Chapter Six

Supply side responses – Alternative fuels from gas, coal and shale

Introduction

6.1 While exploring for more oil in Australian territory may find new resources that will increase self sufficiency in liquid transport fuels, this cannot be guaranteed. Australia is fortunate however in having available a range of other options for meeting transport requirements.

6.2 To some extent, fuel substitution is already taking place. Liquid petroleum gas (LPG) has achieved substantial market penetration in the motor vehicle fleet (currently six per cent of volume), and some biofuels, particularly ethanol, are now marketed as blends with conventional fuels. Overall though, alternative fuels, with the exception of LPG, make an insignificant contribution to Australia's transport energy mix, less than 1 per cent of transport fuel requirements.

6.3 Submissions and evidence drew the committee's attention to a wide range of possible alternative fuels, some derived from fossil sources (gas and coal), and some from biomass. There is also an extensive literature on alternative fuels, including a range of government and independent research reports prepared in Australia and overseas over the past decade or longer that have identified options which could be applied in Australia if required, or if appropriate market conditions existed. Yet with some minor exceptions,[1] in Australia, little has changed. Fossil derived petrol[2] is still the fuel of choice in the light vehicle market, and similarly produced diesel powers heavy transport and off road applications, as it has for decades.

6.4 Most alternative fuel options have already been well canvassed in expert reports such as *Alternative Fuels in Australian Transport*, a report prepared by the then Bureau of Transport and Communications Economics in 1994; in the recent significant report of the biofuels taskforce, and in a range of other publications, all of which are readily available.

6.5 In evaluating alternative fuel options for Australia, the committee is conscious of its limitations in this task. It is not possible for a parliamentary committee with limited expertise and resources to come to a definitive position on such a complex subject. Rather, the aim in the rest of this chapter is to canvass a range of transport fuel options that were particularly drawn to the committee's attention during this

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1 For example, the introduction of fuel standards, and increases in the market share of LPG.

2 That is, refined from conventionally produced oil.

inquiry, highlight those options that appear most viable and to discuss the broad advantages, disadvantages and obstacles to implementation of each, within the framework laid down by the terms of reference.

6.6 In preparing this material, the committee acknowledges and draws on a range of diverse material including submissions, evidence, a selection of the many comprehensive reports referred to in the preceding paragraphs, and some of the research literature that is available on the subject.

6.7 The options the committee has elected to canvass in the remainder of this chapter include:

- substituting gaseous fuels such as LPG, natural gas (methane) or hydrogen for conventional liquid fuels;
- producing fuels by liquefying natural gas or coal; and
- producing oil from oil shales.

6.8 In the following chapter, the committee examines the option of producing a proportion of fuel requirements from biomass.

6.9 In relation to alternative fuels, the terms of reference for this inquiry ask the committee to report on 'the potential of… alternative transport fuels to meet a significant share of Australia's fuel demands, taking into account technological developments, environmental costs and economic costs'.

6.10 Economic considerations (which may or may not include carbon costs) will ultimately decide whether any or all of the alternative fuels options are eventually developed and brought to production. Governments may provide incentives or tax breaks which may encourage the development of particular options, but ultimately, companies will make decisions to invest what must be substantial sums (if there are to be any real inroads made on replacing imported supply) based on their assessments of longer term risks and returns.

6.11 As with petroleum exploration, financial risks associated with unknown future costs and prices (e.g. the long term oil price, the cost of feedstocks, a possible price on carbon) inhibit investment until potential investors consider that risks are sufficiently quantified and returns likely to be realisable before they are willing to proceed. This can mean that action may be delayed past the point where it would be timely, as many of these potential technologies have long lead times. Some point to this as a market failure.

6.12 The long term oil price appears to be the most significant risk factor for companies contemplating alternative fuels developments. Conventional oil has long been cheap energy, and alternatives to it are inevitably more costly than pumping oil out of the ground. These alternatives must compete against oil, and many are only viable if the long term oil price is maintained over a certain level. For example, in the case of coal to liquids (CTL), Dr Brian Fisher of ABARE told the committee that CTL was viable at an oil price of $US40. Similarly, alternatives such as ethanol and biodiesel can only be competitive on an open market if they can be produced and marketed at rates which are competitive with or better than the price of conventional petroleum products. A prime example of this is LPG, the price of which is now sufficiently attractive to provide strong substitution incentives even after the costs of converting vehicles are taken into account, stimulating the development of this energy source.

6.13 In the weeks leading up to the tabling of this report, the long standing issue of climate change associated with the emission of greenhouse gases, particularly carbon dioxide (CO2), has also received intensified attention. While transport currently contributes only 14.4 per cent of Australian greenhouse gas emissions,[3] this is relative and appears of minor importance only because of Australia's large scale use of coal for stationary energy (electricity generation) – it would be higher if more stationary energy was derived from renewables such as hydro, or from gas. Transport sector emissions of CO2 are also growing rapidly, in line with the strong growth of demand for transport. The Bureau of Transport and Regional Economics (BTRE) projects that under a 'business as usual' scenario, transport sector emissions will have risen by 47 per cent in the period 1990 – 2010, and be 68 per cent above 1990 levels in 2020.[4]

6.14 The Australian Government has stated that Australia 'will play an active role in developing an effective global response to climate change'.[5] While a smaller part of the problem, there are possible opportunities in what may be an evolving transport fuels mix to contribute to reducing Australia's emissions. There are also possible pitfalls that must be considered. Different fuel choices can lead to quite different CO2 outcomes, and increasingly, it is becoming clear that this factor may need to be considered as part of any decision making process on future fuel supply options, particularly in relation to any incentives that the Government may decide to provide to encourage the development of alternative fuel options. The committee notes that this is a core message in the IEA's *World Energy Outlook 2006*.

6.15 Several of the alternative fuel sources to be considered, such as coal to liquids and gas to liquids, require substantial energy inputs (and consequently produce CO2 emissions) during manufacture, in addition to that released when they are used. Technologies such as carbon capture and storage are under active development to address this issue and have the potential to reduce the adverse greenhouse implications of some of these technologies if they can be proven viable at a large, commercial scale. The Government has provided substantial funding for this research.

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3 Australian Government, *Securing Australia's Energy Future*, Dept of the Prime Minister and Cabinet, 2004, p. 134 (2002 estimate).

4 BTRE, *Greenhouse Gas Emissions to 2020: Projected trends for Australian Transport*, Information sheet 21.

5 *Securing Australia's Energy Future,* Prime Minister's foreword.

6.16 Other options, such as natural gas, are commonly promoted on the basis that they release less CO_2 when used in place of petrol or diesel, and while this is generally true in the use phase, a 'well to wheels' or lifecycle analysis, (that is, an examination of the total CO_2 or CO_2 equivalents released from the original production phase right through to final consumption), shows that this is not always so.

6.17 If a policy decision is taken by Government to encourage the development of a particular alternative fuel source, it would appear prudent to consider the CO_2 consequences, not just because of how it might affect emissions targets, but also because of possible future carbon pricing and effects this will have on future economic viability of companies developing the resources.

6.18 In a similar vein, biofuels proponents commonly argue that fuels such as ethanol and biodiesel result in substantially lower greenhouse gas emissions because they are derived from renewable biomass. This is true in some cases, however, closer examination reveals that for some biofuels, almost as much or more fossil fuel energy is consumed to produce the fuel as is made available in the fuel itself. This is because of factors such as the use of fertilisers derived from fossil resources (natural gas is used to produce some common fertilisers for example) and conventional diesel to operate tillage and harvesting equipment. Here, consideration of the 'energy return on energy invested' is important.

Gaseous fuels – LPG, natural gas and hydrogen

6.19 Naturally occurring gases such as natural gas, propane and butane, and synthetic gases such as dimethyl ether (DME), can be used in appropriately converted petrol and diesel internal combustion engines as a substitute for liquid petroleum fuels. As such, they offer another option for replacing liquid fuels, should oil supplies become constrained or governments choose to encourage their use for economic reasons such as import replacement or supply security.

6.20 While Australia has limited and declining supplies of conventional oil, it has large reserves of natural gas, which is principally methane. Natural gas wells frequently also contain a range of heavier hydrocarbons, ranging from gases such as propane and butane (the components of Liquid Petroleum Gas, or LPG) to light liquids described as condensate.

6.21 The committee received evidence from a number of witnesses that advocated the use of these gaseous fuels as a substitute for imported oil. Natural gas was also suggested as a bridging fuel to a hydrogen-based transport system.

6.22 Proponents argue that using locally produced gaseous fuels could have significant economic benefits by reducing the impact on the balance of payments that will otherwise result from the inevitable decline in oil self-sufficiency. Proponents also argue that using domestically produced gaseous fuels would improve longer-term energy security by reducing dependence on oil produced in the Middle East.

6.23 Further, they point to environmental benefits of using these fuels, as they generally burn cleaner than oil products and produce less CO2 for each unit of energy supplied.

