9. Liquefied Natural Gas (LNG)

9.1 Background

Natural gas (NG) is a mixture of hydrocarbons, mainly methane (CH_4). LNG is generally refrigerated to –180^{o}C for liquefaction, and requires vacuum-insulated cryogenic tanks to maintain it in liquid form for storage. Natural gas consumed in Australia is domestically produced from Australian oil and gas fields.

9.2 Results

Three LNG scenarios are examined. The base scenario (marked LNG) is that of piped movement of natural gas that is liquefied at central liquefaction plants. A shipping scenario (LNG to E. Coast) assumes that LNG from the Northwest Shelf is shipped to the East Coast of Australia. The road scenario (LNG to Perth) assumes that LNG is trucked (in LNG road trucks) to Perth from the Northwest Shelf.

9.2.1 Greenhouse gas emissions

Figure 9.1 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 LNG tanks over diesel fuel tanks has been built into these figures.

Exbodied emissions of greenhouse gases are lower from LNG than from LSD under all three scenarios.

9.2.2 Particulate matter emissions

Figure 9.2 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 LNG are markedly lower than those of LSD.

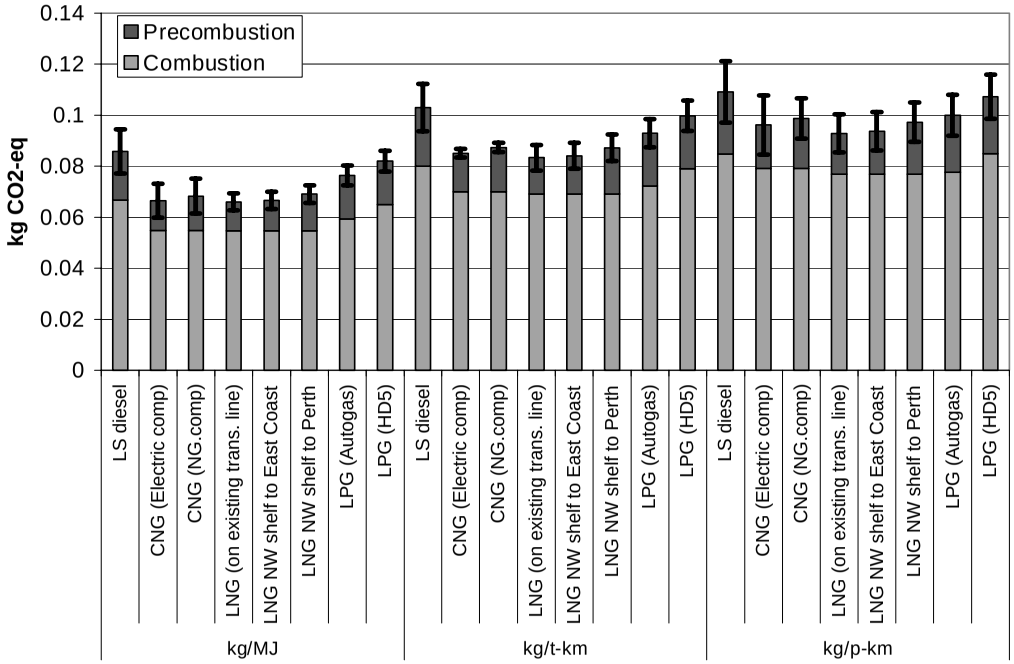

Figure 9.1
Exbodied emissions of greenhouse gases for gaseous fuels

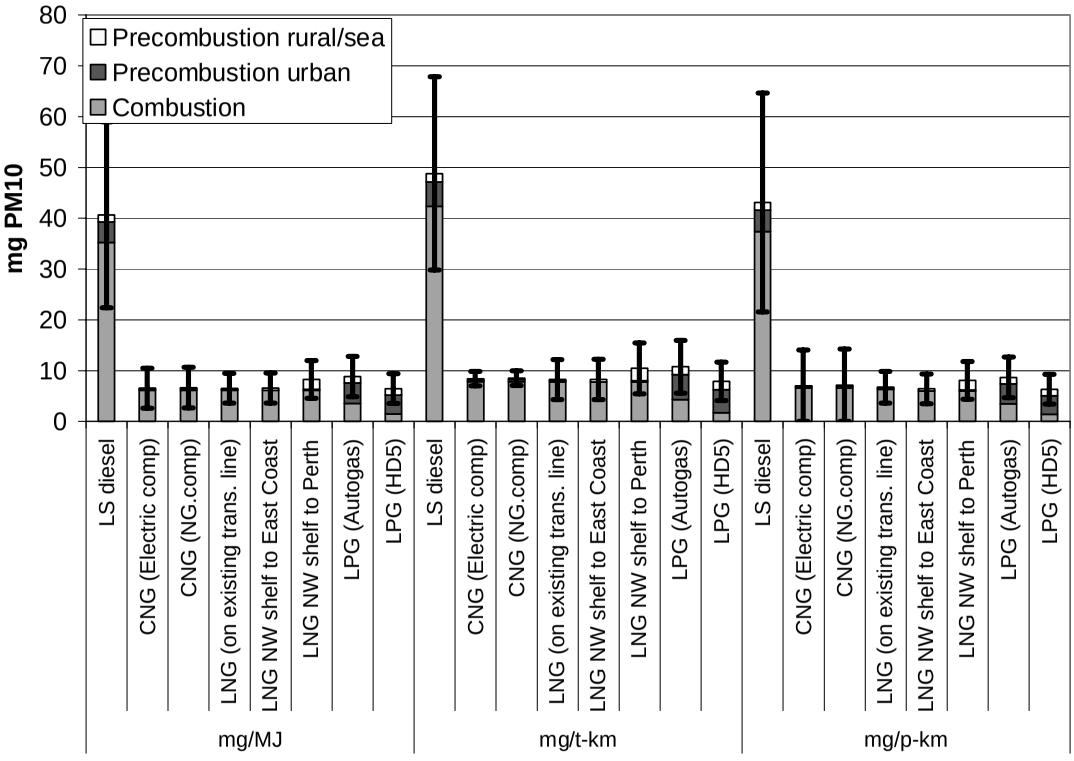

Figure 9.2
Exbodied emissions of particulate matter for gaseous fuels.

9.2.3 Emissions of oxides of nitrogen

Figure 9.3 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.

LNG emissions of NOx are lower than those from LSD.

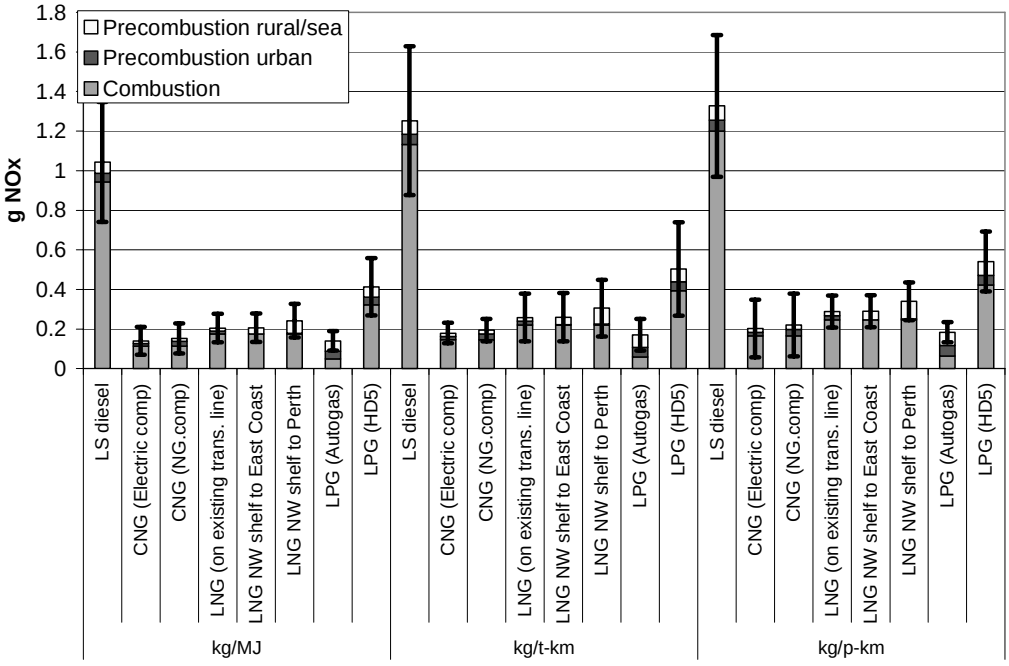

Figure 9.3
Exbodied emissions of oxides of nitrogen for gaseous fuels.

9.2.4 Emissions of hydrocarbons

Emissions of hydrocarbons for the gaseous fuels are shown in Figure 9.4. In every case, the gaseous fuels have lower hydrocarbon emissions than low sulfur diesel, both on an upstream and tailpipe basis.

