8. Compressed Natural Gas (CNG)

8.1 Background

Natural gas (NG) is a mixture of hydrocarbons, mainly methane (CH_4). It is stored onboard a vehicle in a compressed gaseous state (CNG). Natural gas is distributed throughout Australia in extensive pipeline systems. A national fuel standard for CNG is to be developed in 2001-2002 under the *Fuel Quality Standards Act 2000.*

Most gas losses from the distribution systems are by way of leakage from the low pressure network (7 kPa). This includes both the reticulation network and appliances operated by end users. Losses from the distribution network are difficult to estimate as they may occur both upstream and downstream from the meters.

8.2 Results

Two modes of compression were examined: compression using natural gas and compression using electricity. The assumptions that are made in terms of methane losses, both upstream and during vehicle operation, determine whether one concludes that CNG (or LNG) emits more, or less, greenhouse gases. We assumed for Australia, on the basis of the advice received from stakeholders, that fugitive emissions are 0.1% of supply. This leads to the results, depicted below, that exbodied emissions of greenhouse gases are less than that of diesel. Earlier studies and overseas studies, based on assumptions of higher fugitive emissions, produce opposite results in relation to greenhouse gases. We undertook a sensitivity study, as depicted in Figure 8.3 of Part 2, that indicates that if fugitive emissions exceed approximately 4 % of supply then exbodied emissions of greenhouse gases exceed those of low sulfur diesel.

8.2.1 Greenhouse gas emissions

Figure 8.1 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). An extra allowance of 400 kg for the weight of CNG tanks over diesel fuel tanks has been built into these figures.

Exbodied emissions of greenhouse gases are lower from CNG than from LSD under both scenarios.

8.2.2 Particulate matter emissions

Figure 8.2 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 CNG are markedly lower than those of LSD.

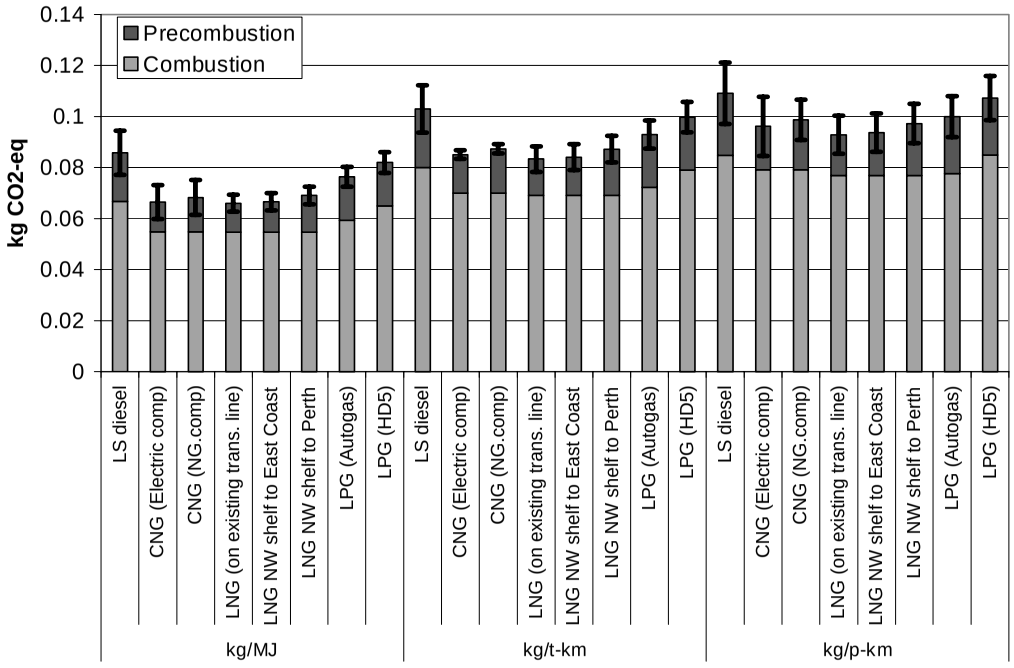

Figure 8.1
Exbodied emissions of greenhouse gases for gaseous fuels. The two CNG scenarios consist of gas compression and electric compression of the gas