6.24 The three principal gaseous fuels commonly discussed are natural gas, liquid petroleum gas (LPG) and hydrogen.

6.25 DME is also a gaseous fuel with similar properties to LPG (ie: liquefies readily and at relatively low pressure, without the need to reduce its temperature, unlike LNG) that is suited to use in suitably configured diesel engines, as it has a high cetane number, but as far as the committee is aware, it has not been suggested as an alternative fuel in this country. It can be produced from natural gas, coal or biomass. Considerable work has however been done on this fuel in Scandinavian countries, and in China.

Natural gas

6.26 Natural gas (which is predominantly methane) is used as a transport fuel in two possible forms:

- a compressed gaseous form (typically stored at between 16 and 25 megapascals) known as compressed natural gas or CNG; and
- a refrigerated liquid form (cooled to -163C and stored in cryogenic tanks) known as liquified natural gas or LNG.

6.27 Natural gas can be used in both diesel and petrol engines. Both require extensive modification, but the technology is regarded as mature. Cummins Australia told the committee that it now has in excess of 12,000 gas engines (ie: heavy diesel engines built specifically to operate on gas) in operation around the world.[6]

6.28 Natural gas has both advantages and disadvantages as a transport fuel. Its advantages include its ready availability, gas being reticulated to 70 per cent of Australian urban areas; the extensive pipeline system for distributing it now in place; its relative abundance (although this is disputed); relative price stability; and environmental advantages.

6.29 Disadvantages include the weight and size of cylinders necessary to store the gas on board which in the case of trucks reduce load capacity; limited range (particularly for light vehicles which normally operate on CNG rather than LNG); a considerable energy cost associated with compressing and liquifying gas (where used as liquid natural gas or LNG) and the cost of conversion. For potential users of the fuel, a nationwide lack of refuelling infrastructure appears to be the single greatest obstacle to wider use, particularly for heavy vehicles.

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6 Cummins, *Submission 84*.

6.30 Natural gas use as a transport fuel in Australian light and heavy vehicles is minimal, although the committee notes that a number of companies are trialling the use of natural gas trucks and several public authorities operate natural gas buses. Gas is, however, extensively used in some other countries as a transport fuel, and some countries are planning to expand this use substantially.

6.31 The Asia Pacific Natural Gas Vehicles Association (ANGVA) told the committee that in Brazil, there are in excess of 1 million natural gas vehicles (NGVs) on the road; and that the European Union had set a target for 10 per cent of vehicles to run on this fuel by 2020.[7] In Europe, there are reportedly 575,000 NGVs, of which 375,000 are in Italy, which has used gas as a fuel since the 1930s.[8] Similarly, Motive Energy stated that the market penetration of NGVs was up to 30 per cent in some countries.[9] In Argentina for example, there are reportedly 800,000 CNG vehicles.[10]

6.32 While the committee received a number of submissions advocating the wider use of natural gas as a transport fuel, other evidence cast doubt on whether available reserves are sufficiently large to meet transport fuel requirements.

Natural gas supply

6.33 So, is there enough gas in Australia for it to be used on a large scale as a transport fuel? Natural gas reserves are estimated to be substantial, although there was a wide variation in estimates given to the committee in submissions and evidence, some claiming that reserves are sufficient for over 100 years use. According to Geoscience Australia, which the committee regards as an authoritative source, current and recoverable reserves total 146 trillion cubic feet (Tcf) or 4085.46 billion cubic metres.[11] At current rates of production, this corresponds to a resource life of 65 years.[12]

6.34 These reserves do not include coal seam methane, which is an emerging and potentially large natural gas resource. Coal seam methane resources on the Eastern Seaboard alone have been estimated at up to 400Tcf.[13] The coal seam methane industry is developing rapidly, particularly in Queensland, where it now reportedly supplies 30 per cent of the state's gas requirements.[14] If coal seam methane estimates

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7 Asia-Pacific Natural Gas Vehicles Association, *Submission 75*.

8 Envestra Pty Ltd, *Submission 105*, attached report by Mr O. Clark AM, p. 10.

9 Motive Energy, *Submission 64*, p. 13.

10 Reuters news article, *Natural gas cars a hit in Argentina*, 9 April 2003.

11 Geoscience Australia, *Submission 128*, Table 6, p. 28.

12 Geoscience Australia, *Submission 128*, p. 32.

13 Chemlink Consultants, NSW, http://www.chemlink.com.au/nswchem.htm, as accessed 17 November 2006.

14 Keith Orchison, *Abundance, ease of access make methane attractive*, article in *The Australian* newspaper, 9 September 2006.

are correct and a significant proportion of the resource is readily recoverable, then Geoscience's estimate may be conservative.[15]

6.35 With the exception of coal seam methane, the bulk of Australia's reserves are on the North-West shelf of Western Australia. As such, they are currently inaccessible to the eastern seaboard, where most of the population lives. A large proportion of the WA reserves are also considered 'stranded' – it is not currently economic to recover and use them.

6.36 A further possible obstacle to the wider use of natural gas is doubt about the long-term price. Unlike oil and LPG, which are readily transportable and therefore priced at world parity, natural gas is much less amenable to long distance transport and consequently is not subject to international pricing. Nonetheless, the development of LNG tankers has meant that a world trade in natural gas has developed, and indeed most of the output of the North West shelf is for export. According to some commentators, declining natural gas production in Europe and North America and rapidly increasing demand in China has stimulated a boom in LNG exports. World LNG export/import capacity as been estimated to double by 2010.[16] This has led to concerns that the price will rise substantially and international natural gas pricing may emerge – that is, the Australian price will track the international price.

6.37 Dr Kelly Thambimuthu, CEO of the Centre for Low Emission Technology and Chair of the IEA greenhouse gas R&D program, told the committee that international pricing for natural gas was possible in the near term:

> In relation to the situation with gas that you mentioned, certainly Australia has a lot of gas, but I would argue that a lot of the vast deposits of gas that we have is currently earmarked as LNG exports. Once LNG becomes a tradable international commodity in the world in a big way—and by all estimates the International Energy Agency is estimating that the gas rate is going to grow phenomenally through countries like China, India and the United States, for example, picking up the demand—it will command international prices. We would be left behind in a sense in terms of our own domestic users relying upon traditional sources of gas, on a land based source. How long are we going to be immune from international gas prices? I do not know. But I think it will be a short period of time before we start competing at international levels.[17]

15 The coal seam gas industry has been described as 'burgeoning', and as the main driver of continuing investment in pipeline construction – Australian Pipeline Industry Association, Media release, 16 October 2006.

16 See for example Mr Brian Fleay, *Submission 74B*, p. 4.

17 *Committee Hansard*, 30 June 2006, p. 45.

6.38 Others however dismiss concerns about future gas pricing, pointing out that there is not yet an international price for gas, and unlike petroleum, the price of natural gas in many parts of the world is reliable and relatively stable.[18]

6.39 Mr Kevin Black, representing the Natural Gas Vehicles Group, maintained that the price of gas was much more stable than other fuels, and compared it to the price of diesel:

> … natural gas is the only one of the gaseous hydrocarbon type fuels that does not operate on world parity pricing. Indeed, a lot of the cost of natural gas is regulated by government. For instance, the transmission cost through pipelines is regulated. The retail price of natural gas today is 52c per cubic metre, which is equivalent to 52c a litre for diesel, 47c a litre for petrol and 32c a litre for LPG. The price has gone up since 1996 from 38c to 52c. That is 4.4c for the GST inclusion and the rest is CPI adjustments, and that is all that happens with the price of gas. Sydney Buses, as an example, who are a huge buyer of natural gas for their buses, have a 10 year fixed price contract, which is only adjustable for CPI, and they know today what their fuel is going to cost them in 10 years time. Ask any operator on diesel, 'What are you going to be paying in 10 years time?' and they will just roll their eyes.[19]

6.40 Similarly, the ANGVA said that pricing is stable, and that fleet operators in some cases have fixed pricing contracts as much as ten years in advance. The ANGVA maintained that extensive use of natural gas as a fuel would provide an effective buffer to the effects of international crude oil pricing.[20]

6.41 Mr Blythe of Advanced Fuels Technology Pty Ltd told the committee that stability of pricing was one of the most attractive features of the fuel for fleet users. He thought though that the prospect of excise posed a risk:

> One of the big selling opportunities to the LNG and CNG markets is that the gas companies are able to offer five- and seven-year fixed term price contracts with CPI escalation. That is extraordinarily attractive to a fleet operator who is running on margins of less than 1c per kilometre. The big risk right now, I would say, is the excise regime; that is No. 1. What is helping the industry right now is the Alternative Fuels Conversion Program. It certainly does de-risk it from a fleet-user perspective.[21]

Natural gas vehicles in Australia

6.42 Much of the committee's evidence on natural gas vehicles in Australia focussed on heavy vehicles, concerning which there seems to have been the most

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18 Envestra Pty Ltd, *Submission 105*, attached report by Mr O. Clark AM, p. 2.

19 *Committee Hansard*, 9 June 2006, p. 106.

