Global Trends in Transport Fuels and the Role of Natural Gas

An Australian Perspective

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Tony began his petroleum career in 1982 in Houston with the Gulf Oil Exploration and Production Company. With the Chevron/Gulf merger in 1985, Tony relocated to California, and held a series of international exploration and production assignments followed by stints supporting the Corporation's Executive staff and with Strategic Planning. Tony then came to Australia in 1994 where he has held a number of commercial and managerial assignments with the Chevron Australasian Business Unit in both Melbourne and Perth.

Tony was appointed to his current position with Sasol Chevron in January 2000 and is responsible for developing a new Gas to Liquids business based on Australia's abundant gas resources.

Introduction

It is well known that the developed world wants future transport fuels and technologies that deliver:

- Lower toxic emissions
- Lower greenhouse emissions
- Greater efficiency of energy use
- Less dependence on foreign oil imports
- Affordable transport

For many people, this kind of energy future invokes the idea of a "hydrogen economy". In 2002, the European Union committed 2.1 billion euros (about US$2.2-2.3 billion) to hydrogen research. Japan has a national goal of 50,000 fuel cell vehicles on the road and 2,100 megawatts of fuel cell power plants by 2010. US President George W. Bush laid out a vision of a hydrogen-powered future and announced US$1.2 billion in hydrogen research funding over five years to jump-start a long-term research program – the key here is "long-term".

For the foreseeable future, hydrogen will remain an industrial feedstock rather than a fuel and, whilst it may find niche fuel markets over the next decade, it will require major technological breakthroughs to become commercially viable. Hydrogen is expensive to produce, costly and complex to transport and store and uncompetitive because of its low volumetric energy density. Research will need to focus on the best source of hydrogen since the use of fossil fuels will not resolve energy security or supply issues. A second research focus area will be to establish hydrogen as a serious player in reducing greenhouse emissions. Today, other technologies can deliver the same greenhouse benefits at lower cost. Then there is the "chicken-and-egg" problem – without hydrogen re-fuelling stations, consumers will be reticent to use hydrogen-powered vehicles and, without customers, investors will be unwilling to build refuelling stations.

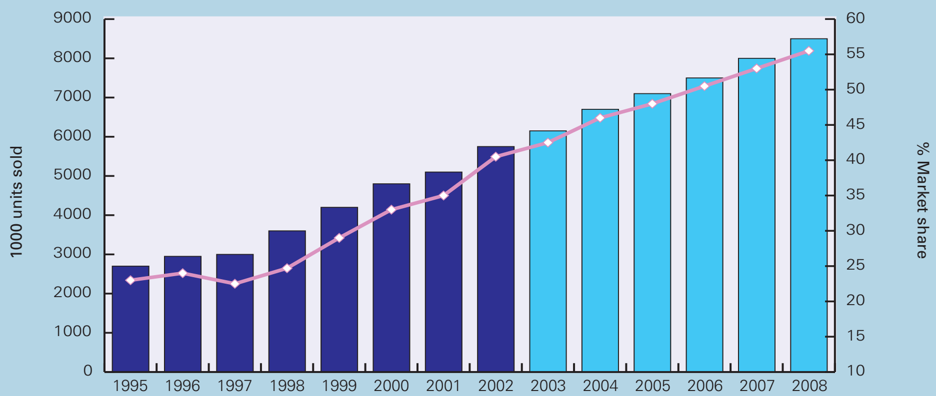
The only certainty about a shift to a hydrogen-powered world is that it is still a long way in the future. The extent of investment in research and development highlights how little is known and how much effort is still required to develop hydrogen technology and new energy innovation. Can the world wait to see what happens with hydrogen? The answer is that it can't; and neither is it.

Over the last decade, Europe has led the world in developing clear policy and implementing incentives and regulations to ensure it meets the sustainable transport objectives listed above in the near to mid-term. The pathway Europe identified as best delivering these objectives involves ultra-clean diesel fuels and advanced diesel engine technologies. There are a number of reasons for this:

- Diesel cars use 30-50% less fuel than petrol cars of similar power
- Diesel cars produce more drive force at lower engine speeds
- Diesel engines are built to last well over 300,000 kilometres, require less maintenance and have longer service intervals than petrol engines (Diesel Technology Forum 2001)
- Diesel fuel efficiency means lower emissions of greenhouse gases
- The latest diesel technology is both clean and quiet, offering a good alternative to less efficient petrol cars

In 2002, 40% of new passenger cars in Europe had diesel engines compared with less than 20% a decade earlier (Diesel Technology Forum 2001), highlighting Europe's success in implementing its chosen transport policy (Figure 1). This transition has not occurred without government intervention. European governments encourage the use of diesel technology through fuel tax structures and vehicle sales taxes. At the same time, stringent emissions regulations encourage advances in emissions reduction technology and maintain the market viability of diesel vehicles.

Figure 1 - European diesel car market share



Source: AID: Diesel Car prospectus to 2008; Nov, 2002

In the US and Australia, many policy-makers and consumers still see diesel as both dirty and noisy. Until recently, most policy and discussion in these jurisdictions has centred on alternative fuels such as CNG, LPG, biofuels and hydrogen. All of these fuels, however, are limited in the extent to which they can penetrate markets and achieve each of the objectives above. This is now being recognised in the USA with California leading the way in defining the increasing role that diesel needs to play in the near to mid term on the path to sustainable transport fuels and technologies (CEC and CARB, 2003).

