

Greenhouse Implications of Natural Gas Development in Australia

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Explanation of units used in the text

Joule: a unit of work or energy equal to the work done by a force of one newton acting through a distance of one metre. One *newton* is equal to the force required to impart an acceleration of one metre per second per second to a mass of one kilogram.

CO₂-e: carbon dioxide equivalent

MT: megatonne. 1 MT = 1million tonnes

GJ: gigajoule. 1 GJ = 1 billion joules

Exponential units

Symbol	Prefix	Exponential
k	kilo	10 ³
M	mega	10 ⁶
G	giga	10 ⁹
P	peta	10 ¹⁵

1. Introduction

'We need to move from fossil fuels to gas' said Denis Burke, the former NT Chief Minister (*NT News*, 9/6/01, p2), speaking after the Council of Australian Governments meeting in Canberra on 8 June. His comment came in response to the NSW Premier Bob Carr's proposal to set enforceable national greenhouse targets, which the meeting had duly rejected. Queensland Premier Peter Beattie also lauded the greenhouse benefits of natural gas as he envisaged the possibility of Timor Sea gas being piped over to eastern seaboard. At present gas makes up 17% of the overall Australian energy market, whilst 3.1 million Australian households are currently using gas for domestic purposes. With the gas industry set to expand in the next decade, with a whole gamut of development proposals already in train, are these claims credible? Or will the increasing exploitation of Australia's large gas reserves, together with an associated expansion of domestic and overseas energy demand, lead to an overall increase in greenhouse gas emissions? And will the focus on gas deflect attention away from the renewables sector? This paper explores the many sides of this debate and reaches the conclusion that natural gas is more likely to provide additional fuel for the climate crisis, rather than provide a sustainable solution.

2. Overview of existing and proposed gas developments in Australia

Figure 1 depicts the recoverable gas reserves in Australia and current and proposed pipelines - see http://www.isr.gov.au/resources/gas_reform/Gas_Map- March 2001_Proposed-Existing_.pdf

Timor Sea

- Phillips Liquid Natural Gas (LNG) plant proposed for Darwin Harbour will supply possibly up to 9 million tonnes of LNG per annum (Dames & Moore 1998).
- Woodside proposes an LNG plant at Glyde Point for processing Greater Sunrise field gas.
- Shell put up an alternative proposal for the Greater Sunrise Field – an LNG plant now might be built offshore rather than the gas being piped to Bayu Undan then to Phillips' LNG plant (*NT News* 13/8/01).
- The Tassie Shoal Methanol Plant proposed by Methanol Australia would produce 3.45 million tonnes of methanol per annum by 2010 (Methanol Australia Ltd 2001).

- Methanex are hoping to build the world's largest methanol facility in Darwin Harbour, which would produce 2 million tonnes of methanol per annum.
- GTL Resources propose a methanol plant for Middle Arm.

North-West Shelf

- The Woodside JV has approved a fourth train at its LNG plant on Burrup Peninsula WA, which will add a further 4.2 million tonnes per year to 2000 production of approx 7.5 million tonnes (Woodside www.woodside.com.au)
- A major LNG proposed development, the WAPET \$9 billion Gorgon LNG venture will tap into 5 gas fields that have been discovered some 400km to the west of the present North West Shelf fields (Roarty 1998). The LNG facility is proposed for the Burrup Peninsula (Pilbara Development Commission www.pdc.wa.gov.au).
- Syntroleum Corporation proposes a synthetic hydrocarbons (syntroleum) plant for Burrup Peninsula (Environmental Protection Authority 2000).
- NW Shelf gas will also supply a large number of mineral and petroleum processing projects such as the BHP iron plant in Port Hedland and five power stations in the Pilbara and Goldfields (North West Shelf Gas 2000 www.nwsg.com.au).

Other

- Major proposals include the possible building of a number of large pipeline transmission projects enabling gas to be transported from the PNG highlands to North Queensland, from the Timor Sea to south-east Australia via Moomba with connections to Gove and Townsville, from the Gippsland Basin in Victoria (Longford) to Tasmania, from the Otway Basin in Victoria to Adelaide, plus a couple of extensions to existing networks in WA (see map).
- 19 gas-fired power stations are either under construction, in the planning stages or under early evaluation (see Table 1). A further four expansions of existing stations are being mooted. In addition to the proposals outlined in Table 1 there are a number of others being bandied about for places like Broome, Geelong and Bell Bay, Tasmania. The Australian Gas Association has also supplied information about two more in South Australia: Origin Energy - 95 MW at Quarantine; Origin Energy - Extra 40 MW at Labroke Grove.
- Bass Strait production by the BHP-Esso JV is projected to increase by 80% by 2004 (Energy Information Administration www.eia.doe.gov).