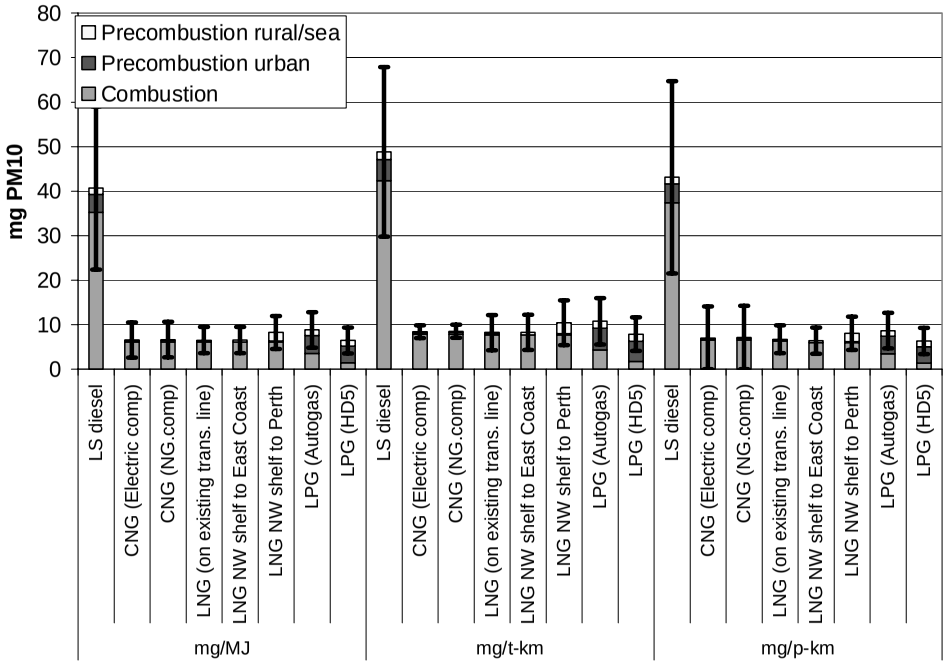

Figure 8.2
Exbodied emissions of particulate matter for gaseous fuels. The two CNG scenarios consist of gas compression and electric compression of the gas

8.2.3 Emissions of oxides of nitrogen

Figure 8.3 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. NOx emissions from CNG are lower than those of LSD.

8.2.4 Emissions of hydrocarbons

Emissions of hydrocarbons for the gaseous fuels are shown in Figure 8.4. In every case, the gaseous fuels have lower hydrocarbon emissions than low sulfur diesel, both on an upstream and tailpipe basis.

