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24 February 2006

The Secretary
Senate Rural and Regional Affairs and Transport Committee
Parliament House
CANBERRA ACT 2600

C/- email address: rrat.sen@aph.gov.au

Envestra

Dear Sir/Madam

We write in response to your invitation for submissions with respect to the "Inquiry into Australia's future oil supply and alternative transport fuels".

This Company is a major distributor of natural gas in Australia, our distribution networks delivering gas to almost one million industrial, commercial and domestic addresses in Queensland, NSW, Victoria, South Australia and the Northern Territory.

We have had an interest in the use of natural gas as a transport fuel for many years; our former Managing Director, Mr Ollie Clark AM, was, until recently, the President of both the International Natural Gas Vehicles Association (IANGV) and the Asia Pacific Natural Gas Vehicles Association (ANGVA). In these capacities he has contributed to the growth of the natural gas vehicles industry globally, and is considered to be an authority on the subject. He has presented papers to conferences in many parts of the world.

Late last year we asked Mr Clark to provide us with a review of Natural Gas as a vehicular fuel worldwide and in Australia, and we believe much of what he had to say will be of use to your Committee. We have therefore forwarded to you an abridged copy of that rather candid review and would urge you to seriously consider the positive impact that the significant use of natural gas as a transport fuel would have in Australia.

We believe there is an increasing number of alternate transport fuel options which, together, could meet a significant share of Australia's transport fuel demands. Natural gas (methane) use in vehicles is internationally recognized as the leading fuel to replace traditional petroleum products given its ability to contribute to reduction in CO_2 emissions and other qualitative environmental outcomes; it clearly has an economic advantage in Australia over other alternative fuels, combined with the fact that local natural gas prices are so low in comparison to both current and expected prices in North America, Europe and north Asia. Given the state of the technology and the environmental and economic benefits its use would deliver, it is hard to understand why neither State nor Federal Governments have failed to significantly support its widespread use.

We would highlight six key points, among many, which we would ask the Committee to consider:

- Worldwide, to this point, with a market share approaching 1%, natural gas is really the only proven, readily available alternative of significance to petrol and diesel at present.

- Australia imports about one third of its crude oil and refined products requirements, and this fraction is expected to increase dramatically in the medium term.

- Australia's gas reserves are reported to be sufficient for the order of 70 to 100 years (and increasing) at present rates of consumption, (which includes exports of around one third).

- Natural gas (methane) is available via conventional production, from coal seams and from such renewable sources as biogas from the decomposition of waste and via crops.

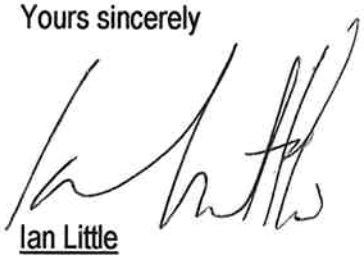
- Natural gas is considerably more environmentally friendly than both petrol and diesel.

- Natural gas technology is readily available and has proven to be safe and practical.

We commend the forwarded material to you, and we would welcome the opportunity to meet with the Committee to expand on the subject in due course.

Thank you for the opportunity to contribute. There could hardly be, in our view, a more important national issue to be addressed.

Yours sincerely



Ian Little
Managing Director

Report to Envestra Limited

Review of NGV Worldwide and in Australia

O G Clark AM
January 2005

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1 Natural Gas Vehicles (NGV)

1.1 General

I propose to report on the status of NGV, on a regional basis, in some detail, but start by putting forth some generalities and explaining some factors which have had a significant effect on the uptake of this option, under a number of headings, to put the subject into perspective. As the Immediate Past President of both the International Association of NGVs (IANGV) and the Asia-Pacific NGV Association, and having attended eight global conferences relevantly recently at which NGV was either the focus or a priority topic, I consider myself well placed to provide a real insight into the past, present and likely future status of natural gas as a vehicular fuel. These are, however, my personal views.

1.1.1 Natural Gas as a Vehicular Fuel

Natural gas is primarily methane which is chemically, the simplest hydrocarbon and which has the lowest carbon : hydrogen ratio of all of the fossil fuels, i.e. of coal, oil based fuels, LPG and natural gas. As a result, when a thermally equivalent quantity is burned, less carbon dioxide is released than for LPG, petrol and diesel, i.e. it is, intrinsically, the most greenhouse friendly fossil fuel.

Further, natural gas has a high octane rating which enables it to be used in internal combustion engines (ICEs) with compression ratios considerably higher than in standard petrol and LPG engines. It can thus drive a megajoule further. Although at this time diesel engines operating with diesel oil as a fuel operate with higher compression ratios, it is generally acknowledged that, given time and the investment of resources, engines specifically developed to operate with natural gas will operate at similar compression ratios.

Natural gas, being a gas at all atmospheric temperatures and pressures does not require vaporisation and mixes readily with air or oxygen ensuring more complete combustion within the cylinders of an ICE with resultant comparatively lower emissions of gases caused by incomplete combustion. Its use therefore results in the emission of lower levels of urban air pollutants.

Natural gas can be stored as compressed gas (CNG) or as liquefied gas (LNG), the former necessitating the use of high pressures for a meaningful range (around 25 kPa), the latter necessitating cryogenic storage. Liquefaction, by the way, requires the input of more energy than compression.

Fundamentally, natural gas is a superior fuel for an ICE compared with LPG, petrol and diesel and suffers only from the fact that it cannot be handled as a liquid by conventional means. This "disadvantage" could, however, be regarded as a benefit in that the resulting technologies bring about less waste and a higher degree of safety.

1.1.2 Natural Gas Availability

It is generally agreed that global reserves of crude oil and (conventional) natural gas are about equal (at about 6,500 EJ as I recall) and that as petroleum products are currently consumed at a faster rate, natural gas reserves will endure far longer.

Petroleum reserve estimates have been rather conjectural for many years and are, after all, based mainly on the assessments of oil companies and oil producing countries, and are, in some cases, believed to be "optimistic". Natural gas reserves do not include coal seam methane or methane available from methane hydrate, both of which, we are told, are immense, possibly exceeding conventional reserves.

Methane (and natural gas is predominantly methane) is also available as biogas from waste deposits and can be produced very efficiently via crops, i.e. there are "renewable" options for methane also.

A major advantage of natural gas is that reserves are very much more equitably distributed globally. Although there are vast stocks of natural gas beneath Middle East countries, so there are beneath Russia, North and South America, parts of Asia and in North Africa.