3. Greenhouse implications of natural gas

Industry and Government sources regularly point out that the carbon dioxide emissions from burning natural gas are significantly lower than emissions produced from coal and oil. Roarty (1998) provides the following emissions factors for various fuel types (expressed in kg of CO₂ per GJ):

Natural gas - 55
 Petroleum - 68
 Black coal - 91
 Brown Coal - 95

The actual figures can vary depending upon the CO₂ content of the natural gas, which can range from 0% in the Amadeus field in the NT to 26% in some parts of the Evans Shoal gas field in the Timor Sea. Natural gas contains a very high proportion of methane (around 85-90% for most gas supplied in Australia) (Australian Greenhouse Office 1998). Methane has a global warming potential 24.5 times higher than that of carbon dioxide (Dames & Moore 1998). Nevertheless, in the process of extracting, distributing and consuming natural gas it is primarily the CO₂ emissions we should be concerned about. For example the Phillips LNG Plant proposed for Darwin Harbour will emit 1.8 megatonnes (MT) of CO₂-e per annum, of which 98% will be in the form of CO₂ (Dames & Moore 1998).

Table 1: Proposed New Gas-Fired Power Stations 2000.

Source: Electricity Supply Association of Australia 2001, p59.

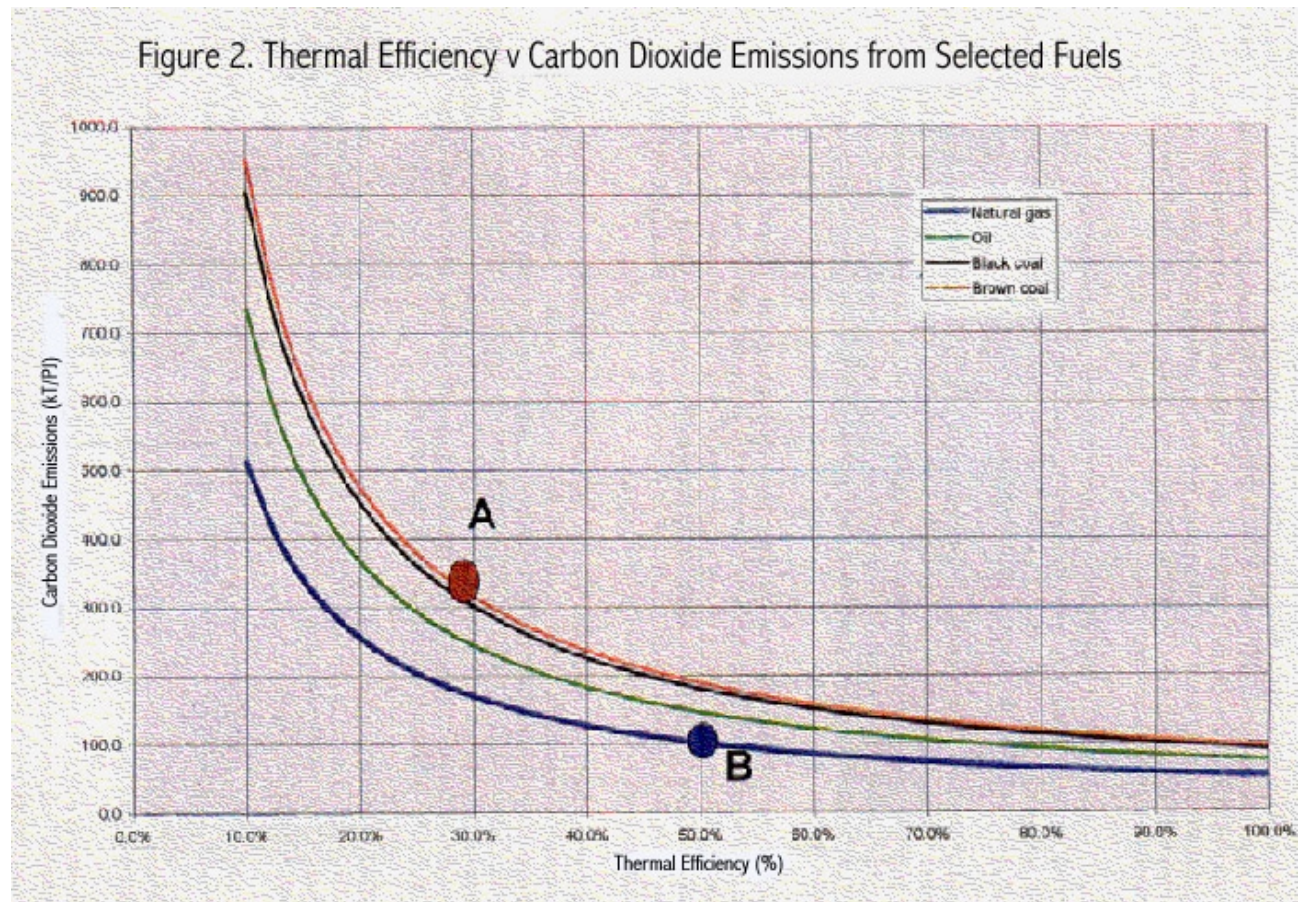
Developer	MW	Type	Location	Status	Proposed commission year
New South Wales					
Eraring Energy	350	CCGT	Illawarra	Under evaluation	
Eraring Energy	100	CCGT	Wagga Wagga	Under evaluation	
Delta Electricity	700	Steam	Munmorah	Planned refurbishment	
Victoria					
Duke Energy	43	GT	Bairnsdale	Construction	2001
Mission Energy	320	GT	La Trobe Valley	Planned	2002
AGL	150	GT	Somerton	Planned	2001/02
Paperlinx/Duke Energy	200	Cogen	Maryvale	Under evaluation	2002/03
AES	500	GT	S.Ballarat	Under evaluation	2002/03
Queensland					
CS Energy/SEAP	380	CCGT	Swanbank E.	Construction	
Stanwell	766	CCGT	Townsville	Planned	2001/03
ERM Power/AIDC	450	GT	Wambo (Kogan)	Planned	
South Australia					
Origin Energy	100	GT	Torrens Island	Planned	2001