20 Asia-Pacific Natural Gas Vehicles Association, *Submission 75*, p. 2.

21 *Committee Hansard*, 29 June 2006, p. 3.

operational experience. There was also comprehensive discussion of natural gas vehicles in general.

6.43 In relation to light vehicles and cars, the committee notes that a fledgling light vehicle natural gas industry showed signs of developing in Australia some years ago, but it did not develop. The two largest factors that have prevented development appear to be a lack of vehicle range, and a lack of refuelling infrastructure. These are problems common to both light and heavy vehicles.

6.44 Ford Australia told the committee that it did a number of trials with compressed natural gas cars, but found that the size of the tanks that were necessary to give adequate range significantly intruded on luggage space, and range was limited.[22] Similarly, Honda's dedicated natural gas Civic, which is now sold in several states in the USA, has a range of only 200 miles (320km).[23]

6.45 In Australia, Boral Transport Ltd is one of a number of companies that is using natural gas to power some of its shorter haul trucks such as concrete agitators as part of a demonstration project under the auspices of the Government's Alternative Fuels Conversion Program, which is administered by the Australian Greenhouse Office.[24]

6.46 Similarly, the Murray-Goulburn Co-operative (MGC) has converted 33 of its heavy transport prime movers to LNG, advising the committee that 21 of these conversions attracted 50 per cent funding from the Federal Government Alternative Fuels Grant Scheme, the remaining 12 being fully funded by MGC.[25]

6.47 The MGC, which stated in its submission that it has the largest privately owned fleet of LNG vehicles in Australia, told the committee that it considered that LNG offered significant potential benefits to both light and heavy vehicle operators:

> The benefits to transport operators are real and many, and include:
>
> Economic - reduced diesel costs and operational cost per kilometre, oil change frequency reduced, fuel filter changes reduced, greater export sales and being able to compete at a sustainable level.
>
> Environmental - reduced particulate emission, reduced noise, reduced greenhouse gas emissions.
>
> Social - improved business viability means greater job security and the flow on effects throughout the wider community are potentially very great.[26]

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22 *Committee Hansard*, 11 August 2006.

23 The US Federal Government offers a tax credit of $US4,000 to purchasers of such vehicles - see www.honda.com for specifications and details.

24 Boral Transport Ltd, *Submission 106*, p. 2.

25 Murray Goulburn Co-operative, *Submission 53*, p. 7.

26 Murray Goulburn Co-operative, *Submission 53*, p. 10.

6.48 However, the MGC expressed a number of concerns about its continued use of the fuel, stating that the company is exposed to a significant risk of changing availability and price for the fuel, and the possibility of taxation changes. The MGC also expressed concern that there is currently only one LNG supplier on the Eastern seaboard. The lack of distribution infrastructure appears to be of a lesser concern to MGC as its trucks are depot based, but the lack of infrastructure would severely limit operations over a wider area:

> If however, we were a general freight carrier not operating specific routes, we would be unable to operate freely through any of the normal and highly used transport routes without an extensive infrastructure rollout most particularly at strategic locations up and down the Eastern and across the Southern Seaboard.[27]

6.49 The MGC listed a number of issues that it thought needed to be addressed if the fuel was to be used more in the heavy vehicle industry, including future availability, price and excise on LNG; lack of refuelling infrastructure; and chassis length and weight limits. The MGC listed the following possible incentives that State Governments and the Commonwealth could introduce to encourage the wider use of LNG as a heavy transport fuel:

- vehicle length and weight concessions [to compensate for reduced load carrying capacity caused by the weight of the tank]; and
- continued supportive funding of conversions, technology development, education and training support.[28]

6.50 Boral Transport's experience with natural gas is with CNG powered heavy vehicles, as distinct from LNG. Boral's view was far less optimistic than that of MGC.

6.51 Boral told the committee that the cost of converting trucks was high (in the case of concrete agitators, 25 per cent more expensive than the standard truck)[29] and that it was not an attractive proposition from an economic perspective unless fuel consumption and mileage were very high.[30] Mr Rowlands of Boral told the committee that in the case of the concrete agitators used by his company, the payback period was estimated to be 7½ years.[31] He also highlighted how the lack of refuelling infrastructure acted as a disincentive to the wider market penetration of gas trucks:

> Potential customers, like ourselves, are very reluctant to invest in alternate fuel technology unless they can get the fuel. You would really have to ask why a small operator would go out and put a CNG engine in his truck now. He just has nowhere to fill up. Unless you have a lot of trucks, you cannot

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27 Murray Goulburn Co-operative, *Submission 53*, p. 9.

28 Murray Goulburn Co-operative, *Submission 53*, p. 9.

29 Murray Goulburn Co-operative, *Submission 53*, p. 9.

30 Boral Transport Ltd, *Submission 106*, p. 2.

31 *Committee Hansard,* 9 June 2006, p. 88.

> amortise the cost of your own in-house refuelling station, and you are just going to burn money.[32]

6.52 Boral representatives also confirmed that the extra weight of tanks makes it more difficult for gas fuelled trucks to operate profitably:

> If it costs more to buy the truck and it is heavier, you have higher costs to overcome and the vehicle is going to earn less because it can carry less. That, in many cases, far outweighs the fuel cost, so you are not going to get people wanting to change. It is a simple equation in the transport industry. The more you can carry, the more you get paid.[33]

6.53 Like MGC, Boral called for changes to the allowable mass limits for alternate fuel trucks, identifying this as the 'best incentive':

> The best incentive for take-up of an alternate fuel, including natural gas, is to simply increase the allowable mass limit for trucks using alternate fuels to conventional diesel engine trucks.

Infrastructure limitations

6.54 The requirement for new distribution infrastructure is a major barrier to the introduction of any alternative fuel that cannot be blended with existing fuels. This creates an economic 'chicken and the egg' dilemma in that companies are reluctant to invest in infrastructure unless assured of a customer base and reasonably secure supply; and potential customers will not buy gas cars and trucks if there are no refuelling facilities available.

6.55 In some cases, refuelling issues can be addressed to a limited extent by depot refuelling (such as described by Boral Transport in its submission) or in the case of cars, home refuelling devices such as that marketed by the Fuelmaker corporation of Canada.[34] However, for natural gas to make major inroads into the fuels market, particularly for heavy haulage, much more widely available facilities would almost certainly be required.

6.56 The Commonwealth has previously conducted a number of programs to encourage the take-up of natural gas as a fuel. These include the Alternative Fuels Conversion Program (AFCP) and the Compressed Natural Gas Infrastructure Program (CNGIP). Mr Kevin Black of the Natural Gas Vehicles Group submitted that these programs, particularly the CNGIP, had failed to achieve their aims because of:

> … constant Government policy changes and inappropriate AGO [Australian Greenhouse Office] policy and administration settings… effectively killed off the industry in Australia. No sensible investor was prepared to fund the infrastructure without a secure and supportive policy environment and since

32 *Committee Hansard,* 9 June 2006, p. 91.

33 *Committee Hansard,* 9 June 2006, p. 88.

34 See http://www.myphill.com/index.htm

> 2004, most of the infrastructure that was in place has been wound back or removed.[35]

6.57 Mr Black argued that one factor that had contributed to the program's lack of success was what he considered to be the AGO's flawed administration of the program, which had included a requirement that the refuelling stations put in place had to remain open for three years:

> … so three years and one day later they were gone. Through some financial partners in Singapore, we were prepared to buy all of their natural gas vehicle infrastructure. They had five refuelling stations—three in Sydney, one in Goulburn and one in Canberra—they [AGL] had 50 depot based refuelling stations for a courier company and forklifts and what have you. We said, ‘We’re happy to buy that in a single package and continue to operate it,’ and they [AGL] broke it up piecemeal and sold it off for export.[36]

6.58 A report prepared for Envestra Pty Ltd by Mr O. Clark OAM also said that the Commonwealth's announcements to introduce excise on LGP and natural gas when used as a transport fuel 'put paid to the level of interest that had been generated over many years' in the fuel.[37]

6.59 The committee asked Mr Black what it would take to revitalise a natural gas vehicles program in Australia. He argued that the most effective strategy would be a variant of the previous policy:

> The most effective strategy, I believe, is a variant of what they did before, but instead of paying up-front, providing some form of subsidy for the refuelling infrastructure post installation and requiring them to operate not for three years but for 10 years. The life of a natural gas refuelling facility, be it CNG or LNG, is a minimum of 15 years. Within 10 years of having a comprehensive roll-out of refuelling sites, the calculations we have done indicate that for eastern Australia, Tasmania and South Australia—we have not taken Western Australia and the Northern Territory into consideration at this stage, simply because we do not have enough information—you would need around 800 refuelling sites. That would provide sufficient security of supply to encourage people to buy vehicles, both as fleet operations and as private vehicles.[38]

6.60 Advanced Fuels Technology also put forward a detailed set of recommendations to increase the use of natural gas as a transport fuel:

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35 Natural Gas Vehicles Group, *Submission 119*, p. 3.

36 *Committee Hansard*, 9 June 2006, p. 102.