Further, there is not (yet) a global price for natural gas and to date efforts to tie its price to the price of petroleum is limited to a relatively small number of countries. Whether the increasing trade in LNG, and for that matter, the increasing construction of international pipelines, alters this situation, remains to be seen.

The point of the above is that whereas, as recent history has shown, petroleum availability and price are, respectively, risky and volatile, the availability and price of natural gas in many parts of the world, including Australia, are, respectively, reliable and relatively stable.

1.1.3 Transportation Fuel Pricing

It is unfortunate that global oil prices are reported by the media in $US per barrel, whereas in most countries, petroleum products are sold on the basis of local currency per litre or per (US) gallon. In what follows it is worth remembering that a barrel is equivalent to about 160 litres, so that $US20 per barrel is equivalent to US 12.5c per litre and $US60 per barrel is equivalent to US 37.5c per litre.

The costs of transporting crude oil and refining it into LPG, petrol and diesel varies depending on location, scale etc, but is in general a small component of final cost.

This all begs the question as to why it is that the products of a globally traded, parity priced commodity like oil varies between around A 60c per litre in the US and $A 2.00 per litre in most parts of Europe.

The answer of course is the different fuel taxing regimes of the various nations which varies from say about 10c to $1.50 per litre!! The global pre tax price of petrol (June 2004, when oil prices were around $US50 per barrel), was within the range of A45c to A55c per litre.

The price of natural gas varies fairly widely in global terms due to a variety of factors, ranging from location, quality, production and transportation through to government taxing regimes.

To compare natural gas prices it is worth bearing in mind that a cubic metre contains around 39 MJ which is thermally equivalent to about 1.5 litres of LPG, 1.1 litres of petrol and 1.0 litre of diesel. The following table expresses the basic cost equivalents of LPG, petrol and diesel to natural gas at a range of natural gas prices per GJ, on a thermal basis.

Table 1: Comparison of Fuel Prices (Thermal Basis)

Natural Gas Price ($A per GJ)	LPG	Petrol	Diesel
	Ac per litre equivalent		
5.00	19.3	14.3	12.8
10.00	38.5	28.6	25.6
15.00	57.8	42.9	38.4
20.00	77.0	57.2	51.2

This table indicates, that, for example, a Melbourne domestic gas user who has gas delivered to the door for $8.65 per GJ, is paying the equivalent of around 25c per litre of petrol and a sizeable Adelaide industrial user, receiving gas delivered for say $7.50 per GJ is paying the equivalent of 19.2c per litre of diesel.

1.1.4 Taxation Regimes in some Countries

From the above, it can be seen that the volatility of the global crude oil price, while an important factor in determining (and predicting) petrol and diesel prices, (although even at $US50 per barrel that cost is only around US31c or A40c per litre), it is, in most countries, by no means the major determinant.

Taxation regimes are the major determinant; they determine not only the price relativity between LPG, petrol and diesel, but also the cost of natural gas for transportation use.

The range of fuel tax regimes is almost unbelievable and they are predicated on a great many factors, real and imagined, and are country specific. Some oil and gas producing countries have a very low tax on gas to encourage its use internally, making local travel inexpensive and preserving oil for sale to the global market, e.g. Venezuela, where gas is sold for 4% of the price of petrol (which is fairly cheap anyway). Iran has in train a stunning plan to move to NGV for similar reasons.

A number of countries are of special interest in this regard. For example, in the USA, the prices of petrol, diesel and CNG are within about 25% of one another (although gas prices vary quite widely, and well head prices have been high in recent times). The American populace would be up in arms were the US Government to increase the tax on petrol and diesel significantly despite the fact that a large proportion of global transport fuel is devoured annually by US motorists and the transportation industry. Because of the low taxation on petrol and diesel and the current relatively high cost of gas at the well head in the US, there is little price incentive the government is able to work with.

The purpose of this chapter is to point out that it is governments via their fuel taxation regimes which influence the success or otherwise of the NGV programs around the world more than any other factor. And governments follow quite different agendas depending on political, economic and environmental issues currently in vogue (in that order!)

1.1.5 Other Transportation Energy Options

Transport fuels represent a multi-billion dollar industry worldwide and this isn't about to change. In fact, as a number of, particularly Asian countries (and specifically China and India), develop, and their

citizenry begins to enjoy the mobility enjoyed by people in the developed world, for decades, the demand for sources of transportation energy supplies will continue to grow at an alarming pace.

On the other hand the deleterious effect that the use of energy sources, particularly the fossil fuels (coal, oil and natural gas) is having on the global and urban environments is the cause of mounting concern world wide.

Not surprizingly, the world is in search of, first, additional energy sources and second, energy sources which are renewable, i.e. non finite and which, when used, minimize environmental damage. So we have witnessed the passage of many options to the traditional liquid fuels, all preceded by hype and in many cases by obviously indefensible claims. Oddly, we have seen the strong promotion of, e.g. electric vehicles and hydrogen powered vehicles (ICE or fuel cell based) without, it would seem, any real understanding of the consequences, environmentally, of their large scale adoption.

And we have seen promotion of a range of "renewables" such as methanol, ethanol and biodiesel, particularly by parties wishing to prop up ailing agricultural ventures, such as sugar cane.

All have one thing in common ... they are long on promotion and short in substance. Unfortunately, however, they occupy "airspace", attract the attention of politicians and the media and provide opportunities for the all important vehicle manufacturers to build prototype after prototype for display in an endless procession of "motor shows" worldwide, knowing full well, I suspect, that they are using a delaying tactic, i.e. putting off the time when the future must be addressed in real terms.

Hopefully, after the passage of electric vehicles, the acceptance of methanol, ethanol and biodiesel blends as mere "extenders" and a dawning of the realities with respect to hydrogen production and fuel cell development, not to mention recent oil price hikes, the focus is returning to practical options.

I have not mentioned LPG specifically to this point, and I should because it has shown itself to be (and particularly here in Australia) a credible, in fact, desirable substitute for petrol. It is not well suited for heavy vehicle use however and its availability and pricing are closely tied to the oil industry. Its supply is limited and it sits somewhere between natural gas and the traditional fuels with respect to ease of handling/storage and environmental advantages.

1.1.6 Hydrogen and Fuel Cells

The population could be excused for believing that for a vehicle to be powered by a fuel cell it must be fuelled by hydrogen. This is not so however, and natural gas, for example, can be used as the energy source for a fuel cell.