Australian National Power	65	GT	Mintaro	Planned expansion	2002
Australian National Power	40	GT	Dry Creek	Planned expansion	2002
AGL	200/250	GT	Hallett	Planned	2002/03
Australian National Power	250/300	GT	Pelican Point	Planned expansion	2004
Australian National Power	230	GT	Port Pirie	Under evaluation	
Auspine	60	Cogen	Tarpeena	Under evaluation	
ATCO	180/200	GT	Osborne	Expansion under evaluation	
Western Australia					
Siemens AG	400	CCGT	Pilbara	Under evaluation	
TransAlta	470	CCGT	Oakajee	Under evaluation	
DESTEC Energy	660	GT	Dampier	Under evaluation	
Australian Capital Territory					
AGL	90/300	GT	Canberra	Under evaluation	

Cogen - Co-generation
CCGT - Combined cycle gas turbine
GT - Gas Turbine

Gas-fired power stations emit less CO₂ than coal or oil-fired stations, although exactly by how much depends upon the type of gas-fired station. There are three main types – the steam boiler, the gas turbine and the combined cycle – all of which are currently used in Australia. The first two are approximately 20% more CO₂ intensive than combined cycle plants (Bureau of Resource Sciences 1998). The Geraldton gas-turbine station emits 52.5 kg CO₂/GJ compared to the Gladstone black coal station, which emits 92.1 kg/GJ, or oil fired stations, which emit around 70 kg CO₂/GJ (Australian Greenhouse Office 1998). A study by Energetics Pty. Ltd. for the Australian Gas Association claimed that over the power generation life cycle from extraction to end use (otherwise known as the full fuel cycle), greenhouse emissions from a large gas fired electricity generator would be approximately 38% less than from an average black coal generator (Australian Gas Association & Energetics 2000). This was assuming that there was minimal or zero use of a distribution network. When use of a distribution network was taken into account, natural gas still had a lower full fuel-cycle rate of emissions than various coal sources. These types of gas-fired generators are generally smaller and emit 10% more greenhouse gas per GJ of energy than larger gas-fired generators.