In all jurisdictions, understanding is growing that natural gas can be an important part of the diesel pathway. The role of natural gas in liquid transport fuels and gas-to-liquids technology (GTL) is not widely understood in the broader community although the technology has been around since the 1920s. The Fischer-Tropsch process, fundamental to GTL technology, has been successfully used on a large scale in South Africa where it is used to produce about 40% of South Africa's domestic liquid transport fuels. GTL technology has not been used on a global scale before simply because global oil supplies have been so abundant and crude oil refining has been less expensive. The cost of the technology today is increasingly competitive with crude oil refining because refining costs for cleaner fuels are increasing and because GTL producers can target the product slate to produce diesel and other middle distillates, for which demand growth is highest. In addition, GTL diesel is already ultra-clean with virtually no sulphur or aromatics. Because of this, there is continuing research and development focus on GTL technology to further lower capital and operating costs. A number of companies are active in GTL process development, including Sasol Chevron, Sasol, ExxonMobil, Shell, and ConocoPhillips.

Sasol, with over 50 years GTL experience in South Africa, together with Qatar Petroleum, is currently building the largest and first truly commercial-scale GTL plant in the world – a 34,000 barrel per day facility, ORYX GTL, in Ras Laffan in Qatar. This is scheduled for start-up in 2005. Sasol is targeting selected Asian and European markets for its premium, ultra-clean GTL diesel and naphtha (http://www.sasol.com). Chevron Nigeria (CNL) and the Nigerian National Petroleum Corporation (NNPC) are planning a further 34,000 barrel per day GTL plant in Escravos in Nigeria and this will use the same technology as ORYX GTL. Products from this plant are aimed primarily at the European market (http://www.sasolchevron.com).

Further, Sasol and ChevronTexaco, through their joint venture, Sasol Chevron, have announced the most ambitious slate of GTL projects to date with a six billion dollar package that will include an expansion for ORYX (65,000 bbl/day), an integrated project (130,000 bbl/day plus 80,000 bbl/day associated condensates) and a GTL base oils production facility.

Both Shell and ConocoPhillips have also announced large-scale GTL projects and Shell's 12,500 barrel per day plant in Bintulu in Malaysia is selling GTL diesel and naphtha into Asia Pacific markets, including Thailand, Japan and California.

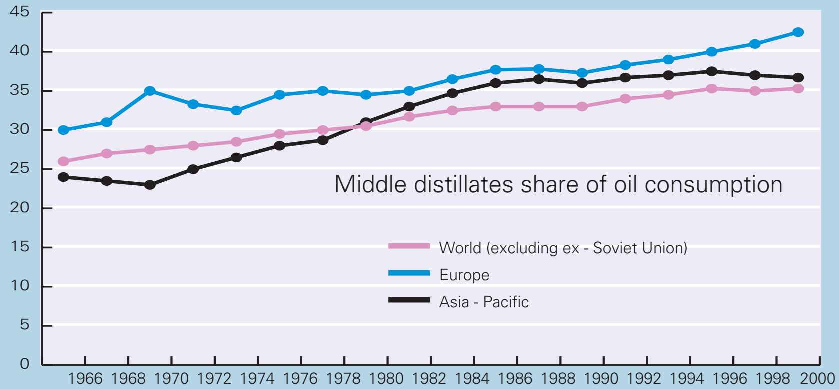
For Australia, with its abundant but remote natural gas resources, GTL technology offers the opportunity to create a new value-adding industry whilst capitalising on the global trend toward dieselisation and building a pathway to best meet the sustainable transport objectives listed above.

This paper explores the global trend towards diesel technology, highlighting the role of natural gas in the diesel pathway, comparing the European and American experiences and commenting on the sustainable transport possibilities for Australia in the future.

The Global Diesel Market and the Role of GTL Diesel

World diesel demand in 2001 was about 12.5 Mmbbl/day (Petroleum Economist 2003). Demand has grown close to 3% per year for the past decade, making diesel the fastest growing segment of the refined products market (Figure 2). In the first half of the 1990s, global demand growth was dampened by the decline of the Soviet Union and in the second half by the Asian slowdown (Petroleum Economist 2003). Diesel demand is closely correlated to economic growth since it is the fuel used to drive the global economy and is preferred for mining, agriculture and road freight. In Europe, passenger transport is now contributing to demand growth. Globally, diesel demand is likely to continue to grow at around 3% per year while demand for certain other refined products is likely to flatten and even decline (Petroleum Economist 2003). Against this backdrop, refiners are facing significant challenges to meet diesel demand into the future.

Figure 2 - Market outlook for diesel; increasing share of the oil barrel



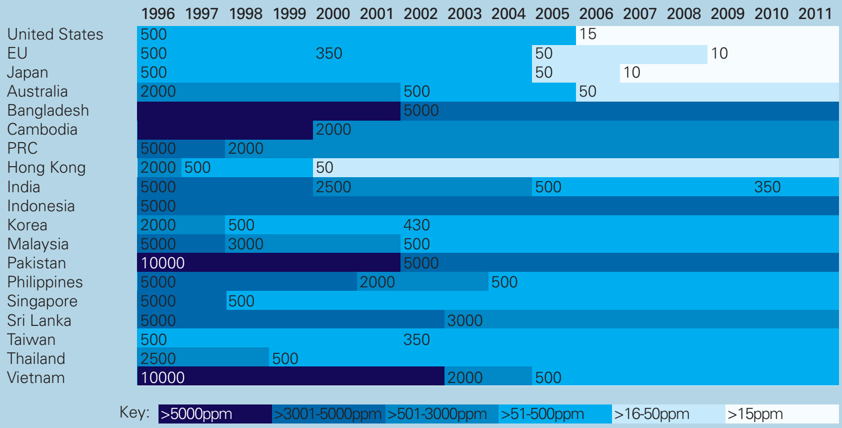
Source: BP Statistical Review of World Energy, June 2003

