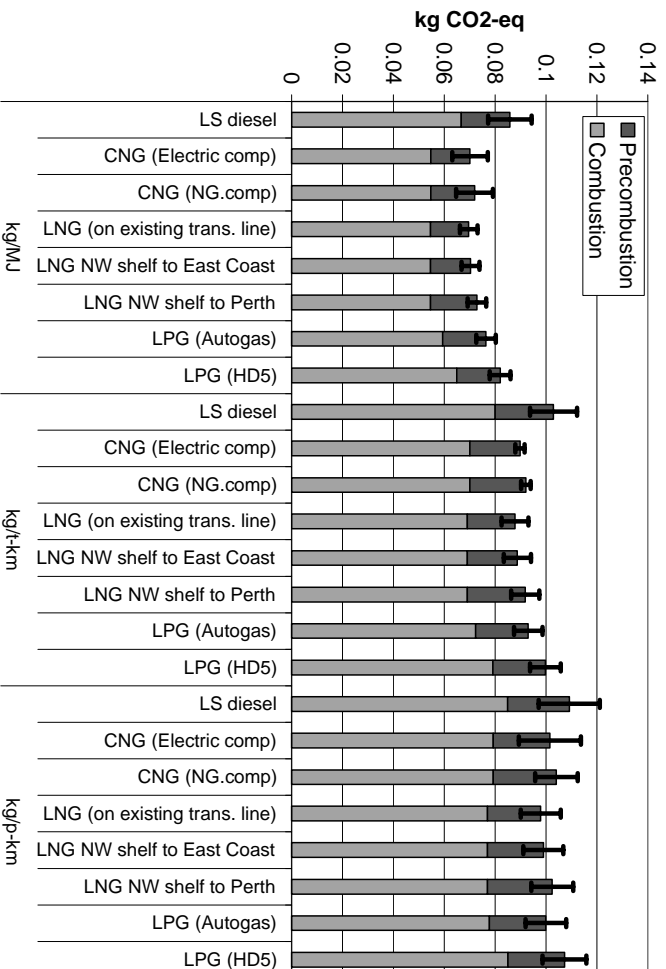
Figure 10.1 depicts the greenhouse gas emissions estimated for gaseous fuels. These are shown as emissions on an energy basis, as emissions on a per tonne-km basis for trucks, and on a per passenger-km basis for buses. We have used data from Apelbaum Consulting Group (1997) for the passenger task and 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).

Embodied emissions of greenhouse gases are lower from Autogas than from LSD.

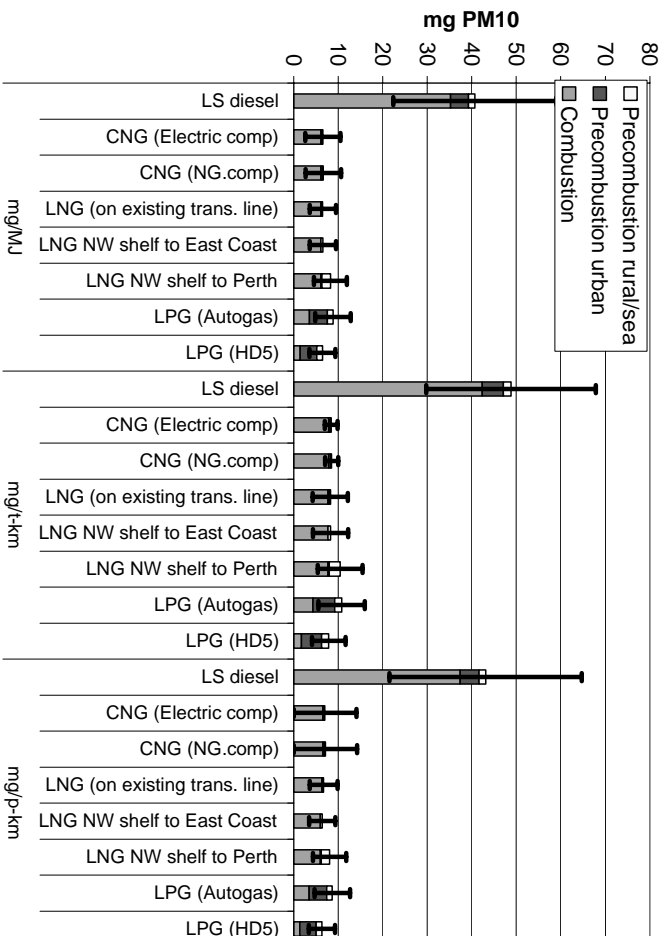
##### 10.2.2 Particulate matter emissions

Figure 10.2 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 Autogas are markedly lower than those of LSD.