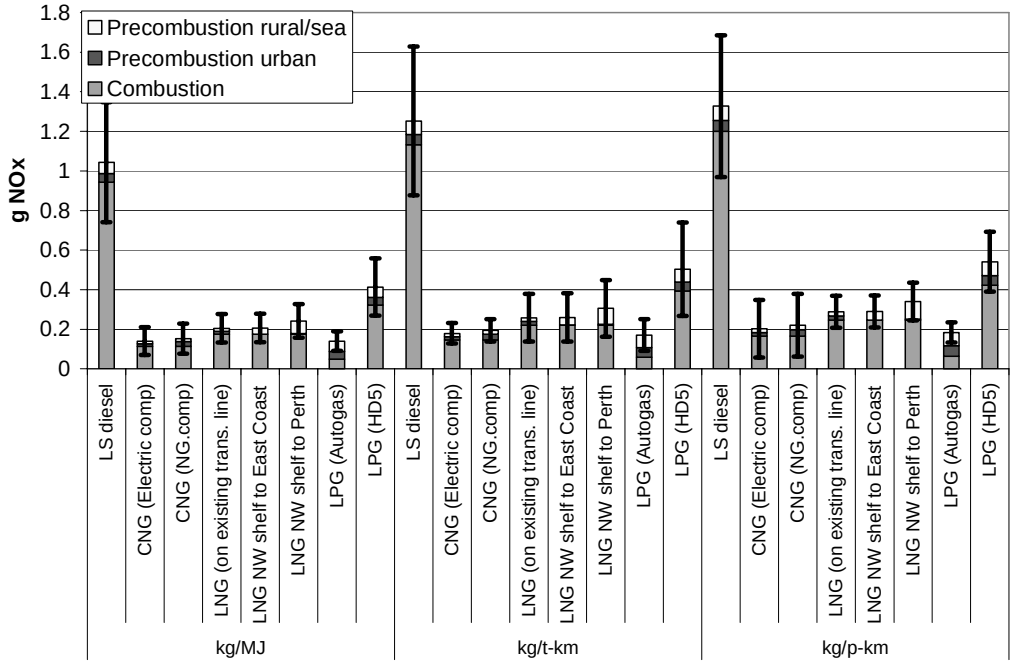

Figure 8.3
Exbodied emissions of oxides of nitrogen for gaseous fuels. The two CNG scenarios consist of gas compression and electric compression of the gas

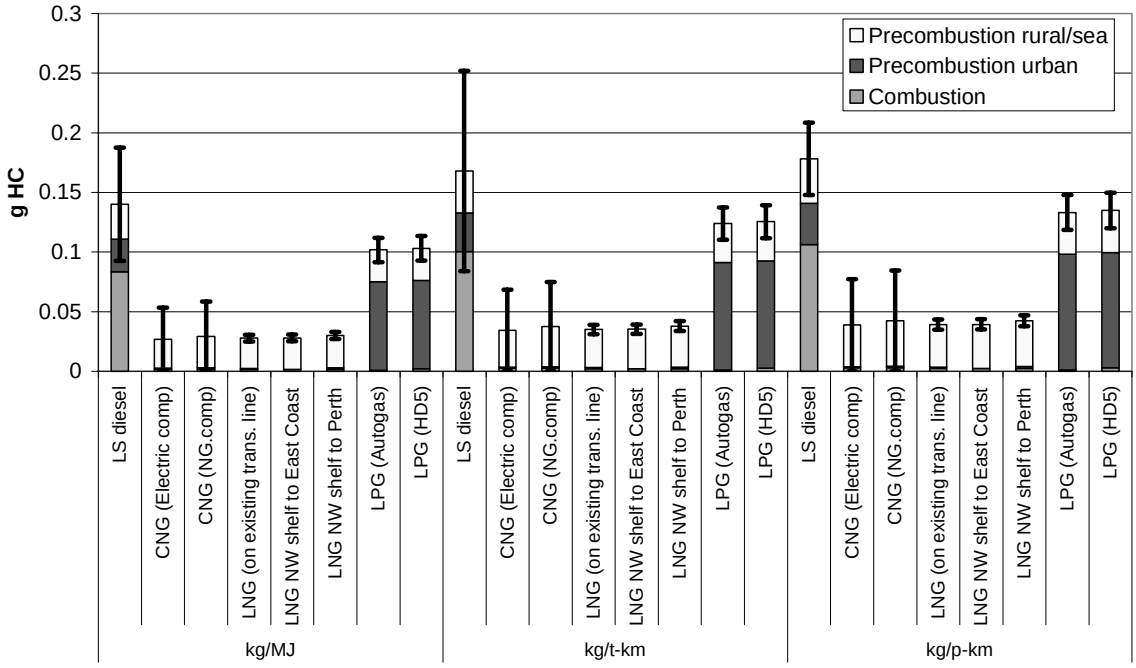

Figure 8.4
Exbodied emissions of hydrocarbons for gaseous fuels. The two CNG scenarios consist of gas compression and electric compression of the gas.