A second area of pressure for refiners arises from global demand for cleaner diesel. Concerns over air pollution in many jurisdictions have led to a continuing tightening of diesel vehicle emission specifications. Vehicle manufacturers have improved exhaust treatment technology and enhanced engines significantly, but these technology advances have required the introduction of cleaner diesel fuels. Even in developed economies there is still some way to go to achieve the "sulphur-free" diesel (10ppm sulphur or less) that is required by vehicle manufacturers for further advancement of emission control systems.

The European Union is in the final stages of adopting legislation which will mandate sulphur-free diesel for on-road use by 2009. Most parts of Europe are already using 50ppm or lower sulphur diesel well ahead of the target date of 2005. The US will introduce 15ppm sulphur diesel by 2006 while Japan is likely to mandate the use of sulphur-free diesel by 2008 (World Diesel 2003). Australia will introduce 50ppm sulphur diesel in 2006 and could go to "sulphur-free" diesel by the end of the decade. At the end of the 1990s, "clean" diesel around the world still contained about 500ppm sulphur, highlighting the magnitude of clean fuel advances in recent years (Figure 3).

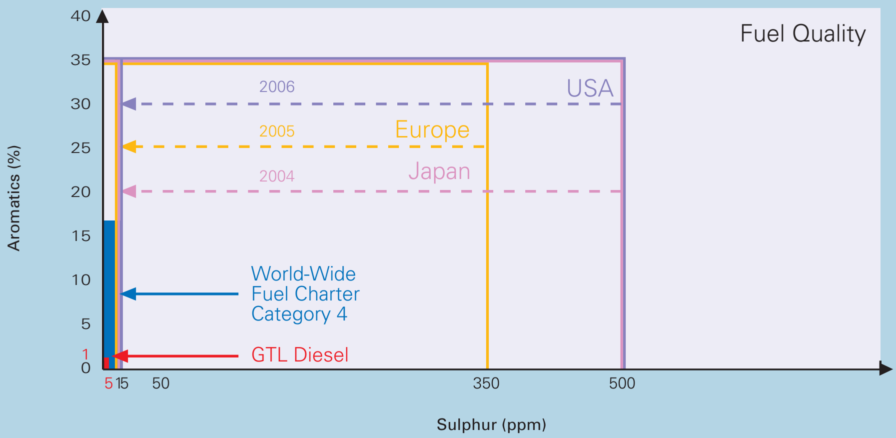
Significant refinery investment will be required to meet the sulphur-free specifications. In Europe, tight specifications for other parameters such as cetane (min 51) and polyaromatic hydrocarbons (max 11%wt) pose additional challenges to refiners.

Figure 3 - Supply side challenges; Systematic removal of sulphur



GTL diesel could play a significant role in assisting refiners on both fronts – quantity and quality. Typically, the diesel yield of GTL plants is around 70%, much higher than refineries at around 40% (Petroleum Economist 2003). In terms of quality, GTL diesel fits the future. With virtually no sulphur or aromatics and a very high cetane of over 70, GTL diesel today exceeds the clean fuel specifications of tomorrow (Figure 4). GTL diesel can be used as a neat fuel or as a fuel blend in existing diesel engines and future advanced diesel, diesel electric hybrid and some fuel cell technologies. It can also utilise existing fuel distribution infrastructure, which provides significant market penetration and economic efficiency advantages compared to many other clean fuels. The UK's Green Fuels Minister commented on the positive economic potential for GTL diesel because it can be used in conventional diesel engines and can utilise the current supply infrastructure (Jamieson, 14/07/03).

Figure 4 - GTL diesel quality in perspective



The properties of GTL diesel make it an ideal blending component to upgrade lower quality middle distillate streams to on-road diesel fuel quality. This could be particularly valuable in Europe where refinery configurations make upgrading these streams increasingly difficult and expensive. GTL diesel's lower density, low aromatics and high cetane are the properties needed. On a volume basis alone, GTL diesel will allow refiners to increase their diesel output.

GTL diesel has already demonstrated its potential in the global diesel market. The availability of fuel from Bintulu has allowed the product to be trialled extensively in international markets (The GTL fuels produced in South Africa are consumed domestically). GTL diesel from Bintulu is being used in the Thai, Japanese and Californian markets and has just been introduced to a bus trial in central London.

One of the most frequently raised concerns about the GTL production process is that it produces more CO2 than the refinery process, although the end use of GTL fuels is more efficient. In 2002, PricewaterhouseCoopers was commissioned by Sasol Chevron to conduct a lifecycle assessment of transportation fuel processes, including a modern complex refinery and a GTL production facility, using the ISO 14040 standard for such assessments. The finding was that GTL offers substantial air quality benefits compared to a refinery as a result of its lower sulphur dioxide, nitrogen oxide and hydrocarbon emissions. These benefits are achieved without incurring a greenhouse gas penalty compared to crude oil refining. One benefit of GTL technology lies in the fact that it can produce ultra-clean GTL diesel without producing the heavy residual fuel (with its high associated environmental burden) that a refinery produces. The GTL process thus facilitates the move towards cleaner forms of electricity generation through natural gas instead of heavy residual fuel oil or petroleum coke.