37 Envestra Pty Ltd, *Submission 105*, p. 16.

38 *Committee Hansard*, 9 June 2006, p. 105.

1. Set a minimum target for the conversion of a percentage of the diesel fleet to operate on Natural Gas (10-15% of all new commercial vehicles being by 2010).
2. Sponsor the development of a strategic corridor of LNG refuelling stations along the Adelaide – Melbourne – Sydney – Brisbane corridor.
3. Fund the introduction of new gas engine technology to the Australian market.
4. Continue to support end-users via the Alternative Fuels Conversion Programme (AFCP) funding of 50% of the conversion cost of a diesel vehicle to enable it to operate on gas.
5. Establish a long-term view of fuel excise to ensure fleet users can confidently invest in new fleets that have a typical life of 5 years or more.
6. Sponsor the development of small LNG and CNG depot based refuelling stations.
7. Implement an Import Duty Regime that will enable products imported for use in the gaseous transport fuels industry to have zero duty.[39]

Environmental impacts of natural gas as a transport fuel

6.61 Natural gas is frequently claimed to be amongst the most environmentally friendly fossil fuels. For example, Advanced Fuels Technology Pty Ltd submitted that natural gas vehicles:

- are up to 30% quieter;
- reduce oxides of nitrogen by up to 90%;
- reduce particulate matter by as much as 99%; and
- reduce Greenhouse gas emissions by up to 17%.[40]

6.62 Some of the published literature confirms that emissions resulting from its use are typically lower than petrol or diesel, particularly in relation to CO2, non-methane hydrocarbons and particulates.[41] The reason it is associated with lower CO2 emissions is because of the physical make up of methane, which is the lowest carbon weight of all fossil fuels. The combustion of one megajoule (MJ) of natural gas will result in the emission of about 40 grams of CO2, compared to 67 from petrol. However, well-to-wheels analysis or full fuel cycle analysis shows a somewhat less favourable outcome.

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39 Advanced Fuels Technology Pty Ltd, *Submission 50*, pp 6-7.

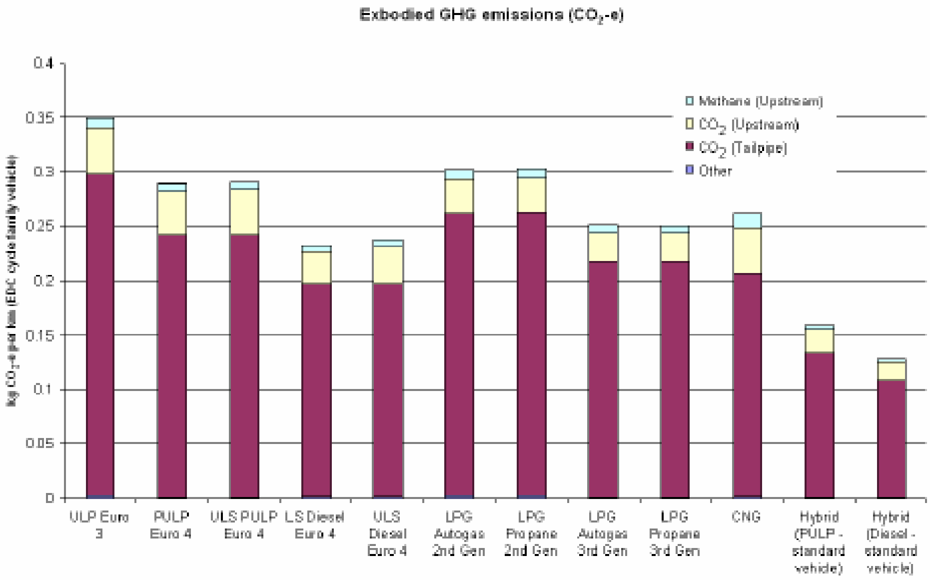
40 Advanced Fuels Technology Pty Ltd, *Submission 50*.

41 For a comprehensive analysis of this subject, see Bureau of Transport and Communications Economics, *Alternative Fuels in Australian Transport*, Information Paper No. 39, 1994, Chapter 7.

This shows a reduction in CO2 of 16 per cent for natural gas compared to petrol.[42] These statistics will vary according to the configuration of engines and their relative efficiency.

6.63 A 2004 study conducted by the CSIRO for the Australian Greenhouse Office showed that on a full fuel cycle basis, for light vehicles, CNG vehicles have lower emissions than petrol or 'second generation' LPG vehicles, but emit more CO2 per kilometre than Euro 4 diesels. Diesels however emit more particulates than any other vehicle class. The following table graphically illustrates the findings of this study.

Figure 6.1 – Exbodied greenhouse gas emissions from family-sized vehicles[43]



6.64 A similar study conducted by CSIRO in relation to heavy vehicles shows that the total greenhouse gas emissions for LNG powered heavy vehicles may be worse than for vehicles powered by conventional diesel. The following graph illustrates the findings in relation to non-bus heavy vehicles:

42 Bureau of Transport and Communications Economics, *Alternative Fuels in Australian Transport*, Information Paper No. 39, 1994, Chapter 7.

43 CSIRO, *Life-cycle Emissions Analysis of fuels for light vehicles*, Report to the Australian Greenhouse Office, May 2004.

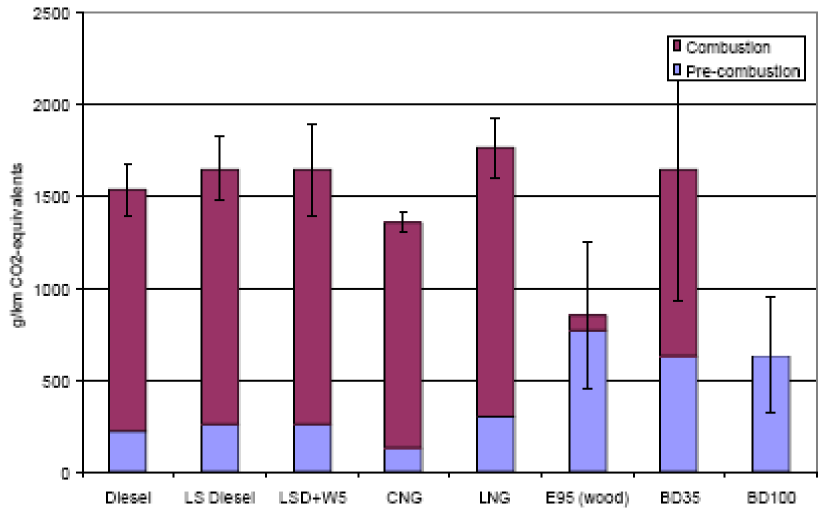


Figure 6.2 – Total greenhouse gas emissions (CO2 equivalents) in g/km for non-bus heavy vehicles[44]

6.65 There are a number of other issues that also need to be considered in relation to the environmental impact of natural gas as a transport fuel. First, energy has to be expended to compress or refrigerate natural gas to make it useable for a transport fuel. In the case of LNG, as the study cited above shows, this energy expenditure apparently cancels out any CO2 advantage over conventional petroleum.

6.66 Secondly, methane itself is a powerful greenhouse gas, so any inadvertent release, for example from fuel tanks or distribution systems, will detract from its advantages over conventional petroleum transport fuels. The Department of Environment and Heritage (DEH) advised the committee that on a life cycle analysis, natural gas has the potential to offer greenhouse gas emissions reductions of up to 20 per cent, but cautioned on the effects of losses:

> However, natural gas is primarily composed of methane, which has a global warming potential 21 times that of carbon dioxide. This means that if not managed, fugitive methane emissions may cancel out the greenhouse gas reductions from the lower carbon content of natural gas and in some cases may give rise to a negative greenhouse outcome.[45]

6.67 Thirdly, natural gas wells themselves frequently contain substantial quantities of CO2 which is generally released in the production process. The Cooper Basin fields for example are 35 per cent by weight and 12.7 per cent by volume CO2;[46]and Gorgon

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44 CSIRO, *Life-cycle Emissions Analysis of Alternative Fuels for heavy vehicles*, Report to the Australian Greenhouse Office, March 2000, p. xvii.

45 Department of Environment and Heritage (DEH), *Submission 171*, p. 3.

46 Bureau of Transport and Communications Economics, *Alternative Fuels in Australian Transport*, Information Paper No. 39, 1994, Chapter 7, p. 114.

field (production from which is planned to include CO2 re-injection and geo-sequestration) contains 13 per cent CO2.[47]

6.68 These findings do not mean that natural gas should be dismissed as a transport fuel on environmental grounds. In some situations, it does appear to offer advantages, but the picture is not as clear or unequivocal as sometimes painted by proponents.

Conclusions on natural gas as a transport fuel

6.69 The committee has altered its view expressed in the interim report, that it would be prudent to put in place measures to encourage the rapid take-up of natural gas in the transport fuels mix.