The most efficient natural gas turbines are the combined cycle plants where hot exhaust gases are used to raise steam in a waste heat boiler. In the Energetics study, best practice combined cycle gas turbines were said to produce 57-64% of the emissions produced from black coal fired stations over the full fuel-cycle (Australian Gas Association & Energetics 2000). Combined cycle gas plants also have the potential to generate electricity at a lower cost than new coal-fired power stations (Bureau of Resource Sciences 1998). As depicted in Figure 2 a typical combined cycle gas turbine (B) has a thermal efficiency of 50% and CO₂ emissions of 103000 tonnes CO₂/PJ compared to 28% and 340000 tonnes CO₂/PJ for a typical brown coal power station (A). Thermal efficiency is the ratio of the net work output to the total heat input. Note, however, that further increases in the thermal efficiency of natural gas plants would not significantly reduce greenhouse gas

emissions (Bureau of Resource Sciences 1998). And unfortunately, Table 1 demonstrated that the majority of proposed gas-fired stations will be gas turbine ones rather than best practice combined cycle.



There was very little evidence of fuel substitution occurring during the 1990's. Net greenhouse gas emissions in Australia in 1998 totalled 455.9 MT CO₂-e (Australian Greenhouse Office 1998). Of this total, 42 MT came from natural gas combustion, up from around 30 MT in 1990. This represents an increase of 40%. Meanwhile, coal still increased from just under 150 MT in 1990 to 185 MT in 1998, an increase of 27%. And overall emissions from the Stationary energy sector increased by 25%.

Fugitive emissions from natural gas, which are inadvertent leakages occurring during the process of extraction and distribution, amounted to almost 4 MT in 1998. This is clearly significant, although negligible in the context of emissions from electricity generation and a slight decrease on 1990 levels, although fluctuations have occurred from year to year.

The Energetics study also looked at the greenhouse benefits of direct gas supply to households and commercial customers for water and space heating. A 3-star rated gas water heater using direct gas supply emits approximately 44% of the greenhouse gas emissions that would be released from an electric heater using NSW black coal (Australian Gas Association & Energetics 2000). Similarly, direct gas supply space heating produces 88.4 kg CO₂-e per GJ of delivered heat compared to emissions of 129-192 kg for electric heating from gas-fired generation and 276-379 kg from coal-fired generation. Thus there are some greenhouse benefits to be had if people switch to direct gas supply. According to the Australian Gas Association, around 95000 new consumers a year choose to connect to gas (www.gas.asn.au). Nevertheless, the consumption of gas is still highly skewed towards supplying the needs of industry. Eighty five percent of Australia's gas supplies are taken up by less than one percent of customers, comprised of large industrial users and power generators (www.gas.asn.au).

Projections

Natural gas consumption in 2009-10 is projected to be 1642 PJ by the Australian Gas Association, or around 25% of the overall energy market (up from 17% currently) (www.gas.asn.au). This represents a 90% increase on the 1998 level of consumption (860 PJ) so, if left unchecked, and even taking into account future increases in the thermal efficiency of gas-fired power stations, CO₂ emissions from natural gas might also be expected to increase by close to 90% by 2010. Total energy consumption in 2014-15 is projected by ABARE to reach 6087 PJ from 4528 PJ in 1998 – a smaller increase of around 33% (ABARE 1999).

Australia's estimated recoverable gas reserves in December 1998 amounted to 109051 PJ, sufficient to meet current production rates for 91 years (www.gas.asn.au). The Carnarvon Basin (NW Shelf) and the Browse Basin off the Kimberley account for 79% of these reserves. **If all of Australia's recoverable natural gas reserves are consumed there will be an additional 5998 MT of CO₂ emitted into the atmosphere, or around 13 years worth of Australia's 1998 net emissions.** Exploitation of Timor Sea gas alone, with an estimated 22 trillion cubic feet of natural gas reserves (*NT Business Review* June 2001, p10), would contribute 1353 MT of additional CO₂ (1). The Suzuki Foundation (2001) has made comparable projections for Canada and demonstrated that the exploitation of new gas reserves would make it all but impossible to meet the country's Kyoto emissions reduction target.

4. Case Studies

Proposed Phillips LNG Plant for Darwin Harbour

As previously mentioned, the higher the carbon dioxide content of natural gas the higher the greenhouse gas emissions tend to be. The natural gas that will be fed down the proposed pipeline from the Bayu-Undan field in the Timor Sea to the plant proposed by Phillips at Wickham Point in Darwin Harbour contains 6% carbon dioxide (Dames & Moore 1998). Despite having a lower CO₂ content than the natural gas that will feed the proposed WAPET LNG plant in WA, where the CO₂ level reaches as high as 12-15% (Fleay 1999), the Darwin Harbour plant will still emit a high level of greenhouse gas.