Unlike other fuel lifecycles, where greenhouse emissions are predominantly generated through distributed exhaust emissions, one of the advantages of the GTL production process is that the waste is a single-source, CO2-rich stream that can be sequestered, further reducing CO2 emissions to the atmosphere (CSIRO 2002).

In summary, the outlook for the global diesel market is very strong and natural gas, together with GTL technology, could play a significant part in supplementing supply and meeting future fuel specifications in developed countries.

Advanced Diesel Technology

Diesel technology has long dominated the heavy duty vehicle sector around the world because of its inherent fuel efficiency, power and durability. The Europeans have now taken this advantage, together with the technologies that were developed for the heavy duty sector in the US, into the light duty vehicle sector without sacrificing vehicle performance (Diesel Technology Forum 2001). There are two key areas of technological advancement:

- Advanced direct injection lean-burn combustion technology
- Advanced light duty diesel emissions control technology (combined with a shift to ultra-low sulphur diesel fuel)

Lean-burn internal combustion engines are engines that operate at an air-to-fuel ratio higher than that necessary for complete combustion of the fuel. Advanced lean-burn operation provides a 20-40% improvement in fuel efficiency over conventional diesel technology and 40-60% compared to conventional petrol engines (Diesel Technology Forum 2001). The technology also delivers better efficiency than petrol-electric hybrid cars. Lower toxic emissions are also achieved. Using the latest Peugeot direct injection engines as an example, hydrocarbon emissions are reduced by 40%, CO and CO_2 by 20%, particulate matter by 60% (without particulate filter systems) and ozone precursors by 50% (Diesel Technology Forum 2001).

Advanced lean-burn combustion incorporates a number of specific advanced engine technologies including direct fuel injection, electronic fuel injection, common rail fuel injection, improved combustion chamber design and advanced turbo-charging. Sophisticated computer-controlled technology is used to optimise the lean-burn process. This allows for direct injection of fuel into the combustion chamber, rather than use of a pre-chamber, and eliminates heat loss that decreases efficiency. Common rail fuel injection makes engine operation smoother and quieter by allowing pre-injection of a carefully controlled ultra-high-pressure "mist" of fuel and air into the engine before the main injection. This cushions the impact of sudden temperature and pressure changes that caused vibration and noise in older diesel engines.

While diesels naturally perform better than petrol engines in terms of hydrocarbon, CO and CO_2 emissions, they tend to produce more particulate matter and NO_x than petrol engines. Historically, the sulphur in diesel fuel has prevented use of effective exhaust treatment technologies such as catalysts and particulate filters in diesel vehicles, although catalysts are widely used in petrol cars. With the advent of ultra-low sulphur diesel fuels, however, both of these technologies can now be used effectively in diesel cars. "Sulphur-free" diesel (10ppm sulphur or lower) has been used in Sweden for more than a decade and will be mandated throughout the European Union by 2009, allowing further improvements in the longevity and effectiveness of these technologies. Engine enhancements like air-to-air charge cooling and exhaust gas recirculation have also contributed to significant NO_x emission reductions in the latest diesel engines (Diesel Technology Forum 2001).

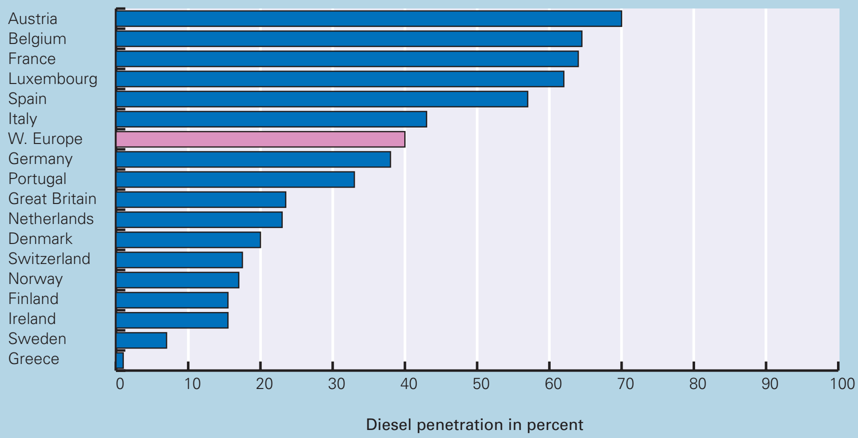
Peugeot again provides a good example of the significant advances in emissions control technology. The latest Peugeot particulate filter is regenerative and has achieved particulate emissions reduction of more than 95% (Diesel Technology Forum 2001). The Peugeot system uses common rail fuel injection to increase the temperature of the exhaust when necessary to oxidise or burn excess soot from the filter. This occurs every 400-450km, takes only two to three minutes, and has no effect on driving (Diesel Technology Forum 2001).

In summary, advanced diesel passenger cars deliver all of the key sustainable transport objectives that the developed world desires in high performance vehicles if they are to have broad-based consumer appeal. Numerous studies around the world have confirmed that the diesel (and diesel-electric hybrid) technology pathway consistently and cost-effectively delivers the best overall energy, greenhouse efficiency and environmental outcomes of today's transport technologies (Ricardo 2002; CSIRO 2002).