Further, natural gas is regarded as the most practical feedstock for hydrogen production at this stage should vast volumes be required, for a number of reasons, including its availability and its low carbon to hydrogen ratio. The trouble is that producing hydrogen from natural gas or any of the other finite hydrocarbon resources results in the production of carbon dioxide in greater volumes than if the hydrogen producing hydrocarbon was used without reformation.

When misinformed people consider the use of hydrogen (in fuel cells or ICEs) they are enthused by the fact that the products of combustion (ICEs) or electrolysis (fuel cells) are simply water vapour and heat. They fail to appreciate the obvious chemistry of hydrogen production. Many will agree that hydrogen

can be produced by splitting water molecules using electricity (hydrolysis). But there is the all important matter of producing the electricity, and electricity generation releases globally more carbon dioxide than transportation because it is based generally on the inefficient use of coal, oil and gas and because the demand for it is growing even faster than the demand for transportation fuels.

There are exceptions of course, because electricity can be produced using hydro schemes, nuclear power stations, wind power, hot rocks for steam production etc... However, mankind's distaste for the flooding of large tracts of land and his phobia of nuclear waste disposal, especially in Australia, don't seem to be on the wane; in fact quite the reverse. So far as wind power, tidal power, etc, are concerned, their contribution is miniscule and will be quite insignificant for many years.

Iceland is often cited as a leader in renewable energy and it's quite true. Electricity is produced cheaply in that country to the point where it is home to a very large aluminium smelting industry. But Iceland sits above a large hot rock formation which enables cheap steam production for power generation. And unlike Australia, the resource is close to points of usage, so that the substantial cost of a long distance transmission system is not a barrier.

Much is spoken and written about fuel cells, and I clearly recall conversations within the Australian gas industry in the 50's regarding the displacement of electricity infrastructure as fuel cells become available for general use. Although we are 50 years closer we may well be a further 50 years away from a practical application.

Despite the hype and the prototypes, the fact is that there are less than 100 fuel cell powered vehicles around the world at present. They are unrealistically high priced despite the investment of billions of dollars.

1.1.7 Vehicle Technology

Altruistically the aim of Original Equipment Manufacturers (OEMs) i.e. the vehicle building fraternity, and of mankind generally, should be to produce vehicles that, all other things being equal, travel the longest possible distance for a given amount of fuel, be it natural gas, LPG, petrol, diesel, ethanol, methanol, biodiesel, hydrogen or electricity (or anything else).

Practically the OEMs have to balance this factor with customer appeal, production costs, operational practicalities etc, so what has been marketed for several decades are vehicles using ICEs powered by petrol or diesel ... take it or leave it.

The venture into electric vehicles led to the recognition and the evaluation of the principle of the so called "hybrid" vehicle. This vehicle is in effect an electric vehicle i.e. it is powered by electric motors turning the driving wheels. To reduce dependency on battery size (mass and volume), to reduce cost, to extend battery life and to avoid the need to plug-in to recharge, the concept of a smaller than usual ICE in combination with a smaller than usual storage battery was developed, the "hybrid".

In essence the hybrid uses an ICE (or it could be a fuel cell when sufficiently developed) to charge batteries and also to use retardation (braking) to charge batteries. The vehicle optimizes between the use of stored electricity and the engine output to gain maximum fuel efficiency.

Several of the Japanese OEMs have released hybrids and it seems obvious that we will see them become the norm over a period of time, since they can almost halve the fuel consumption of a vehicle and because they cost of the order of only 10% more in terms of purchase price.

Although OEMs are improving fuel efficiency marginally all the time, by reducing mass and improving engine technology, the move towards hybrids is the one identifiable step change practically available at present and I think this is becoming generally acknowledged.

One other fairly significant development is to do with after treatment of exhaust products, especially of diesel vehicles. This technology, combined with the growing requirement for fuel suppliers to provide low sulphur diesel, is reducing the urban air pollutants from diesel vehicles. The combination is being forced on fuel producers and OEMs by the requirement to have vehicles conform to the ever tightening EURO 3, 4 and 5 requirements (and their US equivalents).

The so called after treatment equipment is expensive because at this point it is based on precious metals and rare earth elements as catalysts and because they require periodic recharging and/or replacement.

The combination of cleaner diesel, sophisticated engine control equipment and the fitting and monitoring of after treatment devices is expected to drive the capital cost and operating costs of diesel vehicles significantly higher in the medium term.

1.1.8 Testing for Emissions

There are several reasons for including an account of the emissions testing regimes used in the automotive industry. First, it is necessary to ensure the audience knows that the subject of emissions must be addressed on a "well to wheels" basis. Second, the matter has been the subject of gross misrepresentation over a number of years. A third is to provide an update of the types of results currently coming forth.

Fuel efficiency at the vehicular level, usually referred to as "tank to wheels", is frequently reported. Thus a hybrid is significantly more "tank to wheels" efficient than a conventional ICE driven vehicle. But in terms of well to wheels efficiency, account must be taken, as well, of the fuel efficiency of producing and delivering the fuel to the vehicle and of producing the vehicle, as well as the liberation of greenhouse gases in the process.

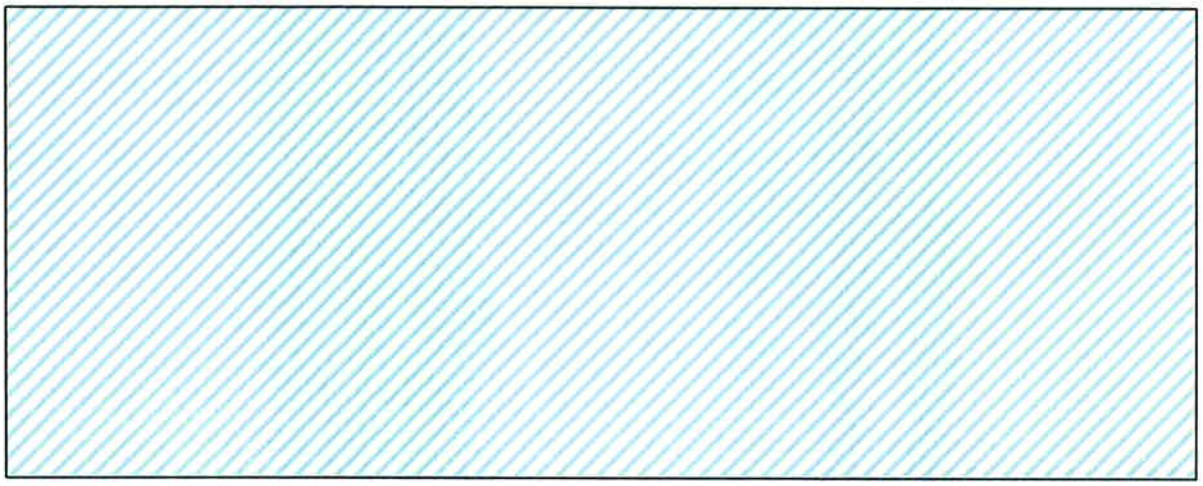
Natural gas is relatively easily produced without a significant amount of energy consumption in the process. It is however, variable with respect to the carbon dioxide content at the field, varying from almost none to concentrations in excess of 25%. This carbon dioxide must be separated (usually before transmission) and must be scored into the overall well to wheels greenhouse gas count and overall energy efficiency.