6.70 From the perspectives of the beneficial impacts on the terms of trade and energy security and as an indigenous replacement for depleting conventional oil stocks, the fuel must be considered, particularly from the perspective of its relative abundance. There are potential economic benefits from using gas for transport. The committee considers that better use can be made of the resource than is currently the case, where most gas is exported.

6.71 The committee is not persuaded by those arguments that supplies are insufficient to make a significant contribution to the transport fuels mix. New and unconventional sources of gas are becoming available (eg coal seam methane) and availability does not appear to be a significant limiting factor within the medium term. Nonetheless, the committee is of the view that consideration should be given to establishing a national domestic gas strategy, to ensure that supplies are sufficient for domestic purposes well into the future.

6.72 From an environmental perspective, consideration is required about whether the gas will be used as fuel, and if so, in what form. Appropriate safeguards would also need to be put in place to minimise possible adverse impacts.

6.73 There are, however, significant obstacles to the wider use of gas for transport. These include a lack of distribution infrastructure, incompatibility with most of the transport fleet, economic penalties for some users if appropriate adjustments are not made, a slow return on investment for some users, and possible consumer resistance from limited range and a lack of a clear price differential from LPG.

Liquefied Petroleum Gas (LPG)

6.74 LPG is comprised of varying proportions of propane and butane. It can be produced as a result of the oil refining process, but also occurs naturally in oil and gas wells, where it can be readily separated out from other gases.

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47 From http://www.chemlink.com.au/gas.htm

6.75 LPG has several significant advantages over other alternative fuels in that there is a high degree of market acceptance of the fuel; vehicle range is between 75 and 100 per cent of that attainable for petrol vehicles[48] (ie: comparable and superior to CNG); and extensive distribution infrastructure is already in place. Unlike natural gas however, LPG is parity priced, and rapid and large fluctuations in the autogas price have been observed.

6.76 Australia is the world's largest per capita user of automotive LPG,[49] and over 500,000 LPG vehicles are now on the roads in Australia[50] and this figure is increasing rapidly, spurred by the Government's recently introduced fitting subsidy. The committee notes the recent Government initiatives to encourage motorists to take up this fuel by paying a subsidy of $2000 for a conversion and $1000 towards the cost of a new vehicle with LPG fitted. This is a major program, which is expected to cost a total of $766.1 million over 8 years.[51]

6.77 The Government's LPG fitting subsidy is expected to substantially increase the use of this fuel, and media reports suggest that there are now long waiting lists for vehicles to be converted. Before the introduction of the subsidy, about 30,000 vehicles per year were converted.[52] The Department of Industry Tourism and Resources expects that 28,800 extra vehicles [ie: a total of about 58,200] will be converted this financial year (2006-07) and 7,200 new LPG fuelled vehicles sold. In 2007-08, this is expected to rise to a total of 42,900 extra vehicles converted over the base rate and 10,700 new LPG vehicles sold, and the number is expected to peak in 2008-09 at 64,000 extra conversions and 16,000 new vehicles sold.[53] Ford report having sold 50,000 dedicated LPG Falcons since 2000.[54]

6.78 The availability of a well developed distribution infrastructure is also a major advantage for this fuel. Over 3,500 filling stations are now available,[55] and there are now sufficient refuelling stations in place for a motorist to drive around Australia.[56]

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48 Michael Gutteridge and others, *Queensland's oil problem: Future considerations for Governments*, in M. Gutteridge, *Submission 76*, p. 23.

49 CSIRO, *Submission 128*, p. 6.

50 Australian Liquefied Petroleum Gas Association, *Media Release*, 13 October 2005, p. 2.

51 Department of Industry, Tourism and Resources, Response to questions taken on notice, 4 September 2006.

52 *Committee Hansard,* 18 August 2006, pp 33-4.

53 Department of Industry, Tourism and Resources, Response to questions taken on notice, 4 September 2006.

54 *Committee Hansard*, 11 August 2006, p. 28.

55 ALPGA, *Submission 91*, p. 5.

56 *Committee Hansard*, 11 August 2006, p. 28 (Mr Scoular, Ford).

6.79 Questions have been raised however about whether Australian LPG resources are sufficiently abundant for LPG to meet a significant proportion of the transport fleet's fuels requirements for an extended period. For example, Michael Gutteridge and others have written that after 2008, the bulk of LPG will come from imported crude oil and from NW Shelf gas fields. He points out that these fields contain a relatively small proportion of propane and butane (around 5 per cent) and that they are propane deficient, requiring the export of excess butane and the importation of propane. Mr Gutteridge pointed out that based on ABARE statistics, Australia produced 107 PJ of LPG in 2001, which compares to a 975PJ energy requirement. He suggests that LPG cannot be produced in sufficient quantities to meet transport energy requirements:

> There is little scope to expand indigenous supplies of LPG especially to meet the quantities required to replace our current demand of 975PJ/a, principally derived from oil, for road transport energy.[57]

6.80 The CSIRO also sounds a note of caution about LPG reserves, submitting that:

> If the Australian oil supply becomes more scarce, then it will be more difficult to source LPG from oil. Thus one would need to look to the gas fields to produce LPG. However, the difficulty with this is that the supply of LPG from gas fields depends on how "wet" or "dry" the gas is. It is possible to estimate present LPG reserves, but not what they would be in the future.[58]

6.81 Others claim that Australian LPG resources are relatively abundant. The Australian Liquefied Petroleum Gas Association (ALPGA) told the committee that it considered that reserves are sufficient to fuel around 1.1 million vehicles, or around 10 per cent of the vehicle fleet.[59]

6.82 ABARE estimates that Australia's demonstrated LPG reserves are currently 210 gigalitres, less than the estimated condensate reserves of 247 gigalitres.[60] Economically demonstrated resources have been estimated to be sufficient to last 34 years at the 2004 production rate.[61] It seems reasonable to suggest that these reserves will diminish more rapidly as more and more people take up the LPG conversion incentives.

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57 Michael Gutteridge and others, *Queensland's oil problem: Future considerations for Governments*, in M. Gutteridge, *Submission 76*, p. 23.

58 CSIRO, *Submission 128*, p. 18.

59 *Committee Hansard*, 9 June 2006, p. 62.

60 Department of Industry, Tourism and Resources, *Energy in Australia 2005.*

61 Department of Industry, Tourism and Resources, Response to questions taken on notice, 12 September 2006, p. 3.

Environmental impacts of LPG as a transport fuel

6.83 Like natural gas, LPG is claimed to be an environmentally friendly transport fuel. The ALPGA claims a saving of up to 20 per cent on CO2 emissions over conventional petrol.[62]

6.84 Independent evaluation of these statistics broadly confirms these claims. While LPG can be used in conjunction with diesel in diesel engines, it is generally considered to be most suited to use in spark ignition petrol type engines rather than diesels, so a comparison with CNG is appropriate. As shown in the graphs produced by the CSIRO in Figure 6.1, greenhouse gas emissions associated with the latest third generation LPG vehicles, which employ more advanced technology than previous conversions, are comparable with CNG. LPG also liquefies more readily than LNG, requiring much less energy in the production and storage processes.

6.85 The picture in relation to other emissions such as carbon monoxide, nitrous oxides and other pollutants is far less clear. CSIRO research has shown wide variations across older and newer vehicles, which were built to different Australian design rules. In relation to the latest Euro-3 petrol engines, the CSIRO concludes:

> The data show that LPG is not the easy clean fuel it was in the time of high emission 'no control' cars. To meet Euro 3, and especially Euro 4, emission specifications requires vehicle and catalytic converter technology to be very tightly designed for optimum performance and minimum emissions. A vehicle designed for optimum petrol performance is very unlikely to be optimised to minimise emissions under LPG use.[63]

6.86 The committee notes that analysis of these issues, in relation to both LPG and natural gas, is extraordinarily complex, and do not lend themselves to either verifying or refuting blanket claims about environmental advantages and disadvantages of various fuels, particularly in relation to non-CO2 emissions.

6.87 The committee commends interested readers to the CSIRO paper, *Life-cycle Emissions Analysis of fuels for light vehicles*, Report to the Australian Greenhouse Office, May 2004[64] for a thorough and up-to-date evaluation of environmental impacts of various fuels; and to the BTCE's paper 39, *Alternative Fuels in Australian Transport*,[65] which contains a thorough if somewhat dated evaluation of a range of other pertinent issues in relation to the use of LPG, natural gas and other fuels.

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62 See for example *Committee Hansard*, 9 June 2006, p. 62.

63 CSIRO, *Life-cycle Emissions Analysis of fuels for light vehicles*, Report to the Australian Greenhouse Office, May 2004, p. 67.

64 CSIRO, *Life-cycle Emissions Analysis of fuels for light vehicles*, Report to the Australian Greenhouse Office, May 2004.

65 Bureau of Transport and Communications Economics, *Alternative Fuels in Australian Transport*, Information Paper No. 39, 1994.

Conclusions on LPG as a transport fuel

6.88 The committee agrees that LPG has the potential to provide an alternative fuel for a proportion of the Australian transport fleet, probably not exceeding 10 per cent. It has a number of clear advantages, not least of which is a well developed distribution infrastructure and apparently good acceptance by consumers.