Comparison of the European and American Experience

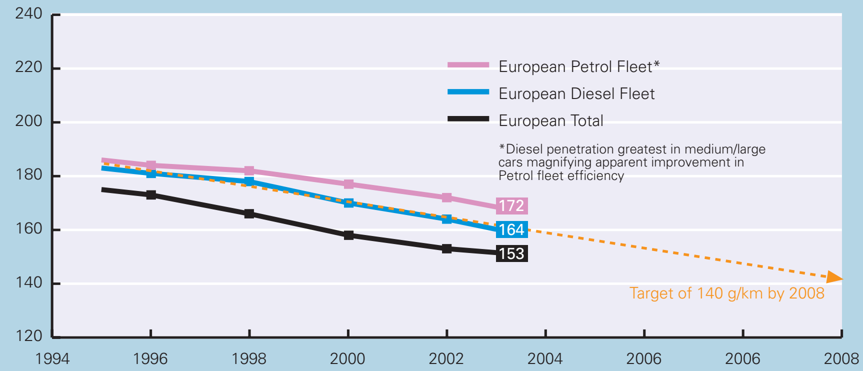
Over 40% of new passenger cars in Europe now have diesel engines compared with less than 20% a decade ago. In France, Austria and Belgium, well over 60% of new passenger cars are diesels and over 80% of luxury cars are diesels (Figure 5). European consumers are taking up advanced diesel technology to get better fuel efficiency, more power, and more durability as well as quiet, clean, premium vehicles that were previously the domain of petrol cars. Because European consumers now have first-hand experience with the performance advantages of advanced clean diesel technology, sales growth continues to accelerate.

Figure 5 - Diesel penetration in new passenger cars in Western Europe; 2002



In the year 2001-2002, diesel car sales across Europe increased by a record 12%, outstripping the record set during the previous twelve months (World Diesel Fuel 2003). Governments and some environmental groups are encouraging this trend, which reduces greenhouse emissions and improves fuel efficiency (Figure 6). Initially, fuel tax and vehicle sales tax policies drove diesel uptake in Europe, although it is likely that consumer preference for power and comfort is now a significant factor due to the performance of the latest diesel technology and diesel fuels.

Figure 6 - Increasing efficiency and decreasing CO^{2} emissions of the European passenger car fleet



Source: Ricardo Consulting Engineers, “Carbon to hydrogen Roadmaps for Passenger Cars”, 2002

The UK Government provides a good example of the range of tax and regulatory incentives which initially drove European automotive technology and fuel development, as well as consumer uptake. Incentives are provided to vehicle users, manufacturers and researchers, and fuel and infrastructure providers. Vehicle excise duty, related to CO2 emissions and fuel type, and company car taxation, related to vehicle CO2 emissions, favour diesel because of its greater efficiency. Other incentives to vehicle users include grants towards retrofitting emissions reduction equipment in pollution hotspot areas and in road haulage vehicles.

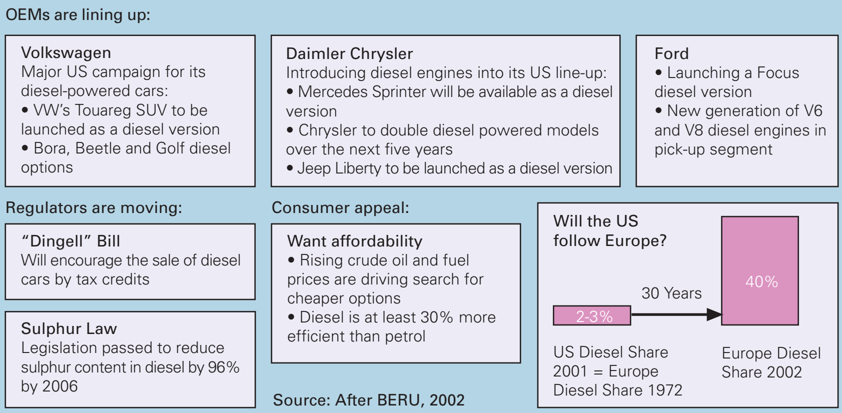
Manufacturers and researchers benefit from grants of up to 50% of the cost of research into future automotive industry products and processes and funding for demonstration projects of new, low carbon, vehicle technologies and fuel cell, sustainable and green technology research. Fuel and infrastructure providers were able to introduce 50ppm sulphur diesel three years ahead of schedule because of a three pence fuel duty differential. Other incentives for the future include exemption or reduction of duty rates on alternative transport fuels for pilot projects (e.g. the GTL diesel bus trial in London) and the funding of renewable, sustainable and green technology research.

In the US, however, consumer uptake and automotive technology development of diesel cars is negligible. A significant factor is that the advanced diesel technology available to Europeans is not available in the US. In part, this is because the application of the advanced engine technology is dependent on the diesel fuel quality which, in the US, is lagging behind the European Union. Consequently, Americans associate diesels with historically lower performance standards than petrol cars, the reverse of the European perception and experience. Lower fuel prices in the US, and taxation and emissions regulation structures that do not encourage diesel fuel and technology, also detract from both consumer uptake and technology development. However, the big change driver of the future for the US could be market-based, with accelerated uptake likely to occur when high performance European diesel cars and SUVs are experienced by American consumers.