The length of the transmission system from process plant to market is also a factor to be considered as compression absorbs energy and liberates dioxide.

Producing the conventional fuels also consumes energy and in some cases requires the removal of substantial quantities of sulphur. Energy consumed in field production, transportation (ship, pipeline and road tanker) and refining can be considerable.

The production of methanol, ethanol and biodiesel can be quite complex in terms of energy input and items such as water consumption, land cultivation, production and transport all consume energy and produce greenhouse gas.

The energy required to produce hydrogen, and the greenhouse gases liberated in the process can be substantial as outlined previously, and when comparisons are drawn they should specify the feedstock and process. It is usually nonsense to claim that hydrogen produced by splitting water is energy efficient and greenhouse gas free. A well to wheels analysis must include the energy input and greenhouse gas emissions for the electricity generated, transmitted and distributed.



A number of studies have been carried out in Europe and North America by parties with vested interests, to the extent that the IANGV found it necessary to fund a project known as the "truth squad" project whereby seven European NGV buses were tested for emissions in an independent Finnish test facility. The results were beyond criticism and found that the NGVs were superior in most respects compared with the diesel models tested immediately beforehand at the same facility.

There have been, among a number, two studies of particular interest, one performed in the USA by a group from within the Massachusetts Institute of Technology (MIT) and the other by a German test authority known as the Wuppertal Institut for Klima, Umwelt, Energie GmbH (Institute for Climate, Environment, Energy).

The first considered the life cycle carbon dioxide emissions from a petrol ICE powered vehicle with what was possible by replacing it with an advanced petrol ICE, advanced diesel ICE, petrol ICE hybrid, natural gas ICE hybrid, and fuel cell hybrids, fuelled with petrol, methanol and hydrogen, and concluded that, notwithstanding the results occupied a range (rather than a point) the CNG hybrid was the option promising the most significant reduction (at about 50% of the baseline petrol ICE vehicle.

The second was a detailed study entitled "Energy System Aspects of Natural Gas as an Alternative Fuel in Transport". Many conclusions were drawn, but basically, for Germany, the appropriate pathway was to promote natural gas (CNG) as a vehicular fuel while continuing to pursue environmentally acceptable methods of hydrogen production. The establishment of an NGV transport fleet and supporting refuelling infrastructure was seen as an investment in a hydrogen future if and when hydrogen production becomes viable. The study suggests that this will be no time soon (between 2035 and 2050).

1.1.9 NGV as a Pathway to Hydrogen

From the above you will have observed a theme that the goal is Renewable Energy Sources (RESs) and that hydrogen, if produced on a renewable energy basis, i.e. not from fossil fuels, would represent an excellent solution. (The world seems not to have recognized and considered any negatives from this gigantic shift, and, optimistically, maybe there are none!).

We are certainly not at that point as yet and as was mentioned in the last section, a view is emerging, even among the hydrogen enthusiasts, that a significant shift toward natural gas would pave the way, by helping develop practical technologies for the introduction of hydrogen.

Twenty years of NGV has seen the development of storage and refuelling equipment that can operate safety and efficiently at 20 MPa and, at this pressure, store enough fuel onboard a vehicle to allow a reasonable range. To be practical, hydrogen refuelling and storage equipment would need to operate at around 60 MPa, which is a lot higher in terms of current technology. Further, hydrogen has a lower ignition temperature than natural gas and a much broader explosive range. All these factors need to be considered before hydrogen can be used widely and safely.

The NGV industry has, by now, developed a comprehensive range of standards and codes of practice, whereas there are virtually none for hydrogen.

Considering the need to devise environmentally friendly processes for producing hydrogen and the need to advance the technology, there is much to be said for developing the NGV industry relatively quickly and the hydrogen industry in its wake.

2 NGV Progress around the World

Having set out the major issues surrounding the NGV industry, I now propose to deal with progress in different parts of the World.

2.1 North America

Salient points bearing on the uptake of NGV in the USA, and to a lesser extent in Canada are:

- Petrol and diesel are relatively inexpensive
- (because) taxes on petrol and diesel are relatively low
- any substantial rise in tax is unlikely in the medium term and therefore there can be little price incentive by governments (State and Federal) to promote NGV
- the alternative fuel industry is driven primarily by environmental concerns
- the USA is a major importer of liquid fuels (and to some extent, of natural gas)
- the USA is acutely aware of the ramifications of oil price volatility
- some States, especially California, are more concerned and therefore proactive with regard to alternative fuels than others
- oil companies and OEMs have very powerful lobby groups as do renewable fuels producers

- the Bush administration has invested billions of dollars in promoting and developing a "hydrogen economy" which is attracting the attention of OEMs and other transport stakeholders

The result is that although NGV is seen as an environmentally superior way ahead, the cost of NGV is of the order of 80% of the already low cost of petrol and diesel, so there is not an adequate price differential to provide an acceptable payback.

Nevertheless, the commuter bus fleets in many major cities have embraced NGV as have other depot based medium and heavy duty vehicles.

A development worthy of note is the purchase of the Canadian "Fuelmaker" home refuelling appliance manufacturing company by the Honda corporation.

As you may know, we experimented with the earlier models of Fuelmaker in Australia, especially in Sydney and Adelaide. The early models worked well and there is every reason to believe that the latest model, which is very neat and compact and is expected to cost around $A2,000 in time, will have a place in the market. I shall return to this subject when considering NGV in Australia.

It is estimated that there are about 150,000 NGVs on the roads of the USA and Canada, which is not a high proportion of the perhaps 200 million vehicles in use in these countries.

Canada, like New Zealand, has spawned a number of impressive companies with NGV expertise and which work globally quite effectively. This is because, like NZ, Canada was an early adopter.

2.2 Europe

The European Union is made up of many demographically different countries, and in terms of NGV, progress differs widely within them.