Total CO₂-e emissions from the plant are estimated at 1.8 MT per year, or 0.3% of Australia's 1994 emissions (Dames & Moore 1998). Over half of the 1.7 MT of carbon dioxide to be emitted every year will be produced during the process of combustion from gas turbines and heaters. Methane will be emitted through the process of flaring. The plant will also discharge substantial amounts of nitrogen oxides, around twice the National Health and Medical Research Council guidelines. Phillips, however, ruled out the use of dry-low-nitrogen oxides (DLN) turbines to reduce the levels of these extremely potent greenhouse gases for a variety of technical and cost reasons (Dames & Moore 1998: 7.26-27).

When producing LNG, carbon dioxide and other impurities need to be removed either before or during the process of liquefaction. Phillips argues that the percentage of carbon dioxide in the Bayu-Undan gas is not significant enough to warrant removal before it is piped onshore. Carbon dioxide will therefore be removed at the Phillips plant through contact with a liquid solution of methyl-diethanolamine (MDEA) then released through the Amine Treatment Plant chimney. But removal of the carbon dioxide from the gas turbine emissions, whilst technically feasible, is not considered an economical option by the company 'as no suitable market or disposal options are available' (Dames & Moore 1998: 7.29). Phillips therefore came up with no specific proposals to utilise or store carbon dioxide, only offering an assurance that it would investigate further should these options become economically viable. It also pronounced that it would minimise the use of flares and regularly conduct audits and reviews of its greenhouse gas emissions.

Woodside's LNG Plant expansion at Burrup Peninsula WA

Currently at the Woodside plant, around 60% of the 5 MT per annum CO₂-e emissions occur during the process of combustion from the various heaters and gas turbines. The proposed fourth and fifth trains would increase overall emissions by 2.9 MT per annum, or by 60%, whilst increasing production by 107% (Woodside 1998). Unlike Phillips, Woodside plans to introduce steam turbines and steam-utilising helper motors to reduce greenhouse gas emissions. It also plans a number of other abatement measures, including recycling the 'flash gas' produced when CO₂ is removed from the natural gas by the Sulfinol absorbant. Together these measures would improve the greenhouse gas efficiency of the planned new liquefaction trains

from 0.32 tonnes of CO₂-e per unit of hydrocarbon product to 0.23 tonnes (Woodside 1998). Woodside claims that even its existing trains are 48% more greenhouse efficient than conventional LNG train designs used around the world (www.woodside.com.au). Woodside estimated the extra cost of these emission reductions at \$10 million, which seems a very small price when you consider the overall cost of the fourth train alone is \$2.3 billion. At the same time it will be increasing the overall energy efficiency of the plant.

Proposed Synthetic Hydrocarbons (Syntroleum) Plant, Burrup Peninsula, WA

The Syntroleum process converts natural gas into synthetic liquid hydrocarbons for products such as synthetic lubricants and drilling fluids. It can be used directly itself or combined with lower quality crude oil derived fuels. According to the Syntroleum Corporation (US), the inventor of the gas-to-liquids (GTL) process, syntroleum 'has the potential to convert a significant percentage of the world's estimated proved and potential gas reserves – estimated to be upwards of 14,000 trillion cubic feet of natural gas – which today hold little or no economic value, into several hundred billion barrels of oil equivalent of great economic value to the companies and countries that control them' (www.syntroleum.com).

The WA EPA's report on the proposal concluded that heat recovery measures and other process improvement measures would result in a saving of approximately 54% of the 1990 'Business as Usual' emissions level - from 2.5 MT per annum CO₂-e for the 1990 pilot plant to 1.16 MT per annum (EPA 2000). Some of Syntroleum plant's power may be supplied to a proposed desalination plant, thereby reducing the need for this facility to source additional natural gas. The EPA considers that this would be a 'beyond no regrets' greenhouse saving. The company also argues that the synthetic lubricants produced can lead to 1-3% better fuel economy in vehicles. Moreover, significant amounts of carbon will be 'locked up as products' instead of being released into the atmosphere if the gas were burnt. However, the company did not specify the actual amount.