As motor manufacturers seek to develop the market for new diesel cars in the US, it is increasingly likely that a number of European diesel cars will be able to meet US "Tier 2" emission standards within the next few years, particularly with the emergence of advanced exhaust treatment technology, cleaner diesel fuels and engine enhancements.

US emission standards have historically created barriers to light duty diesel vehicles because of their focus on particulates and NOx rather than the broader suite of toxic and greenhouse emissions that Europe has focussed on in developing its automotive technology (Diesel Technology Forum 2001). The US approach favours petrol technology and explains the paucity of diesel cars currently available in the US marketplace. The introduction of a broader range of emission-compliant diesel cars to the US market will allow consumers to make their own choices about diesel technology. If the European experience is emulated, high performance, coupled with efficiency, is likely to drive significant uptake of diesel cars in the US by the end of this decade with flow-on benefits in all of the key sustainable transport objectives listed earlier (Figure 7).

Figure 7 - Diesel technology is starting to make an impact in the US at all levels

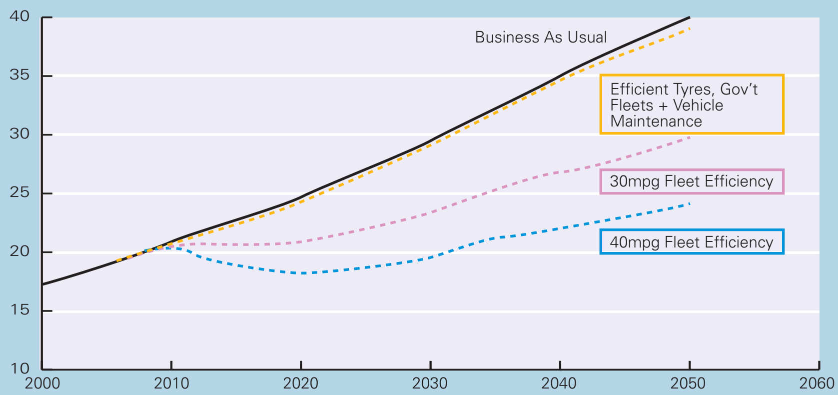


Source: After BERU, 2002

In addition to market-based factors, there is emerging evidence that US regulators may also encourage a shift to diesel. The US Department of Energy has estimated that increasing the market share of light-duty diesel technology to 30% would reduce net crude oil imports by 700,000 barrels per day by 2020 – an amount equivalent to one half of California's total daily energy consumption (Diesel Technology Forum 2001). The California Energy Commission (CEC) and Air Resources Board (CARB) released a report in May 2003 that recommends promoting fuel efficiency improvements combined with use of alternative fuels as a means of reducing the State's dependence on petroleum. The paper warned that unless Californians make a major change to their transport demands, they will have to accept major expansions of refinery and delivery infrastructure, price volatility, further dependence on foreign oil supplies, lower environmental quality and reductions in public health (CEC and CARB 2003).

The Californian agencies looked primarily at fuel efficiency and fuel substitution options to reduce the state's dependence on petroleum. They found the most dramatic reduction in petroleum demand was possible by improving vehicle fuel efficiency. If the fuel economy of new cars and light trucks were improved to 10-15km/l by the year 2010, the growth in demand would be reduced to zero by the year 2020 and would not increase again until 2030 (Figure 8). Existing and emerging technologies, including improvements in engines and transmissions, aerodynamic styling, weight reduction and increased use of hybrid electric and diesel propulsion systems, are available to achieve this target. The agencies concluded that, if these technologies were used, the increased purchase price of a new car would be more than offset by the lifetime fuel savings in most cases. In some cases, vehicle purchase cost is lower anyway. For example, a 2001 turbo-diesel Jetta GLS cost $500 less than the turbocharged gasoline-powered Jetta GLS and the owner of a diesel Jetta could expect to save over $2300 in fuel costs over a 100,000 mile vehicle life at year 2000 fuel prices (Diesel Technology Forum 2001).

Figure 8 - Modelled California demand reduction from fuel efficiency options



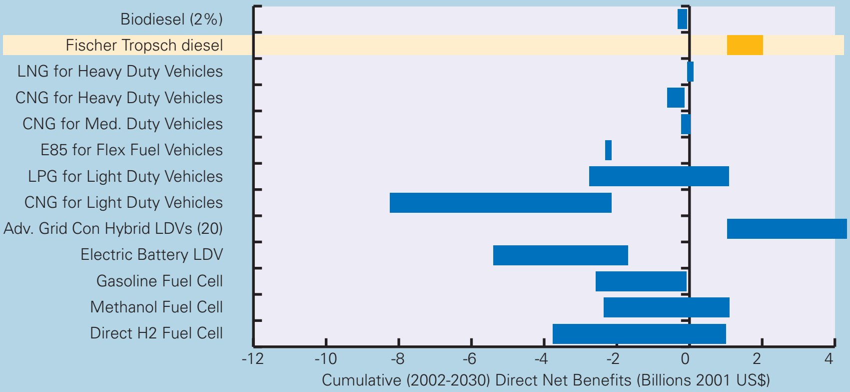
Source: California Energy Commission and California Air Resources Board 2003, Reducing California's Petroleum Dependence, California US

The fuel substitution options examined in the California study were:

- CNG and LNG
- Ethanol blends
- LPG
- GTL diesel and biodiesel blends
- Electric vehicles
- Hydrogen fuel cell vehicles

In general, a penetration rate of 10% of new vehicle sales per year was assumed, with the exception of fuel blends (eg ethanol/petrol and GTL diesel/diesel). The GTL diesel blend (at 33%) was the only fuel substitution option modelled that resulted in a positive direct net benefit at today's fuel prices (Figure 9).