In general however, the European nations, especially the major ones, e.g. UK, France, Germany, Italy and Spain, are characterized by:

- high petrol and diesel prices
- (because) levels of taxation on fuels are high
- dedication to reducing greenhouse gas emissions and to improving the urban environment
- being home to a number of innovative OEMs which seem to have become more serious about environmental concerns
- lower natural gas prices, or at least access to supplies from a number of sources
- dependency on Middle East petroleum suppliers
- a long history (in Italy) of NGV (from the mid 30's)
- a genuine desire to develop alternative fuels to the point of making policy decisions in that regard (the EU 2020 Policy)
- access to a number of highly reputable test facilities and development centres

The European Union, which is the policy making body for the member nations of the European Common Market countries (but does not draw up legislation for any of them) has developed an energy policy

which recognizes the need, for environmental, economic and supply security reasons, to broaden the range of fuels needed for transportation. In effect, Europe, through the EU, is leading the world in questioning the status quo and by putting forward the policy which would see 20% of transportation energy supplied by fuels other than petrol and diesel, by the year 2020 (the so called 2020 policy). Half of the 20% supplied by alternatives, i.e. 10% of the total, is expected to be natural gas.

It is my view that the Europeans are displaying leadership in the use of alternative fuels in general and NGV in particular. They have articulated a policy and they are moving more or less steadily towards its implementation. The 2020 Policy is perhaps ambitious considering the work which would need to be done to achieve its aims, but I note there is very positive action in a key country, viz Germany. The German Government has developed a transport fuel strategy which certainly visualizes a place for NGV (and LPG) to 2020 and beyond. The policy sees little scope for hydrogen until beyond 2020 and beyond 2035 for renewable sources of hydrogen.

As opposed to South America, where NGV take up is greatest, the European OEMs are producing quite a wide range of natural gas powered vehicles, so that take up is not dependent on conversion, which is the case in South America.

As mentioned earlier, the British government has embarked on a taxation regime designed to develop NGV as a preferred fuel for heavy vehicles, and as things stand, the price of NGV is 33% of the price of diesel (Euro 0.33 per litre equivalent compared to Euro1.00 per litre). It must be said that this price differential has not as yet created a stampede towards NGV, but a market participant to whom I am close, who markets LNG (as opposed to CNG), is confident that when vehicles become readily available, and he has been pursuing OEMs vigorously, there will be a shift. He explains that NGV vehicles receive major city access concessions and, in the case of grocery delivery vehicles, are permitted to work around the clock in urban and suburban areas because of their relative quietness.

The situation in France is quite interesting. In that country gas production, transmission, distribution and retailing is still dominated by State owned Gaz de France. The French, despite strong pressure from the EU, has been slow to adopt "liberalization", i.e. the change from vertical integration to horizontal integration of the energy industry. In Germany, on the other hand, while Ruhrgas is the dominant gas wholesaler and transmission company, distribution and retailing is handled by small, often municipally owned, "gas companies". The German structure has resulted in the outlay of substantial funding for the construction of refuelling infrastructure, i.e. most small distributors/marketers have joined a national scheme to install a refuelling network of, I think it is, 400 stations. In France, however, Gaz de France is unable/unwilling to spend the enormous amount of money a comparable action would take, and is said to be working closely with "Fuelmaker" of Canada to back the widespread use of home refuelling. I understand that France was to the fore in encouraging diesel for domestic vehicles, and that around 60% of domestic vehicles on French roads are diesel powered.

As noted earlier, Italy has seen the use of NGV since the mid '30s, and of the estimated 575,000 NGVs within Europe, about 375,000 are in that country.

Europe is showing innovation in the NGV applications it has secured also, there being NGV canal cruise boats, railway trains and heavy duty ferries now in regular service.

2.3 Asia and the Middle East

Activity in these regions is quite breathtaking. Over the past decade, and particularly over the past five years, the growth in the number of NGVs in countries such as Pakistan (500,000), India (225,000), China (80,000), Egypt (55,000) and Bangladesh (30,000), has been phenomenal.

Geographically, crude oil distribution has not generally been kind to Asia whereas natural gas is abundant in countries such as Indonesia, Thailand, Malaysia and Australia, and even in parts of China. Latterly the potential for supplying gas from eastern Russia and from the Russian Sakhalin Islands has been recognized.

The construction of a major pipeline and/or LNG infrastructure to supply Middle Eastern gas to India is more than planned and in China, the 4,200 km NW to SE, 1m diameter pipeline was commissioned in September last year.

Asian cities suffer from poor quality urban air caused commonly by the combined effects of poor urban planning, outmoded manufacturing processes, and, increasingly, as a result of the rapid growth of vehicle fleets. The latter is an immense problem....for the year to June 2003, motor vehicle registrations in China increased by over 30% over the previous year.

The huge increase in motor vehicles in countries such as China and India is having the twofold effect of increasing oil prices as demand increases, and adding to the already severe health problems in major cities (to say nothing of road accident fatalities, allocation of land areas for freeways, traffic congestion, and all the other ills consequent of the mobility sought by people everywhere).

Availability of natural gas to replace much of the coal and oil based processes in energy intensive industries within urban areas is the priority and is having an effect, but the need to press on and use natural gas in significant quantities as a transportation fuel is also gaining recognition.

I am the IPP of the Asia-Pacific NGV Association (ANGVA) and have had the privilege of visiting Mumbai, Abu Dhabi, Dubai, Manila, Kuala Lumpur, Tokyo, Beijing, Tianjin and Shanghai in comparatively recent times, and have spoken frequently with people from Korea, Egypt, Indonesia, Iran, Turkey and other Asian countries and have, as a result, learned of some of the exciting plans for NGV in those countries.

The motivation is environmental to some extent in every country, but is also economic and to do with security of supply. The most aggressive program I have come across is in Iran, where, by the year 2010 the government expects to have 1.5m vehicles on natural gas, growing eventually to 6m. The prime motivation is, like Venezuela, economic, in that Iran, although a major exporter of crude oil, has no oil refineries, and must import, therefore, petrol and diesel. The logic is that natural gas can be collected and distributed widely at low cost, as a totally internal operation.

China, of course, deserves special mention. At present that nation uses natural gas to supply just 3% of its primary energy, but with the completion of the national transmission pipeline and a series of SE coastal LNG terminals, this is expected to rise to around 10% by 2010 and to 15% by 2020. The new pipeline will facilitate gas delivery to 100 cities (probably all of them bigger or as big as Adelaide).