Methanol Production

Methanol producers tend to make the same claim for their alternative fuel, which is used in the manufacture of silicone, paints, resins, adhesives and automotive fuel enhancers. But these products do not lock up the carbon indefinitely. It simply takes longer for the greenhouse gases to be released to the atmosphere. In the meantime methanol production still leads to very high greenhouse gas emissions, as ideally the process requires a natural gas feed with a CO₂ content of 22-23%. If the same natural gas is used to fuel the turbines then emissions escalate. This would certainly be the case with the proposed off-shore Tassie Shoal project in the Timor Sea where the feed gas for the turbines from Evans Shoal contains 18-26% CO₂ (Methanol Australia EIS Consultant, presentation to NT Chamber of Commerce and Industry, Darwin 17/8/01). Methanol can also be used in gas turbines and fuel cells, the latter holding promise for the transport sector (see below).

5. The technical fix? – carbon dioxide sequestration

One potential method of reducing greenhouse gas emissions from natural gas development in Australia is carbon dioxide sequestration. Basically this would involve pumping CO₂ underground into deep saline reservoirs and depleted oil and gas reservoirs. The CO₂ can also be re-injected for use in enhanced oil recovery or coal bed methane recovery. Currently, only one company, Norwegian-owned Statoil, stores supercompressed CO₂ from its natural gas operations underground in the North Sea. Statoil spent \$80 million on the separation and disposal facility and has been re-injecting 1 MT of CO₂ per year into an aquifer 1km below the seafloor (Monastersky 1999). The International Energy Agency has estimated that aquifers worldwide could accommodate 350 years worth of emissions at present rates (Monastersky 1999).

In Australia, a new Australian Petroleum Cooperative Research Centre CO₂ sequestration research project called GEODISC has the support of the LNG industry (www.apcrc.com.au). The APCRC claims that geological sequestration can potentially absorb 60 GT of CO₂ in 49 sustainable sites. This would take care of all of Australia's CO₂ for the next 1000 years (The Parliament of the Commonwealth of Australia 2001). According to the Research Program Manager, once underground the CO₂ will dissolve or form other minerals. A trial is expected to go ahead within the next two or three years (*The Canberra Times* 5/7/01).

Phillips argued that no suitable structures for CO₂ re-injection were found in the vicinity of its potential platform sites in the Timor Sea. The closest would be 10km away and there was a risk that this would not seal properly. Moreover, the ocean was too shallow to prevent re-emergence and biological impacts. It also cited prohibitive costs as a reason for not pursuing this option. Current cost predictions by the APCRC are in the range of \$10 to \$25 for each tonne of CO₂ disposed of (The Parliament of the Commonwealth of Australia 2001). Similarly, Methanol Australia's EIS Consultant explained that this option would make the Tassie Shoal plant uncompetitive relative to developing country producers. He estimated that the disposal facility would cost \$100 million to construct and \$10 million a year to operate (presentation to NT Chamber of Industry & Commerce, Darwin 17/8/01). Woodside, in its PER for the NW Shelf LNG facility expansion also rejected the ocean disposal option for CO₂ separated off during the liquefaction process (Woodside 1998). It acknowledged that this was technically feasible but said it would add an economically prohibitive 10-20% extra onto the total project cost. However, the company has incorporated some gas re-injection technology on a couple of its offshore oil and gas sites and claims that this will save an overall amount of 12 MT of CO₂-e (www.woodside.com.au).

6. A Transition Fuel?

The Commonwealth Senate Inquiry into Australia's greenhouse future last year presented the following arguments with respect to whether natural gas should be treated as a transition fuel on the path beyond fossil fuels (The Parliament of the Commonwealth of Australia 2000). The Gas industry claimed that natural gas would displace coal as it gained a higher share of the energy generation market. Woodside argued that 20 MT of CO₂-e would be saved in Japan if their LNG plant expansion went ahead. AGL asserted that the gas pipeline from the PNG highlands would save 88 MT by 2010 and around 11 MT per year thereafter. Clive Hamilton from the Australia Institute argued that gas would be the transitional fuel for the next 20 years or so, until emissions targets become even more stringent, as they must do if CO₂ levels are to eventually stabilise. Current proposals to pipe natural gas from the Timor Sea to southern Australia as well as over to Queensland would further integrate the national energy market and allow natural gas to compete with coal. Moreover, the greater availability of natural gas would enable additional investment in new coal-fired power stations to be more easily deferred.