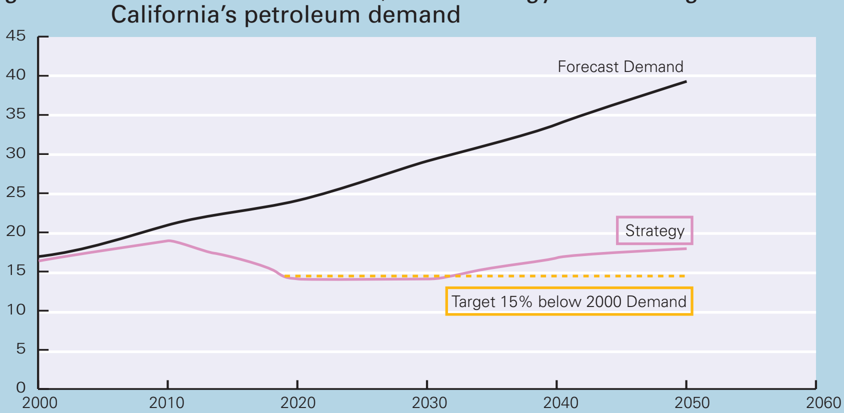
Figure 9 - Modelled direct net benefit of fuel substitution options



Source: California Energy Commission and California Air Resources Board 2003, Reducing California's Petroleum Dependence, California US

Even if used only in heavy duty vehicles, it would reduce the state's total petroleum demand by about 6%. A shift to 10% direct hydrogen fuel cell vehicles in the light duty fleet would reduce petroleum demand by about 8%, but with a negative direct net benefit at today's fuel prices. The recommended combination of vehicle fuel efficiency improvements and increased use of alternative fuels was modelled to reduce petroleum demand in California to 15% below 2000 levels (Figure 10). Although some of the recommendations in this report may be contentious and the modelling results disputed, diesel fuels and technology could play an important role in California's transport energy future.

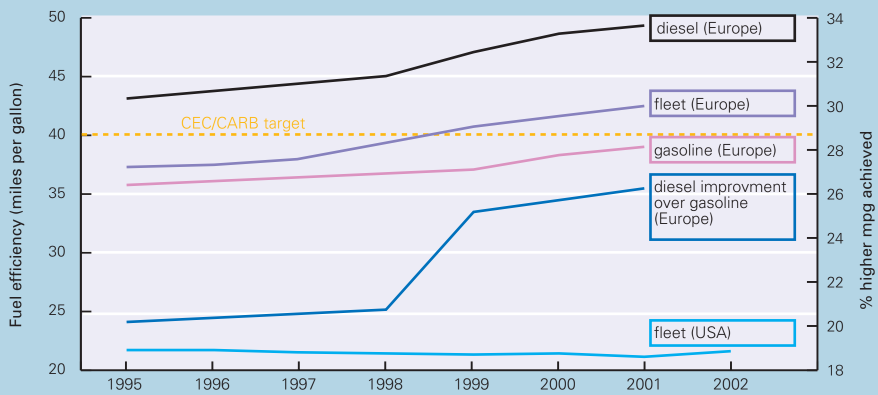
Figure 10 - Modelled results of CEC/CARB strategy for reducing California's petroleum demand



Source: California Energy Commission and California Air Resources Board 2003, Reducing California's Petroleum Dependence, California US

The momentum behind diesel vehicle technology and fuel development is an established fact in Europe and, while it will take some time to flow through to the US, the evidence suggests that diesel will have come into its own in the light duty sector as well as the heavy duty sector by the end of this decade. The fuel efficiency benefits of this transformation for the US will be immense (Figure 11).

Figure 11 - Diesel delivers real fuel efficiency benefits



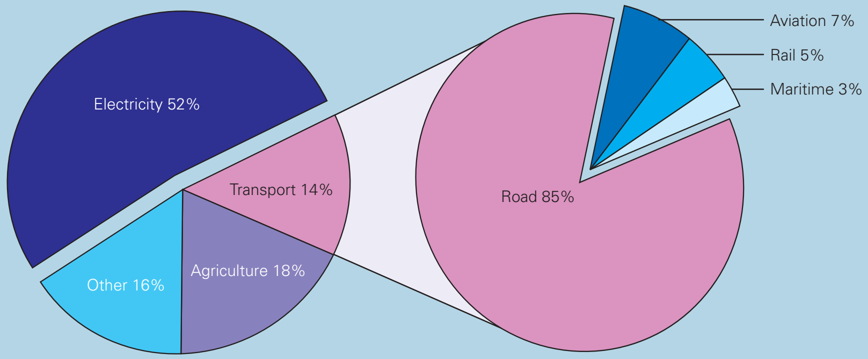
Source: ACEA, US EPA

Sustainable Transport Possibilities for Australia

So where does diesel fit in the Australian transport outlook?