The Chinese Government has nominated 16 cities, including Beijing and Shanghai, which must convert buses and taxis to alternative fuels as a matter of priority. In Beijing, 18,000 buses and 65,000 taxis

must be operating on alternative fuels by the time that City hosts the Olympic Games in 2008 and it is expected that at least 90% will be NGVs. As of now there are 50 refuelling stations in Beijing and all but alternative fuel vehicles are prohibited from access to the City within the area defined by the 3rd ring road.

In Shanghai, the requirement is 20,000 buses and a mere 40,000 taxis, again primarily expected to be completed by 2010 when that City hosts the World Expo.

Japan and Korea, both importers of virtually all transport fuel, have positive plans for NGV and both countries are home to OEMs which are producing NGVs. As noted previously, the Honda Corporation (which I think is partly owned by Ford) has purchased the Canadian home refuelling appliance company, Fuelmaker. Korea is part way through an 8,000 NGV bus program for Seoul, and in Tokyo, like London and Beijing and other cities, access to the CBD is restricted to alternative fuel vehicles. Korea is the base of ANGVA which is receiving considerable financial support from the Korean Government.

India is of special interest because the High Court of the country declared that the Cities of Delhi and Mumbai (and others since, I believe) must, without further redress, convert all buses and taxis (and now I think the tricycle cabs) to natural gas.

Another country of particular interest is Egypt, which is another in which the change to NGV is to allow more crude oil to be sold on the market and to clean up Cairo. Surprizingly the Egyptian initiative is backed by BP and the former British Gas who foot the bill for conversion training and the establishment of a network of registered conversion workshops. The company behind the push to NGV in Egypt, together with the Egyptian government, will host the next biennial IANGV world conference in Cairo later this year.

2.4 South America

Argentina and Brazil are the two leading NGV countries in the world, operating NGV fleets of 1.3m and 0.8m respectively. In the case of Argentina, I think this equates to between 25% and 30% of all vehicles. Nearly all nations on the South American continent and the Caribbean Island nations of Trinidad-Tobago, have active NGV programs in place, adding a further 100,000 to the total fleet. The rate of conversion in Brazil is fairly astonishing, to the point where that nation expects to have overtaken Argentina in terms of the number of NGVs within about three years (and Argentina is still converting in excess of 100,000 vehicles per annum).

In Argentina and Brazil fuel prices (in Australian currency, at say $A1 = Euro 57c) are of the order of:

	petrol	**diesel**	***NGV**
Argentina	70c	67c	27c
Brazil	$1.05	73c	58c

* per litre of petrol equivalent, $-c Australian

Table 2 Fuel costs, Argentina and Brazil

There is virtually no tax on NGV in Argentina and I'm told that to introduce it would be to introduce civil disobedience! The Government lent enormous support to the evolution of NGV when, in 1992, during the 3rd IANGV Biennial Conference, it was announced that all taxis and buses in greater Buenos Aries must become natural gas fuelled within a certain time frame ... maybe it was 5 years.

Throughout South America very few OEM NGVs are available; almost all NGVs are vehicles converted from petrol; diesel conversions are much rarer. I think the Asian and some European OEMs have finally learned that NGV is in South America for the long term and we are, finally, beginning to see the emergence of an OEM NGV presence in Argentina and Brazil.

The Brazilian NGV industry has had something of a stop-start history. When I was in Brazil in 1992 the emphasis was very much on biofuels, largely for collapsed sugar cane farming reasons as we have witnessed in Australia. Problems were being experienced with neat methanol and ethanol usage (leakage and corrosion) and there was a move towards blends. I understand that at present a high proportion of petrol is blended with methanol/ethanol and a high proportion of diesel is blended with biodiesel.

In terms of reserves, some South American countries are endowed with reserves way beyond their needs while others currently import via cross border transmission pipelines. Brazil is the largest Latin American nation by far and it would seem that although it is a net importer at present, it is quite prospective. I think success in identifying and developing domestic gas resources would accelerate the swing to natural gas.

The populations of Argentina and Brazil are, respectively around 30m and 170m, so that pro rata, NGV is modest in Brazil compared with Argentina, except that the standard of living in Argentina is appreciably higher. Sao Paulo and Rio de Janeiro are among the worlds largest and most air polluted cities and I'm sure urban environment considerations will have added impetus to the recent change. (Brazil has achieved its phenomenal growth in NGVs largely over the last five years).

Because most NGVs are converted from petrol vehicles, Argentina has built up a very impressive NGV componentry manufacturing and conversion workshop industry, not to mention the development of a sizeable storage cylinder and refuelling plant-manufacturing infrastructure. The new President of IANGV, Juan Carlos Fracchia, is the owner of a large cylinder manufacturing organization (Inflex Corp) which now exports its wares to many countries outside of South America.

To round off this section, I would offer the following additional statistics. There are over 1,250 refuelling stations in Argentina and almost 850 in Brazil and it is estimated that 10 PJ per **month** of natural gas is dispensed to vehicles in Argentina and 6.5 PJ per month in Brazil.

Standards and Codes of Practice are fairly well in place, but regrettably there is an "Australian Rail Gauge" problem, in that some basic standards (like the refuelling connections!) differ between the countries.

Finally, we are advised that the item stolen most frequently in Argentina (where many items are stolen!) is NGV conversion kits, which are removed from vehicles!

2.5 Australia (and New Zealand)

I start with New Zealand, which country, as you would be well aware, led the NGV thrust immediately after the oil crises of the 70's. The NZ Government, void of indigenous oil, introduced a tax regime and incentive scheme which offered a worthwhile return on an investment in an NGV conversion and introduced subsidies for the development of a sizeable refuelling infrastructure. Consequently NGV took off, and at the peak, about 120,000 NGVs travelled the NZ (North Island only) roads by the mid to late 80's supported by an infrastructure of around 450 refuelling stations ... a truly remarkable achievement.

Just as the NZ Government had paved the way for the NGV industry it then paved the way for its demise almost overnight, in part by changing the fuel price regime in favour of diesel but more by removing conversion and refuelling station subsidies. I suspect NGV cost only about 33% to 50% of the cost of diesel and petrol in the halcyon days, but now the costs are, in Australian currency, of the order of $1.15 per litre for petrol, 75c per litre for diesel and for NGV the equivalent of 70c per litre of diesel. There are now less than 2,000 NGVs in New Zealand.

New Zealand hardware and expertise has since been exported worldwide and many New Zealanders are employed as consultants and contractors, especially in the Asia Pacific area.