6.89 Its use has a number of economic advantages for both users, who enjoy substantial fuel cost savings (although parity pricing can influence these), and more broadly in relation to directly substituting an indigenous fuel for one that will increasingly be imported.

6.90 There are some doubts about the extent of future supplies of LPG, although these appear to be adequate for at least a number of decades, depending on the proportion of the vehicle fleet that is converted to operate on it.

6.91 Environmental advantages are reasonably clear, at least in relation to CO2, particularly in the case of modern, third generation conversion technology. The picture in relation to non-CO2 pollutants is less clear.

6.92 Government initiatives to encourage the take-up of this fuel appear to have been extremely successful, and do not need to be expanded.

Hydrogen

6.93 Hydrogen is often put forward as an alternative transport fuel, although it is more correctly described as an energy carrier. Theoretically, a vehicle fuelled by hydrogen would have zero emissions. However, what is often overlooked is that hydrogen does not occur naturally and must be produced as part of a manufacturing process. It can be produced by reforming natural gas, coal or biomass, or by electrolysis, but currently, substantial CO2 emissions accompany all of these methods of producing this fuel. Geosequestration may alter this picture.

6.94 However, hydrogen is generally not regarded as a near-term transport fuel, as there are formidable technical issues to be overcome before it could be widely used. These include:

- the very large amounts of energy required to convert it to a liquid and maintain it in a liquid state, or compress it sufficiently to make it suitable for transport fuel use;
- storage problems arising from its propensity to leak through and embrittle the walls of metal pipes and tanks;
- in cars, large heavy tanks that limit luggage space and provide very limited range;
- in trucks, similar issues to LNG and CNG in relation to weight and volume of tanks and reduced cargo carrying capacity;

- the lack of a source of supply (although it could be produced in volume by reforming natural gas); and
- a complete lack of distribution infrastructure.

6.95 In the committee's view, hydrogen is a fuel that might be considered in the distant future, but is not a useful option to consider in Australia's current or medium term transport fuels mix. Mr Black of the NGVG summed up the argument in relation to hydrogen very well:

> Everybody seems to pinning their hopes on hydrogen, which is still, frankly, pie in the sky. We do a lot of work with the CSIRO and we talk to them fairly frequently. I am on a hydrogen panel with the CSIRO. The greatest fear of hydrogen researchers in this country is that governments and the media will hype it up so much that people will have expectations that will never be met.[66]

Synthetic fuels derived from coal or gas

6.96 Technologies have been readily available for several decades for synthesising liquid transport fuels from either natural gas or from coal. During the apartheid era, South Africa produced all its liquid fuels from coal using the Fischer-Tropsch (F-T) process and still produces 40 per cent of its fuel needs though this process.[67]

6.97 A range of direct substitutes for conventional oil can be produced from coal or natural gas, using a variety of processes and conversion routes. These include synthetic diesel, light hydrocarbons suitable for producing petrol or which can be used as chemical feedstocks, and kerosene.[68] It is also possible to produce a range of other hydrocarbons which can be used as fuels including methanol, dimethyl ether (also known as DME - a gaseous fuel with similar properties to LPG which is suitable for use in appropriately configured diesel engines), and hydrogen.

Gas to liquids

6.98 A number of companies, including Sasol-Chevron, Shell, and ExxonMobil, have either constructed pilot or commercial plants exploiting variations of this technology. Shell operates a 12,500 barrels per day plant in Bintulu, Malaysia and is reportedly planning to construct a 140,000 barrels per day plant in Qatar.[69]

6.99 Sasol Chevron, whose representatives made a submission and gave evidence to the inquiry, advised the committee that it is close to bringing a 34,000 barrels a day

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66 *Committee Hansard*, 9 June 2006, p. 103.

67 Sasol Chevron, *Submission 54*, p. 4.

68 See for example Chemlink Australasia, *Gas to Liquids*, at http://www.chemlink.com.au/gtl.htm as accessed 16 November 2006.

69 *Catalyzing GTL*, Chemical and Engineering News, Vol 81, No. 29, 21 July 2003.

plant into operation, also in Qatar, and has a plant under construction in Nigeria, to be commissioned in 2009.[70]

6.100 The Sasol Chevron company advocated[71] the construction of a FT-GTL diesel plant in Western Australia. While the committee is aware that there have been other GTL proposals (for example, the now abandoned Methanex proposal to produce methanol in Western Australia) the committee has elected to devote most of its discussion to GTL diesel, as unlike others, this product appears to be most suited to seamless introduction into the Australian market, without modification of infrastructure or vehicles. It is also a proposal about which the committee received detailed evidence.

6.101 Sasol Chevron argued that a GTL industry would have a number of benefits for Australia. Among these, it would:

- create a new value adding market for Australia's natural gas reserves;
- develop strategically important gas infrastructure;
- bring new technology and new jobs to Australia;
- reduce Australia's dependence on imported transport fuels;
- reduce diesel air pollution in Australia's urban centres; and
- become a foundation for the emerging global synthetic fuels industry.[72]

6.102 GTL diesel produced from natural gas has the major advantages as an alternative fuel that it is compatible with existing distribution infrastructure, can be blended with conventional diesel, and does not require any modification of diesel engines in the existing vehicle and machinery stock. It also does not require any further refining to make it ready for use. Its zero sulphur content and high cetane rating also facilitate the introduction of higher efficiency diesel engines which are currently emerging in Europe.

6.103 However, the capital cost of constructing a large scale GTL plant is high, with attendant difficulties in attracting the necessary capital. Sasol Chevron told the committee that building a plant to produce 200,000 barrels per day of oil equivalent from natural gas would require an investment of approximately $20 billion.[73] ABARE estimates a capital cost of US$25-40,000 per barrel of daily capacity for a gas-to-liquids plant, compared with US$15,000 for a conventional oil refinery.[74]

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70 Sasol Chevron, *Submission 54*, p. 6.

71 The Sasol Chevron project has been withdrawn. Source: Chemlink Australasia, at http://www.chemlink.com.au/index-info.htm, accessed 16 November 2006.

72 Sasol Chevron, *Submission 54*, p.14.

73 Sasol Chevron, *Submission 54*, p. 11.

74 *Australian Commodities*, June 2006, p. 306.

6.104 According to the CSIRO, GTL does appear to be economically viable, at least in places where the gas price is low. The gas price, and in particular returns that gas producers are able to achieve for LNG, appears to be one of the major factors preventing the establishment of a GTL plant in Australia:

> With the current robust LNG market climate and LNG's long history, GTL must offer a more compelling value proposition to the gas resource holders to be successful. In Qatar and Nigeria, this has been achieved. In Australia, this has not yet happened.[75]

6.105 Representatives of the Department of Industry, Tourism and Resources confirmed that GTL projects so far have tended to be built where there are low gas prices:

> It is very difficult for us to produce at a rate that is comparable with the Middle East—or Qatar in particular. So gas to liquids, some of those other sorts of downstream users, are more likely to go to those sites where they have a much lower cost feedstock.[76]

6.106 Uncertainty about the longer term oil price also appears to be a factor holding back investment in this country and elsewhere.[77]

6.107 Sasol Chevron submitted that the taxation regime that currently applies to natural gas does not favour large scale, long term investments such as its proposal:

> … the current tax and PRRT regime does not facilitate such large, long term capital investments. The Australian fiscal regime is not internationally competitive with regards to capital depreciation and the facilitation of strategic, Greenfield investment. There are a number of mechanisms available which could allow a more competitive payback for the investor without compromising the value return to the nation. These should be considered if there is a desire to better attract GTL investment.[78]

6.108 Establishing a gas to liquids industry may present economic opportunities for Australia by allowing the use of gas resources which are currently uneconomic. A significant proportion of Western Australia's gas reserves are off-shore, and are considered to be 'stranded', in that it is not currently economic to bring the gas on-shore for processing using current technology. The CSIRO points out that if such gas could be brought ashore by converting it into a more easily transported product, then this could result in significant economic benefits. However, the CSIRO noted that there are difficulties relating to the large physical size of FT–GTL diesel plants which make them less suitable for constructing off-shore on gas platforms. Other GTL

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75 Sasol Chevron, *Submission 54*, p. 13.

76 *Committee Hansard,* 18 August 2006, p. 48.

77 Chemlink Australasia, *Gas to Liquids*, at http://www.chemlink.com.au/gtl.htm , accessed 16 November 2006.

78 Sasol Chevron, *Submission 54*, p. 13.

technologies with a smaller physical footprint may be better suited for this purpose. CSIRO advised the committee that it is currently working on a new process involving methane pyrolysis, which will produce synthetic petrol rather than diesel.[79]

6.109 A number of commentators have cast doubt on the future of GTL in Australia, arguing that the price of gas feedstock will be prohibitive, as natural gas becomes subject to international pricing. (see paragraph 6.36ff above).