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**Figure 10.1**  
Exhobied emissions of greenhouse gases for gaseous fuels.

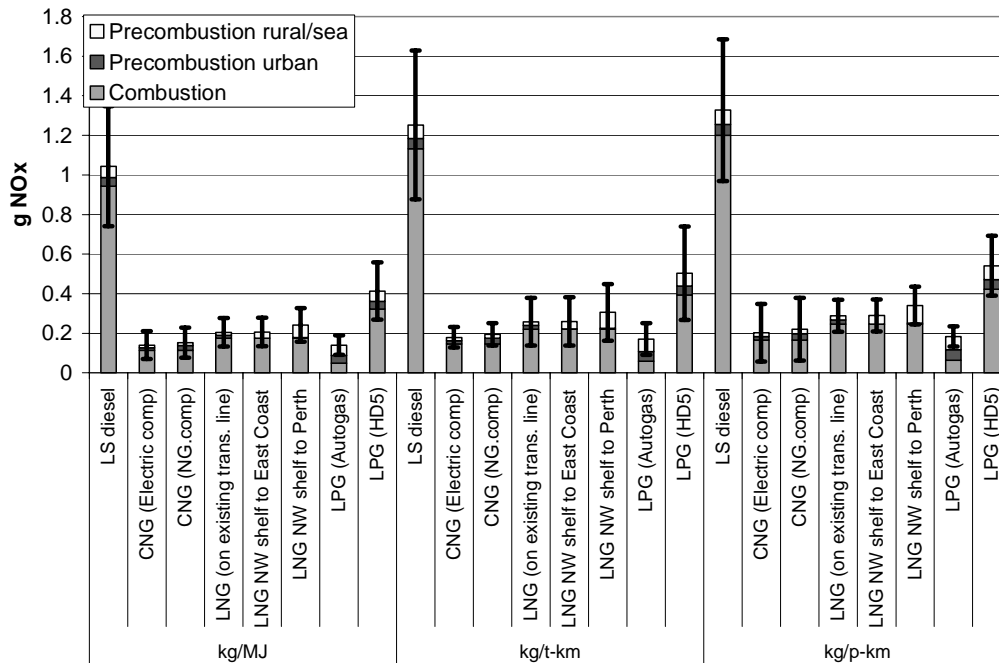


**Figure 10.2**  
Exhobied emissions of particulate matter for gaseous fuels.

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### 10.2.3 Emissions of oxides of nitrogen

Figure 10.3 depicts the oxides of nitrogen (NO<sub>x</sub>) 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 NO<sub>x</sub> from Autogas are lower than those of LSD.