The New Zealand experience is cited often as a case study pointing out the need for (a) Government initiative and (b) tax regimes which permit adequate payback (punters, at the end of the day, aren't interested in environmentally desirable options which don't deliver savings) and the consequences of dramatic policy changes by Governments.

To this day, it's never been clear to me just why the NZ Government took the steps it did to destroy the NGV industry it had encouraged. I suspect it had to do with NZ's paucity of natural gas reserves which may have been regarded as more valuable for other applications. Perhaps it was thought that electric vehicles would take over, a fashionable idea at the time.

NGV in Australia was first considered as a result of the 1970's oil crises also, and to my knowledge, the 1976 SA Gas Co project, whereby six Holden service panel vans were converted and a gas engine driven compression and refuelling plant installed at Brompton, was the first practical demonstration in Australia.

The gas utilities of the time foresaw potential and AGL and the now defunct Gas & Fuel Corporation of Victoria, SA Gas Co and Allgas Energy all started NGV Divisions.

Australia is unique in that since the mid 60's, continuing through the 80's, the LPG alternative to petrol had been well developed, and paradoxically, primarily by the same gas utilities (plus Boral), all of which had sizeable LPG Divisions. The industry had begun to develop LPG in the mid sixties and I believe that today, when over 10% of the petrol market is occupied by LPG, Australia leads the world in its substitution for petrol. It really is remarkable, that as oil companies caught on, an Australia wide LPG refuelling infrastructure was put in place, so that LPG could be purchased virtually anywhere petrol was sold.

It was largely the use of LPG by taxi fleets that brought that industry to maturity, and it is that very maturity which has proved to be a barrier to the introduction of NGV into the light (petrol) vehicle sector.

Again the basic requirements were in place; zero tax on LPG and therefore a reasonable payback (at times LPG was 20% of the price of petrol in Melbourne) and a comparatively reasonably priced infrastructure capable of expanding (without the need of a costly pipeline network) and some environmental altruism. The industry went through the growth phase with, happily, only a few mishaps, with which the media eventually became bored.

Importantly, the success of LPG in the light vehicles market more or less confined the NGV ambit to heavy-duty (i.e. diesel) vehicles (and fork lift trucks in industrial premises).

The NGV activists in Australia therefore concentrated on fleet type diesels, and urban transit buses were an obvious target. Buses do not have a long daily range requirement, they are big enough to accommodate heavy storage cylinders, they are, as diesels, potentially urban air polluters, they tend to be ordered at rates which justify the construction of refuelling stations and the fuel tax regime has so far enabled the delivered gas price to be significantly lower than the cost of diesel.

An opportunity was presented to SA Gas Co in the mid to late 80's in that a series of trials on alternative fuels for transit buses, all of which were owned and operated by the then State Transit Authority (STA), had been conducted and had been assessed as failures. Results for a fleet of about 5 LPG buses based at the Elizabeth depot had proved particularly disappointing.

A team from STA, the University of SA (SAIT at that time) and SA Gas Co was formed to evaluate compressed natural gas as a fuel for Adelaide buses, and so began a very successful, by world standards, program resulting in the first purchase of a sizeable fleet (100) of NGV buses from a recognized OEM (MAN of Germany). The Adelaide group had conducted a conference on NGV buses, which was attended by all major bus manufacturers, all Australian urban transit authorities, many private operators of large urban bus fleets and the majority of Australian gas companies. This conference planted the seed, I believe, in the minds of the OEMs that there was a market for gas fuelled buses, and now I would venture to suggest that perhaps 50% of European manufactured buses are gas fuelled.

The number of gas buses in the Adelaide fleet has reached 214 (of a total of about 750) and as you are aware, we are endeavouring to have this number increased. The Adelaide bus fleet was the largest NGV fleet in the world for a number of years but was overtaken by the Sydney Buses fleet which, as I recollect, numbers about 450 nowadays. It is rumoured that the Sydney authority is about to place an order for diesel buses for the next delivery. In contrast, the Brisbane City Council, which trialled ten buses a decade or so ago and rejected the concept, now has 100 in service and is receiving deliveries of its second 100. There is confidence that more will follow.

While attending the Perth conference on hydrogen and full cell vehicles last September, I learned that that City has ordered 400 new OEM NGV buses to add to the 50 odd converted buses which have been in service for some years.

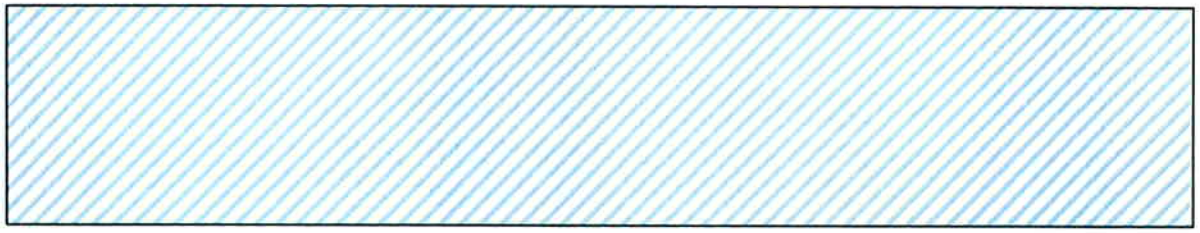
We have been quite successful in convincing industrial customers of the advantages of natural gas as a forklift fuel, stemming from the fact that energy intensive industry can purchase natural gas for $5.00-$10.00 per GJ which is equivalent to diesel at 20c to 40c per litre. Of course, using natural gas obviates the need for access to the plant by large LPG tankers and also produces less harmful emissions within the closed spaces of factories and storage areas. The Adelaide Brighton Cement Co operates a sea going gypsum carrier using natural gas as fuel, and at the price they pay for gas, I imagine the fuel cost is around 20% of what they would pay for diesel.

In the early 90's SA Gas Co conducted trials with the L S Booth wine transport group and using a grant from the Federal ERDC funds, converted a 40t capacity prime mover to run daily between Adelaide and Nhill, proving the fact that a Melbourne-Adelaide service was possible. Nowadays gas is available at Adelaide, Murray Bridge, Horsham, Stawell, Ararat, Ballarat and Melbourne so range would not be a problem.

It is my view that, had there been access to OEM heavy-duty NGV trucks in Australia for the past 10 to 15 years, NGV would have made considerable inroads into the market. There were not however, and, understandably, fleet operators are not prepared to carry the risks associated with converted heavy-duty trucks. This is slowly changing however, as Japanese and European NGV truck OEMs are contemplating the extension of their markets to this country.