On the other hand, NSW energy producer Pacific Power argued that natural gas was not the answer to meeting Australia's greenhouse commitments (Commonwealth of Australia 2000). Gas would be unlikely to replace existing coal-fired plants in an industry characterised by high capital costs and long life assets. Coal-fired power station costs are dominated by capital costs – fuel costs are lower than natural gas combined cycle plants (under 40% of the cost in the case of brown coal). In a deregulated environment the electricity industry will tend to fully utilise existing plants rather than bear the cost of new plants (Bureau of Resource Sciences 1998). And at present there is an oversupply of capacity in the market (The Parliament of the Commonwealth of Australia 2000). Increased gas use would therefore only mean that emissions would increase at a slower rate, rather than achieve outright reductions. This scenario seems more than likely when you consider that, even taking into account the mandatory 2% renewables target and generator efficiency standards, one study conducted for the Australian Greenhouse Office predicts that overall electricity emissions in 2010 will be 147% of 1990 levels (p.xxxv). Plus, it should also be remembered that the fossil fuel industry currently receives direct and indirect government subsidies in the order of \$6 billion per annum (The Parliament of the Commonwealth of Australia 2000).

In the Northern Territory there is potential for natural gas to replace other sources of fuel for industrial operations in remote areas. Nabalco bauxite mine and alumina refinery at Gove, which is currently the single biggest polluter in the NT with CO₂ emissions of 1.3 MT in 2000, has plans to switch from oil and diesel based power over to gas. It recently received \$7m under the Commonwealth Government's Greenhouse Gas Abatement Program in order to facilitate this change. This is contingent upon a gas pipeline being built out to Gove through Arnhem Land providing gas from the Timor Sea. According to press releases at the time, the changeover would reduce greenhouse emissions by 1.2 MT over 5 years (www.minister.industry.gov.au/minchin/releases/2001/may). That said, Nabalco also has concurrent plans to expand production at the alumina refinery from 1.8 million tonnes to 3.3 million tonnes (Nabalco 2001). So it

is highly questionable whether there will be any actual reduction in overall annual emissions. The \$7 million may turn out to be nothing more than yet another subsidy for the fossil fuel sector.

Transport

The Senate Committee nevertheless concluded that natural gas would be an important transitional fuel for some time to come (p231). It was particularly interested in its application to the transport sector, citing Californian research which demonstrated that 'a light van converted from petrol to Compressed Natural Gas (CNG) would produce 24% less CO₂ emissions, 76% less CO and 83% less NO_x amongst other pollutants. Yet last year there were only 12 CNG refuelling stations in Australia compared with 3300 Liquid Petroleum Gas outlets (The Parliament of the Commonwealth of Australia 2000). Methanol is another alternative fuel with the potential to reduce emissions from transport. A methanol fuel cell powered vehicle can decrease greenhouse emissions by 50% compared to a petrol vehicle (Bureau of Transport & Communications Economics 1996).

Another potential contribution natural gas will make in the transport sector is in the production of hydrogen for hydrogen-powered fuel cell vehicles. Major auto manufacturers such as GM and Toyota are already planning to make hydrogen-powered cars in the next few years, with GM aiming to be the first to sell a million soon after it begins mass production in 2010. Currently, most of the world's hydrogen is extracted by treating natural gas with steam, though in the long run, hydrogen can be derived from renewable sources. According to the Worldwatch Institute, 'in many instances, the best route to a renewable energy-based hydrogen economy would be to pipe natural gas to fuel stations, and turn the gas into hydrogen at the station for use in fuel cell vehicles. This infrastructure could then be converted to handle hydrogen produced from renewable energy' (Worldwatch Institute, <http://www.worldwatch.org> 2/8/01).

Cogeneration

Cogeneration occurs when what was formerly excess heat from a coal, biomass or gas-fired power station is used in a nearby or associated industrial process, or when energy produced by these industrial processes is itself harnessed. Recently, the Australian Government has spent \$26 million on two new cogeneration projects that will use natural gas to produce the excess heat. The first project will supposedly save 2 MT of CO₂-e between 2008-12 and the second 1.25 MT over 5 years (ENS March 29, 2001). Presently, cogeneration is hampered by transmission pricing arrangements in the National Electricity Code, which offers an advantage to large-scale generation (The Parliament of the Commonwealth of Australia 2000).

7. Current government policies and industry attitudes

In August last year, the Howard government decided not to begin mandatory emissions trading ahead of an international emissions trading market out of concern that it would harm the LNG industry. Nick Minchin was quoted at the time as saying: 'Measures that would see Australian industries move overseas make no economic or environmental sense. The national interest lies in maintaining the competitiveness of Australian industry'. This is also typical of statements coming out of the resources sector. Woodside had warned that greenhouse measures could threaten its planned fourth train expansion. Many of its competitors are located in developing countries that have no emissions targets under the Kyoto Protocol (Akehurst 2000).