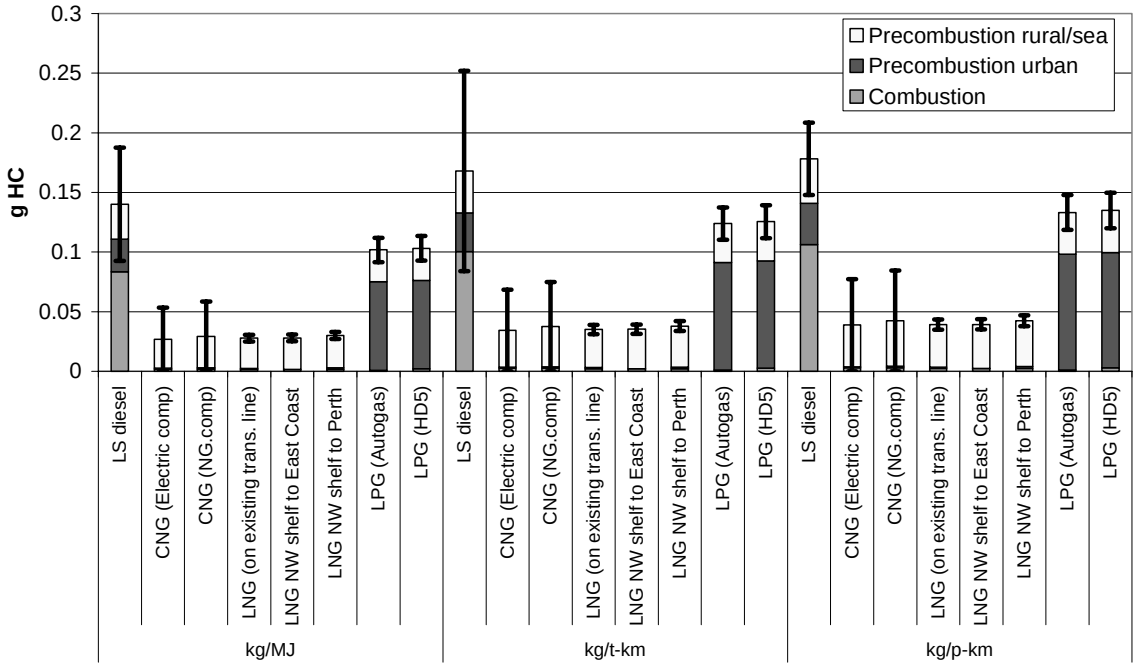

Figure 9.4
Exbodied emissions of hydrocarbons for gaseous fuels.

9.3 Viability and Functionality

LNG buses have the same reliability and operating cost issues as CNG buses. There were problems with earlier generations of heavy vehicle gas engines that appear to have been overcome. LNG vehicles have the advantage of less bulky fuel storage and longer vehicle operating range than CNG vehicles.

9.4 Health Issues

Emissions of particulate matter, some of which is carcinogenic, are almost eliminated with natural gas use. Lubricating oil appears to be the source of remaining particulate emissions. LNG upstream emissions of both particulates and air toxics are substantially less than LSD. LNG tailpipe emissions of particulates are substantially less than LSD. LNG tailpipe emission of THC as well as benzene, 1,3 butadiene, formaldehyde and acetaldehyde are less than LSD.

When released to the atmosphere and evaporated LNG is much lighter than air and thus it is safer than spilled diesel.

9.5 Environmental Impact and Benefit

ESD principles

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

Groundwater

LNG is a gaseous fuel at normal temperature and pressure. Being a gaseous fuel, it does not impact groundwater.

9.6 ADR Compliance

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

9.7 Summary

9.7.1 Advantages

- LNG 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.
- When released to the atmosphere and evaporated 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.

9.7.2 Disadvantages

- There is considerable extra infrastructure involved with gas liquefaction.
- It requires dedicated catalysts with high loading of active catalytic components to maximise methane oxidation.
- 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 and handling of a cryogenic liquid making it suitable only for fleet operations.
- The energy required to liquefy natural gas leads to increased greenhouse gas emissions in comparison to CNG.
- Exhaust emissions of methane, which is a greenhouse gas, are relatively high compared with low sulfur diesel.
- Refuelling time typically is longer than that of diesel.
- It can give rise to backfire in the inlet manifold if the ignition system is faulty or fails in use.

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