In the early days the Australian Gas Association formed an NGV Committee which was, over a lengthy period, quite successful in lobbying government and co-ordinating the efforts of the various utilities and equipment suppliers. However, of the three important stakeholders, OEMs, fleet operators and gas companies, only the latter were involved. So it was decided to form the Australasian Natural Gas Vehicle Council (ANGVC) to attract the input via membership of OEMs and fleet operators and to try to benefit from the NZ experience.

The ANGVC worked very effectively for a number of years,



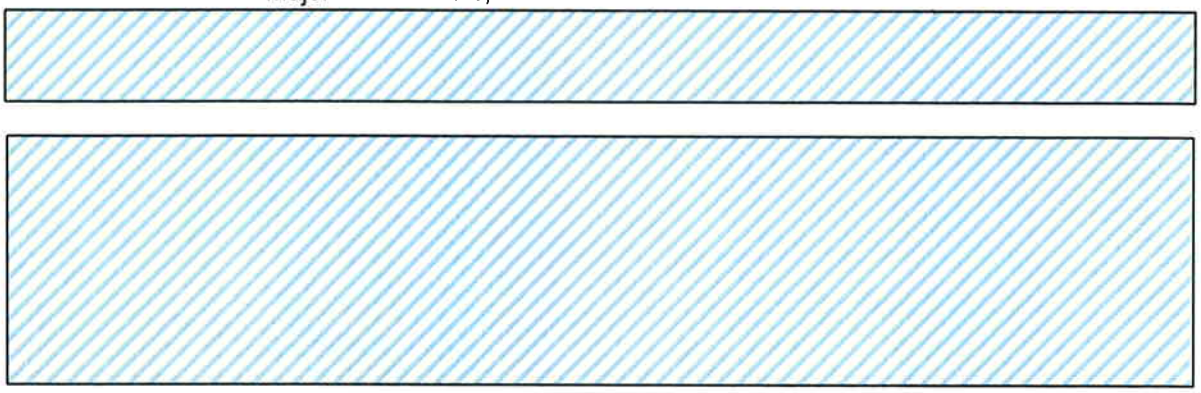
Worldwide, the industry has suffered from the "chicken and egg" syndrome in that there is a reluctance to supply/purchase NGVs while there is an inadequate refuelling infrastructure, but likewise, there is a reluctance to build refuelling infrastructure while there is perceived to be an inadequate number of NGVs to justify the cost of their construction.

The AGO had taken steps to combat this by offering grants to subsidize the provision of the refuelling infrastructure. The project got to the stage of calling tenders and awarding grants to successful tenderers.

It was at this point that things went awry. Both  reneged on the contracts, apparently because the grants, although substantial, were such that each refuelling station would have absorbed considerable capital funding over and above.

The Federal Government then started to make announcements about the proposed introduction of fuel excise on LPG and natural gas when used as transport fuels, and although the tax is to be built up to 50% of the tax, on a thermal basis, of that applied to diesel, and although it is to be introduced over a period of years commencing some years into the future, it effectively put paid to the level of interest that had been generated over many years.

What was (and still is) needed was a strong industry association to lobby government and co-ordinate the efforts of the three major stakeholders,



There has been some refocus on the transport energy mix worldwide and in Australia in recent months, stemming from the very high recent price of crude oil and the perceived reliability of supply risks recently demonstrated by global hostilities and the increasing demand by countries such as China and India.

As prices stand, a sizeable user (bus fleet for example) can purchase gas for $7.50 per gigajoule which is equivalent to diesel at about 19.2c per litre and petrol at 21.5c per litre. The difference, even if excise tax of, say, 25c per litre is added, at current petrol and diesel prices is substantial so that, were OEM NGVs freely available in the range 4t to 25t, there would still appear to be excellent prospects for savings. For petrol at 90c and diesel at $1.00, the price of NGV would be 52% and 44% respectively. A 56c per litre saving for an urban bus, even after allowing for a 10% drop in thermal efficiency, would amount to around $15,000 per annum. One would expect, therefore, a payback of not more than five years for the extra cost of the bus and the refuelling station.

The other application that springs to mind is the use of natural gas for commuter vehicles in Victoria, particularly in Melbourne. At an actual delivered price of around $9.00 per GJ, NGV would be equivalent to petrol at, say, 26c per litre. For a car travelling 30,000 km, consuming 12.5 litres per 100 km, the annual saving would be of the order of $2,400. If/when home refuellers become available for $2000 and conversions cost $1500, a payback is available in less than two years and there is the convenience of home refuelling and, possibly, access to taxi lanes, inner city areas, free parking etc.

It is my belief that, like the European Community and many of the countries I have mentioned in the foregoing sections, Australian governments will, one day, get to realize that a country which has 100 years of gas reserves (excluding coal seam methane) and exports annually 33% of production and has oil reserves of around ten years and imports 33% of demand, would be wise to support an NGV program.

Further, if hydrogen as a transport fuel was a future objective, be it produced from hydrocarbons or from renewable sources, then Australia's fuel policy (if it had one) should recognize that hydrogen supply, in practical terms, is decades away (and if to be supplied "renewably" out to about 2050) and that there would be major benefits in using compressed natural gas in large quantities to develop an infrastructure for the eventual transition to hydrogen, let alone for the environmental benefits available immediately.

3 Conclusions

It is my view that it is inevitable that natural gas will eventually become a significant player in the transportation fuel market globally and it could, depending on industry action and government policy, become so in Australia in an even shorter time.

After all, it offers (a) less greenhouse gas emissions than petrol and LPG and, in the future, not more than diesel (b) reduced urban air degradation (c) self sufficiency and thereby an improvement in the national balance of payments and increased reliability of supply.

What is required is a strong industry association made up of gas retailers, gas transmission and distribution company representatives, vehicle OEMs, fleet owners/operators and refuelling station suppliers.

I would urge Envestra, perhaps through the ENA, to gather the necessary stakeholders together and re-form a professional industry association as soon as possible to keep in touch with NGV developments internationally and to lobby governments and the bureaucracy here in Australia.

The potential rewards are immense. Imagine a 20% share of the transport energy consumed in Australia passing through the natural gas distribution networks. Consumption may be of the order of 200 PJ per annum!

By the way, a lot more fuel is used by a lot fewer heavy vehicles when comparing petrol and diesel consumption and the transition should be easier and quicker than the petrol to LPG transition.