8.3 Viability and Functionality

Due to chronic problems with the engine and fuel system components (of the earlier generation of CNG engines) CNG buses in operation have had a significantly greater defect rate than diesel buses. The industry is confident that these problems have been overcome. Currently there are limited public CNG refuelling facilities, but the industry expects the number of facilities to more than double by the end of 2002.

Australian natural gas is vulnerable to disruption in the gas supply. This was most evident with the Longford incident in 1998 when gas supplies to Melbourne, and much of the rest of Victoria, were halted following the disaster at the Longford plant.

The majority of CNG vehicles in Australia were sourced as new vehicles. However, there has been growing interest in the conversion of conventionally fuelled vehicles to CNG through after-market conversions.

The emissions performance of converted Australian CNG vehicles is unclear due to a lack of comprehensive industry-wide data. The only results available were from one system that was used in a small number of vehicles. That system is currently being upgraded and is no longer sold in the previous configuration. Some tailpipe emissions from the previous configuration were much higher than those for OEM vehicles. It is possible that the difference in emission levels

between converted vehicles and OEMs may decrease as the heavy duty vehicles conversion industry becomes more firmly established.

8.4 Health Issues

CNG upstream emissions of both particulate matter and air toxics are substantially less than LSD. CNG tailpipe emissions of particulate matter are substantially less than LSD. CNG tailpipe emission of benzene, 1,3 butadiene, formaldehyde and acetaldehyde are less than LSD.

On release to the atmosphere CNG is much lighter than air and thus it is safer than spilled diesel. In the case of a CNG leak, because of the gaseous nature of the fuel, the gas will issue as a very high velocity jet into the surroundings, aiding greatly in the rapid dispersion of the fuel.

8.5 Environmental Impact and Benefit

ESD *principles*

Noise levels from natural gas buses are less than those of diesel buses. CNG 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 natural gas.

Sustainability

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

CNG can also be a renewable fuel for vehicles because it can be purified from the biogas extracted from waste treatment facilities.

Groundwater

Being a gaseous fuel, CNG does not impact groundwater.

8.6 ADR Compliance

CNG can be expected to meet all future Australian design rules for all pollutants.

8.7 Summary

8.7.1 Advantages

- CNG has very low particulate emissions because of its low carbon to hydrogen ratio.
- There are negligible evaporative emissions, requiring no relevant control.
- Due to its low carbon-to-hydrogen ratio, it produces less carbon dioxide per GJ of fuel than diesel.
- It has low cold-start emissions due to its gaseous state.
- It has extended flammability limits, allowing stable combustion at leaner mixtures.
- It has a lower adiabatic flame temperature than diesel, leading to lower NOx emissions.
- It has a much higher ignition temperature than diesel, making it more difficult to auto-ignite, thus safer.

- It contains non-toxic components.
- It is much lighter than air and thus it is safer than spilled diesel.
- Methane is not a volatile organic compound (VOC).
- Engines fuelled with natural gas in heavy-duty vehicles offer more quiet operation than equivalent diesel engines, making them more attractive for use in urban areas.
- It has nearly zero sulfur levels and, thus, negligible sulfate emissions.

8.7.2 Disadvantages

- CNG on board a vehicle takes 3 to 4.5 times more volume for storage than diesel.
- It requires dedicated catalysts with high loading of active catalytic components to maximise methane oxidation.
- The composition can vary widely depending on the CNG source, which affects stoichiometric air/fuel ratios.
- Its driving range is limited because its energy content per volume is relatively low as a result of its gaseous state.
- It requires special refuelling stations.
- The extra weight of the fuel tank leads to higher fuel consumption or loss of payload.
- Exhaust emissions of methane, which is a greenhouse gas, are relatively high compared with low sulfur diesel.
- It can give rise to backfire in the inlet manifold if the ignition system is faulty or fails in use.
- Relatively small fugitive emissions of methane can have a significant effect on the exbodied greenhouse gas emissions.