6.110 From an environmental perspective, GTL products have both advantages and disadvantages. GTL diesel is claimed to be a superior product to conventional diesel, in that it has virtually zero sulphur and aromatics content and a very high cetane number.[80] The principal environmental disadvantages of the fuel are that considerable energy is consumed producing it, and it is still a fossil fuel with comparable greenhouse gas (GHG) emissions to conventional diesel in most applications.

6.111 The extent of CO2 emissions associated with GTL is somewhat disputed. Sasol Chevron claimed that on a well-to-wheels basis, its technology for producing GTL diesel is on a par with conventional oil:

> Sasol Chevron, ConocoPhillips and Shell International Gas commissioned a study by Five Winds International to report on the Life Cycle Analysis of GTL production. The study found that production and use of GTL fuel can contribute less greenhouse gas and reduced emissions to the atmosphere than production and use of conventional diesel fuel.[81]

6.112 The Five Winds study quoted by Sasol Chevron acknowledges that higher GHG emissions are associated with the production phase of GTL, but says that these are offset in the use phase.[82] However, other evidence conflicts with this view. For example, a well-to-wheels study conducted by the Mizuho Information and Research Institute for Toyota in Japan showed somewhat higher GHG emissions for FT diesel than conventional diesel, although this was still below the emissions from conventional petrol.[83]

6.113 Similarly, information provided by the CSIRO shows that the production process (using natural gas as a feedstock) results in the emission of about 1.87 tonnes of CO2 for each tonne of hydrocarbon produced, or 233 kg per barrel, or 1.46 kg per litre, before the fuel is used.[84]

79 CSIRO, *Submission 128*, p. 17.

80 Sasol Chevron, *Submission 54*, pp 7-8 and p. 12.

81 Sasol Chevron, *Submission 54*, p. 9.

82 Sasol Chevron, *Submission 54,* Appendix B, p. 9.

83 Mizuho Information and Research Institute, *Well-to-wheels analysis of Greenhouse Gas emissions of automotive fuels in the Japanese context*, from www.mizuho-ir.co.jp/english/knowledge/wtwghg041130.html, accessed 14 November 2006.

84 CSIRO, response to questions taken on notice, 27 June 2006. (Appendix 3)

6.114 The committee asked the CSIRO to calculate what a theoretical carbon tax of $40 a tonne of CO_2 would amount to per barrel of fuel produced. In the case of FT-GTL, this amounts to $9.20 per barrel.[85] Given the potential importance of the possible price being placed on carbon dioxide emissions to the future competitiveness of GTL and CTL projects, the committee has included the CSIRO's letter at Appendix 3.

Coal-to-liquids

6.115 Coal, of which Australia has vast, accessible resources, can be used to produce a similar range of liquids as the GTL processes described in the previous section. Indeed, some of the processes to produce liquids from coal are very similar to the GTL processes, for example conversion of the feedstock to syngas (a mixture of carbon monoxide and hydrogen) and subsequent F-T conversion using a catalytic process to the desired end products.

6.116 Like GTL, coal-to-liquids (CTL) is established technology,[86] and it is seen by a number of groups within Australia[87] and overseas as a viable method of producing liquid fuels on a large scale in the near future.

6.117 In the United States in particular, the Government has been active in encouraging the development of CTL fuel and has established a fuel tax credit of US 50 cents per gallon (US$21/barrel) for diesel fuel produced from coal using the F-T process.[88] ABARE advised the committee that by 2025, up to 10 per cent of liquid fuels used in the USA will be produced from coal.[89]

6.118 Arguments advanced by CTL proponents include:

- potential to reduce reliance on imported fuel;
- quality of the product – a synthetic diesel which is high cetane and low sulphur;
- the process of conversion is versatile, and a range of other valuable products ranging from fertiliser to hydrogen can be produced if required;
- development of the technology can also provide technologies for reducing CO_2 emissions from the electricity industry;
- a large, accessible feedstock; and

85 CSIRO, Response to questions taken on notice, 27 June 2006. (Appendix 3)

86 Although the Sasol plant in South Africa is the only industrial size plant in the world in operation.

87 For example, the Monash Energy Consortium and the Centre for Low Emission Technology, both of which made submissions and gave evidence.

88 Monash Energy, *Submission 58*, p. 14.

89 *Committee Hansard*, 18 August 2006, p. 53.

- feedstock resources are much larger than natural gas, which may be substantially depleted by 2050.[90]

6.119 According to ABARE, these processes become commercially viable once the long-term oil price is above $US40-45 per barrel.[91]

6.120 Like GTL, the capital investment required for building plants to produce fuels from coal is large. ABARE suggests a capital cost of $US50-70,000 per barrel of daily capacity, which is somewhat higher than a GTL plant.[92] The Monash Energy project submission states that it would cost about $A5 billion to construct a plant capable of producing 60,000 barrels of synthetic hydrocarbon liquids a day, 80 per cent of which would be diesel.[93]

6.121 Critics of CTL technology point out however that from an environmental perspective CTL fuels have very high well-to-wheels CO2 emissions compared to most other fuels. Additionally, in terms of greenhouse gas emissions CTL diesel is equivalent to conventional diesel, as confirmed by Dr Kelly Thambimuthu, CEO of the Centre for Low Emission Technology and Chair of the IEA greenhouse gas R&D program:

> Senator MILNE—To finish that off, even if you got this up and produced it as a transport fuel, its CO2 omissions are going to be equivalent to conventional oil?
>
> Dr Thambimuthu—Yes, that is true, if you use the coal…[94]

Should a price be placed on carbon dioxide emissions at some point in the future, this could affect the price at which the fuel could be produced, and thus the viability of this option for producing fuels.[95]

6.122 It is important to quantify the nature of this potential problem. Information provided to the committee by the CSIRO shows that 3.9 tonnes of CO2 will be produced in the gasification phase, and a further 1.2 tonnes at the FT liquids production phase, a total of 4.3 tonnes of CO2 for each tonne, or 537kg of CO2 per barrel of liquid hydrocarbon fuel produced. Calculations prepared for the committee by the CSIRO show that if a carbon tax was ultimately introduced at $40 per tonne of CO2 emitted, the level of tax applied would be $22.60 per barrel.[96]

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90 Monash Energy, *Submission 58*, p. 7.

91 *Australian Commodities*, June 2006, p. 306.

92 *Australian Commodities*, June 2006, p. 306.

93 Monash Energy, *Submission 58,* covering letter and p. 10.

94 *Committee Hansard*, 18 August 2006, p. 46.

95 Monash Energy acknowledges this – see p. 9.

96 CSIRO, Response to questions on notice, 27 June 2006, p. 1.

6.123 In Australia, CTL proponents are obviously aware of and sensitive to the emissions issue and its potential cost implications. Monash Energy (Monash), a wholly owned subsidiary of Anglo-American, proposes to build a 60,000 barrels per day CTL plant in the Latrobe Valley in Victoria. Monash submitted that this plant is planned to be the first CTL project predicated on carbon capture and storage. The first stage of the plant is scheduled to be commissioned in 2016. The project is based on the availability of the very large brown coal deposits in the Latrobe Valley, and the proximity of the depleting oil and gas reservoirs in the Gippsland basin, where the captured CO2 is to be stored.[97]

6.124 The company claims that this project would have significant economic benefits, including avoiding $80 billion in oil imports over 50 years, spending $20 billion on goods and services (mainly within Australia), and paying $15 billion in corporate income tax.[98]

6.125 The company is understandably concerned about the risks involved, not just in relation to possible carbon pricing, but a range of other factors including the oil price and the legislative environment in which it will operate:

> It is a large-scale investment. One of the things that comes with a large-scale investment is that to manage the risks of that large amount of capital you need to have as much certainty about the future as you possibly can. That includes not just country risk but things such as legislative risk. In being able to install this facility the investors are looking at a very long-term plant. We are talking about something that will run for 50 to 100 years, so it is a very long-term investment project. It has a very high level of capital, but it is reliant on having a long-term understanding of such things as oil price, exchange rate and other effects that might come into play—carbon, carbon pricing.
>
> For us that means that having some certainty about the policies that are going forward is critical to being able to manage the risk of the investment, and it certainly helps to have a firm view on what the legislative environment will be.[99]

6.126 The Monash Energy project incorporates a detailed plan to capture and store the CO2 generated. Monash stated that 'this would be the largest carbon capture and storage project in the world when it is up and running'.[100] It follows that if this feature is part of the project, it would reduce pricing risks associated with carbon pricing, assuming that the capture and storage technology is demonstrated as successful on a

97 Monash Energy, *Submission 58*, p. 9.

98 Monash Energy, *Submission 58*, p. 12.

99 *Committee Hansard (private briefing – Monash Energy)*, 29 June 2006, p. 2. (Mr Cochrane, CEO)

100 *Committee Hansard (private briefing – Monash Energy)*, 29 June 2006, p. 2. (Mr Cochrane, CEO)

large scale. Equally however, if no price is ultimately put on carbon, the project would be placed at a disadvantage to potential competitors unencumbered by this cost.

6.127 The committee sought information about whether this technology has been successfully demonstrated, and what the likely costs of implementing it would be.