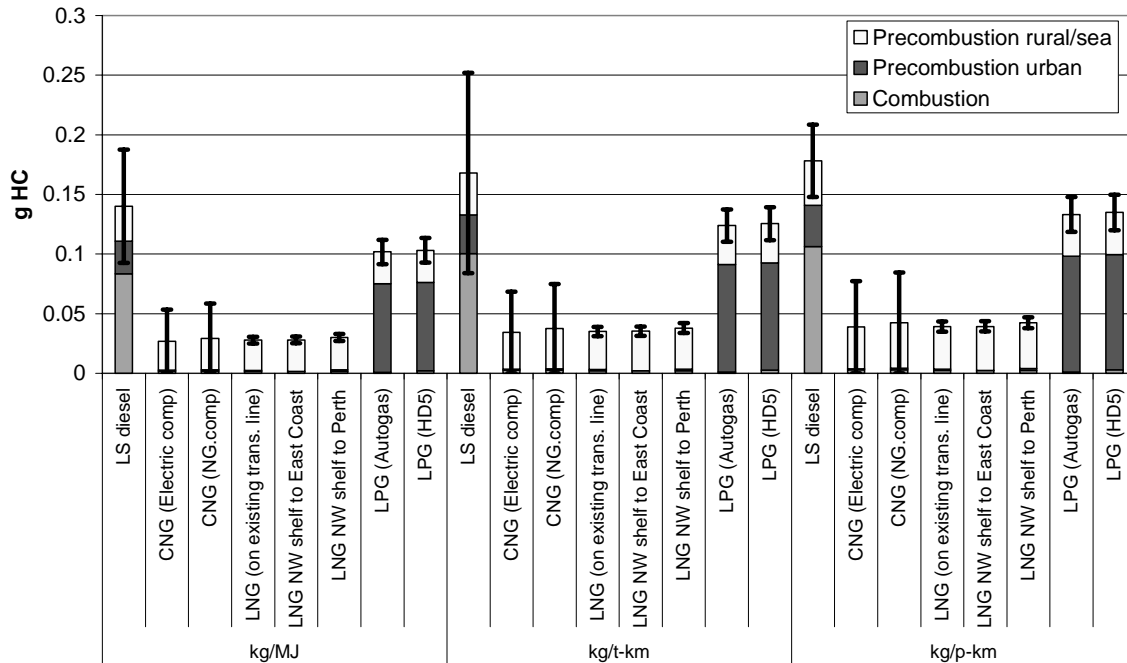


**Figure 10.3**  
Exbodied emissions of oxides of nitrogen for gaseous fuels.

### 10.2.4 Emissions of hydrocarbons

Emissions of hydrocarbons for the gaseous fuels are shown in Figure 10.4. In every case, the gaseous fuels have lower exbodied hydrocarbon emissions than LSD, though we estimate larger pre-combustion emissions of hydrocarbons from autogas than from LSD, primarily as a result of leakage.

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**Figure 10.4**  
Exbodied emissions of hydrocarbons for gaseous fuels

### 10.3 Viability and Functionality

DAF, the Dutch vehicle maker, 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, in fact, no disruption to supply. The NSW cavern storage of LPG at Port Botany provides added security.

Presently there are no data on emissions from diesel vehicles converted to use autogas. It is expected that the performance of such converted vehicles will be similar to vehicles that have been converted to use propane (LPG-HD5). These are dealt with in the next chapter.

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### 10.4 Health Issues

LPG's low emissions have low greenhouse gas effects and low NO<sub>x</sub> precursors. LPG upstream emissions of particulate matter are similar to LSD. LPG upstream emissions of air toxics are greater than LSD. LPG tailpipe emissions of particulate matter are substantially less than LSD. LPG tailpipe emission of benzene, 1,3 butadiene, formaldehyde and acetaldehyde are less than LSD.

LPG vapor is heavier than air, disperses slowly, and can accumulate in local valleys. LPG, when involved in a leak will discharge in a liquid form requiring a period of time to vaporize and disperse. LPG fires tend to persist within the leakage area due to its liquid and heavier than air state. For fuel line ruptures, pressurized gaseous fuels represent higher hazard levels than petrol.

### 10.5 Environmental Issues

The environmental issues surrounding LPG are the same as those for CNG and LNG, in that they are gaseous fuels that do not cause land or water pollution. Air pollutants are reduced when compared to LSD. Dedicated LPG vehicles have lower emissions than dual-fuelled vehicles.

#### *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.

### 10.6 ADR Compliance

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

### 10.7 Summary

#### 10.7.1 Advantages

- It has low cold-start emissions due to its gaseous state.
- It has lower peak pressure during combustion, which generally reduces noise and improves durability; noise levels can be less than 50% of equivalent diesel engines.
- LPG fuel systems are sealed and evaporative losses are negligible.
- It 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.
- It contains negligible toxic components.

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- LPG has lower particulate emissions and lower noise levels relative to diesel, making it more attractive for urban areas.
- Its low emissions have low greenhouse gas effects and low NO<sub>x</sub> precursors.
- Relative to other fuels, any 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.

### 10.7.2 *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.
- The LPG tanks are pressure vessels and therefore weigh more than diesel tanks.
- It is heavier than air, which requires appropriate handling.
- Its vapour flammability limits in air are wider than those of petrol, which makes LPG ignite more easily.
- It has a high expansion coefficient so that tanks can only be filled to 80% of capacity.
- LPG in liquid form can cause cold burns to the skin in case of inappropriate use.