Moreover, the gas industry argues, the global greenhouse benefits of exporting LNG should be recognised. Currently, around one-third of Australia's natural gas energy is exported in the form of LNG (Australian Greenhouse Office 1998: B-100). According to Chevron, proponent of the PNG-Queensland gas pipeline, exporting 4 million tons of LNG per year to China would displace enough coal to cut the world's annual greenhouse gas output by a net 10 million tons per year (Matzke 2000). Under clean development mechanisms Australia should then credit that 10 million tons to itself and thereby cut another 10% off the national greenhouse target. At present, the greenhouse emissions resulting from burning Australia's LNG exports are accredited to the importing country. Again, this argument appears highly questionable. The LNG from the proposed Phillip's plant, for instance, would be exported primarily to the US, where it will be used to fuel industrial expansion. Under President Bush's new energy plan, the consumption of all sources of energy is expected to grow. In short, more information is required to be able to adequately assess these claims.

8. Summary

In conclusion, it looks as though natural gas can play a transitional role in some circumstances, but only if production does not expand so much as to wipe out the associated greenhouse gas reductions. Policy makers and gas industry proponents rarely address this question. Expanded industrial production is simply considered to be good for the economy and therefore lies beyond the bounds of criticism. The environmental movement should continue to press government and industry to substantially decrease emissions from all fossil fuels and encourage a rapid switch to renewables. But in an increasingly deregulated national electricity market, where the primary goals are to increase efficiency and ensure reliable power supply rather than promote ecological sustainability (NEMMCO 2001), it is difficult to see how this will happen in time to meet Australia's generous Kyoto target. On the balance of evidence presented here it seems unlikely that natural gas will be of much assistance.

9. Policy Directions

Natural gas does have some advantages over other fossil fuels. It has a lower carbon content than coal and oil, produces less particulates when burnt and has a positive transitional role to play in the domestic and transport sectors. Nevertheless, the extraction, distribution and consumption of natural gas is still a major source of greenhouse gas emissions in Australia, accounting for over 10% of net emissions in 1998.

Currently proposed natural gas-based projects, such as the NW Shelf and Timor Sea LNG and methanol projects, will increase this contribution by a substantial amount. It also remains doubtful whether natural gas will directly substitute for other fossil fuels in Australia and in LNG importing countries. Indeed in some cases natural gas will simply provide more fuel to meet the increased electricity demand arising from the planned expansion of industrial production. Consequently, there may be no overall decrease in net emissions even though deep emissions cuts are required in order to achieve climate stability.

Natural gas should therefore only be treated as a transitional fuel if it can be clearly demonstrated that natural gas-based projects will lead to an overall decrease in global greenhouse gas emissions.

It is also recognised that some types of gas-fired power stations produce less greenhouse gas than others. Combined-cycle turbines, for instance, are around 20% more greenhouse efficient than open-cycle turbines, whilst co-generation plants can reduce emissions even further. Unfortunately, the majority of proposed gas-fired plants for Australia are open-cycle ones. This is an inefficient use of the non-renewable natural gas resource. There are also ecologically damaging siting and infrastructure impacts associated with some of the current proposals for gas-fired stations.

Nor should government promotion of natural gas as a substitute for other fossil fuels be at the expense of support for renewable energy development. The billions of dollars of direct and indirect subsidies currently going to the fossil fuel industry should be redirected to the renewables sector. Natural gas based projects and power stations should be made to go well beyond 'no regrets' when undertaking emissions reduction measures, by government regulation where necessary. This may include disposal of CO₂ through underground sequestration in deep saline reservoirs or depleted oil and gas reservoirs, although questions remain over the ultimate effectiveness of these methods. Large-scale projects, such as the proposed LNG and methanol plants, should also be subject to a greenhouse trigger under the *Environmental Protection and Biodiversity Conservation Act 1999*.

Note (1). These calculations are based on the following conversion and emission factors:

1 m³ = 35.315 cubic feet (Roarty 1998).

1 m³ of natural gas = ~39.5 MJ. This is the Australian weighted average (AGO 1998).

1 GJ of natural gas emits 55 kg CO₂ (Roarty 1998).

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