6.128 Monash advised the committee that there is a successful project in Norway that captures and stores 2 million tons of CO2 a year,[101] that re-injection is commonly used as an enhanced oil recovery tool in the USA, and that the activities associated with capture and storage have been used routinely by the oil industry for a number of years. Monash also advised the committee that it is participating in a trial CO2 capture and storage exercise in the Otway Basin.[102]

6.129 Dr Kelly Thambimuthu, CEO of the Centre for Low Emission Technology and Chair of the IEA greenhouse gas R&D program also told the committee that the process is well on the way to being proven:

> In fact, it has been practised in many different ways over about 20 years in relation to enhanced oil recovery. Currently, there are three major projects in the world that are actually capturing and storing in the order of three million tonnes per year of CO_2 underground. It is well on the path of being proven.[103]

6.130 The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), which researches the capture and geological storage of carbon dioxide for the purposes of greenhouse gas abatement, also told the committee that this technique has been used in a range of large-scale projects in Norway, Canada and Algeria and is planned for other projects such as the Gorgon project in Western Australia. Representatives also informed the committee that it is in the process of establishing a geosequestration research project in the Otway Basin in western Victoria, which is intended to sequester 50 million tonnes per year of CO2 over a 40 year project life.

6.131 CO2CRC representatives told the committee that their research had shown that in the chosen site, the costs of CO2 capture and storage would be in the range of \$8.50 to \$10.90 per tonne of CO2 avoided.[104]

Comments on GTL and CTL

6.132 The committee considers that from a technical perspective, both GTL and CTL technologies are capable of supplementing Australia's future transport fuels requirements, on a large scale if required. Both use technologies that are proven on a

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101 Sleipner natural-gas platform - CO2 separated from natural gas is re-injected.

102 *Committee Hansard (private briefing – Monash Energy)*, 29 June 2006, p. 7. (Mr Cochrane, CEO)

103 *Committee Hansard*, 30 June 2006, p. 45.

104 *Committee Hansard*, 11 August 2006, p. 17.

commercial scale – there are few unknowns, at least in relation to the gasification and liquids production processes. The resource base for both also appears to be sufficiently large for both to have a place, although this is less certain in relation to GTL. Nonetheless, even for gas, there are large undeveloped resources of stranded gas that may well lend themselves to developments of this kind, if technical obstacles such as processing gas in situ on offshore platforms can be overcome.

6.133 Both technologies offer the prospect of economic advantages, particularly in relation to adding value to resources, trade balances, employment and taxation revenue.

6.134 Further, the products they would produce are compatible with the current vehicle and machinery stock, and with existing distribution infrastructure. The synthetic diesel which both CTL and GTL proponents intend to produce is an ultra low sulphur product and thus has significant environmental advantages over conventional diesels, is ready for use, requires no further refining, and can be blended with conventional diesel. These are major advantages over other alternative fuel options.

6.135 Either technology will require very large capital investments if it is to provide a product stream of sufficient volume to replace fuels that would otherwise have to be imported. The difficulty associated with raising the capital required for such projects in the face of risks that are hard to predict and manage, such as the longer term price of oil, or in the case of GTL, the gas feedstock price, and the possibility of carbon pricing, should not be underestimated. However, this is probably true of any large scale fuel switching program.

6.136 Large scale projects of this type also require very long planning and construction lead times, of at least a decade. There are questions about whether market forces would be sufficient to enable the timely development of such projects, if for example oil supplies were constrained unpredictably by supply-demand imbalances or instability in oil producing countries.

6.137 Both technologies, but CTL in particular, suffer from a number of environmental disadvantages in relation to greenhouse gas emissions. Emissions at the conversion phase are higher than conventional fuels, and in a world that is becoming increasingly concerned about climate change, this cannot be disregarded. The committee notes that a great deal of work is being done on carbon capture and storage in this country and overseas, which if successfully implemented on a large commercial scale, may address this issue.

6.138 On the basis of the evidence the committee received, it appears that there are grounds for cautious optimism that carbon capture and storage technology has good prospects for success. However, the committee also notes the comments in the recently released IEA *World Energy Outlook 2006* that carbon capture and storage has not yet been demonstrated on a commercial basis.[105] The committee notes that the Government is providing financial support for developing and demonstrating this technology, which is likely to be of critical importance if CTL and GTL industries are to proceed in a CO2 constrained world. Demonstration on a commercial scale is essential, and must proceed as soon as possible.

Oil Shale

6.139 Oil shale is a 40 to 50-million year old sedimentary rock which contains a range of organic matter called kerogen. Kerogen is a precursor to oil that has not been subjected to the pressure and temperature regimes over geologic time that are required to transform it into crude oil. Some of the largest deposits of oil shale are located in the United States (in the upper Colorado River Basin), Brazil, Scotland, China, Estonia and Australia.[106]

6.140 Deposits of oil shale exist in the coastal strip between Proserpine and Bundaberg in Queensland. The Queensland Government and others have estimated that this area alone could possibly yield more than 4,629 gigalitres (or approximately 27.774 billion barrels) of oil – which is around 46 times Australia's initial crude oil reserves.[107]

6.141 There are, however, a number of economic, technological and environmental impediments to the commercialisation of oil shale as a future source of oil. Oil shale is surface-mined, and in its natural state does not contain any liquid hydrocarbons. It requires heating and distillation before the shale yields an oil-like product. This process is energy intensive, resulting in a high level of greenhouse gas emissions and other air pollutants such as hydrogen sulphide. The process is also reportedly water intensive.[108]

6.142 Although a number of attempts have been made to produce economically viable oil from shale, so far none have proved successful. The latest attempt to trial commercially viable oil-from-shale was by Southern Pacific Petroleum and its sister company, Central Pacific Minerals. Working on the Stuart oil deposits, the project produced trial quantities of shale oil using a new process developed by a Canadian company, Suncor, a company active in tar sands development.

6.143 The Stage 1 pilot plant began construction in 1998 and was designed to produce 4,500 barrels per day from 6,000 tonnes of shale (1.33 tonnes per barrel). The pilot project involved the shale being mined, crushed and fed into a four stage process which incorporated rotary kilns, similar to those used to manufacture cement. The process involved:

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105 IEA, *World Energy Outlook 2006*, p. 170.

106 Mr Brian Fleay, *Submission 74*, Appendix 2.

107 Queensland Government, *Submission 155*, supporting material, p. iii.

108 Queensland Government, *Submission 155*, supporting material, p. iii.

- a flash dryer operating at 150 degrees centigrade to reduce the moisture content to 8-10 per cent;
- heating to 250 degrees centigrade in a rotary kiln;
- heating to 500 degrees centigrade in another furnace to crack the kerogen to yield hydrocarbons as gases that are then distilled into products as in a normal refinery; and
- the remaining carbonised rock is ignited with oxygen to 750 degrees centigrade in another furnace that provides the heat for the preceding processes.[109]

6.144 A major impediment to the commercial viability of oil shale production is that the volume of overburden removed to access the shale is comparable to the volume of shale mined. In addition, the waste shale from the furnaces expands by approximately 10 per cent and the mine site is not large enough to receive the spent shale and returned overburden. If the project is operated on a large scale, this becomes a large and costly problem.[110]

6.145 Southern Pacific Petroleum, until quite recently, has been having difficulty raising the required funds and the project has effectively been on hold. In November 2006 however, a United States based company, Sandefer Capital Partners, indicated a willingness to advance A$51 million to the project:

> The money is earmarked for both working capital needs and upping the Stage 1 plant to its 4,500-bbl/d design capacity, as well as advancing design and development of Stage 2 – the 'commercial' stage – which would expand productive capacity to some 15,000 bbl/d (as per Suncor's original schedule).[111]

6.146 The committee sought information from several sources about the economics of shale oil production. Dr Brian Fisher, Executive Director of ABARE said that if CO2 emissions are internalised, the cost of producing shale oil is 'about $US70-$US95 a barrel, so shale oil is a long way out of the money at this stage.'[112]

6.147 Mr Lex Creemers, however, said that:

> … world wide only some 5-10 shale oil reserves could be considered economically viable at a price of $US40 per barrel back at 1986 prices… the good news for Australia was that four of those reserves are located in Queensland, so if there were to be any serious development of shale oil, chances are, it would take place here.[113]

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109 Mr Brian Fleay, *Submission 74*, Appendix 2.

110 Mr Brian Fleay, *Submission 74*, Appendix 2.

111 Article entitled *Cavalry Arrives to Help Stuart Project,* www.rigzone.com/news/article

112 *Committee Hansard*, 12 May 2006, pp 17 & 18.

113 Mr Lex Creemers, *Submission* 125, pp 2 & 3.

Committee comments on shale oil

6.148 The committee notes that shale oil could theoretically make a significant contribution towards meeting Australia's transport fuel requirements. However, there are formidable technical issues to be resolved before this is likely to take place. The committee particularly notes Dr Brian Fisher's assessment that shale oil is 'well out of the money at this stage'.