Transport accounts for 41% of Australia's domestic demand for energy and produces 14% of its greenhouse emissions (CSIRO 2002). Road transport generates 85% of these emissions and is the segment where greenhouse emissions reductions are most required (Figure 12). Transport demand growth over the next two decades is forecast to be highest in air transport (4.5% per annum), road freight (2.9% per annum), and sea transport (2.3% per annum) (CSIRO 2002). All of these growth sectors predominantly use diesel and other middle distillate fuels (e.g. jet fuel and marine fuel oil). Combined with the potential for broader migration to diesel in the passenger car market, in line with global trends to achieve greater energy and greenhouse efficiency, diesel demand growth in Australia could rise significantly, whilst petrol demand growth could remain flat or decline over the next two decades.

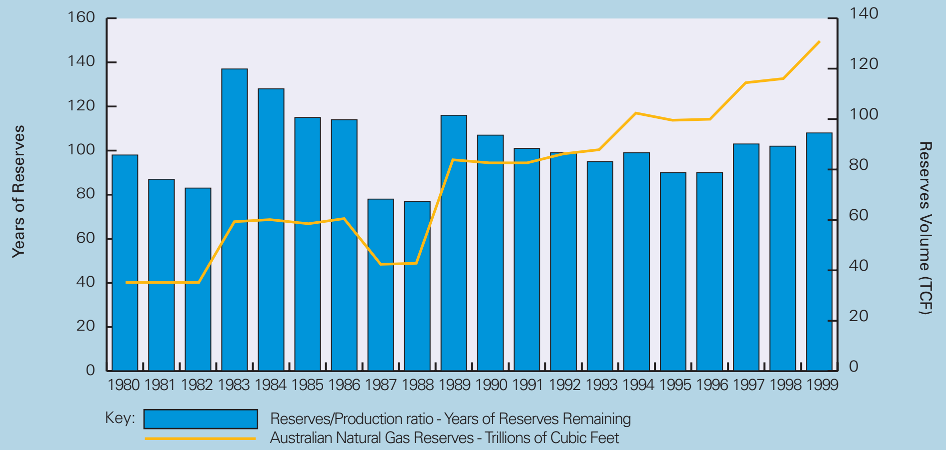
Figure 12 - Australian energy market greenhouse gas emissions



Australia is facing a significant decline in crude oil production and a reduction in refining capacity. For the seven years, to 2002, domestic crude oil consumption outstripped discovery rates by three times (CSIRO 2002). By 2010, Australia will need to import 50-60% of its crude oil requirements which will have a negative impact on balance of payments of $7-8 billion (CSIRO 2002). It will also be increasing its imports of refined products, primarily diesel and jet fuel.

Conversely, Australia has abundant natural gas reserves and, over the past 20 years, new natural gas discoveries have exceeded gas production (Figure 13). Reserves are estimated to have increased fourfold to about 115Tcf, or 105 years supply at 2002 production levels (CSIRO 2002). In 2003, appraisal drilling in northwestern Australia has further increased reserves, probably to around 140Tcf. More than 130Tcf of these reserves are located in the far northwest of the country and away from the gas markets of the eastern States. This is energy equivalent to over 20 billion barrels of oil. Liquefied natural gas (LNG) markets for power generation and natural gas distribution in Japan, China, Korea and the US are the primary focus to develop these reserves but GTL technology could open up the diesel fuel markets in these countries, and Australia, to these resources.

Figure 13 - Australia's growing gas reserves and production



Australian LNG has made inroads to Asia Pacific markets because it provides diversification of supply away from Middle East sources and it is a clean fuel for power generation and direct energy. Australian GTL diesel could offer the same benefits in the transport sector of these Asia Pacific markets.

In the Australian transport market, GTL technology would allow fuel manufacturing to target the growth sector of the market – diesel and other middle distillates. A GTL industry would reduce Australia's growing dependency on foreign crude oil and refined products and replace lost capacity in Australia's refining industry. In addition, the availability of GTL diesel and refined ultra-low sulphur diesel in the marketplace later this decade would allow introduction of advanced diesel technology in Australia. With increased consumer uptake of diesel in the passenger car sector where greenhouse emissions are currently highest, Australia could achieve significant reductions in greenhouse emissions on a scale experienced in Europe over the past decade. Only 8% of Australia's overall vehicle fleet runs on diesel today, mostly in the heavy duty vehicle sector. There is enormous scope for diesel to make inroads into the Australian market in the future. In its 2002 report titled, "The Energy and Transport Sector Outlook to 2020", CSIRO noted:

"The global future for the evolution of transport fuels and vehicles is driven by greenhouse gas and oil supply issues and is very uncertain. Australia's strategy must be flexible and segmented. The proposed strategy, offering a 60% reduction in GHG emissions, decreased dependence on oil and a platform for future H2 use, involves:

- Migration to diesel, using best practice technology and fuel standards
- Production of "clean" diesel from natural gas or coal with CO2 sequestration
- Development of hybrid cars and light vehicles, fuelled by diesel
- Niche segments may be developed for compressed natural gas, with the added advantage of commencing infrastructure options for future hydrogen-based systems"

In addition to the transport benefits, a GTL industry would offer Australia the tangible economic benefits that come with multi-billion dollar investments:

- Employment growth
- Resource value-adding
- Increased Government revenue
- Higher GDP
- New exports
- National infrastructure that could provide a platform to deliver natural gas to remote domestic markets in the future

There is no doubt that Australia's abundant world-class natural gas resources, combined with GTL technology, offer the opportunity of creating a new, value-adding industry. Australia is well-placed to capitalise on the global trend toward diesel, building and reinforcing strategic trading partnerships whilst forging a pathway to a sustainable domestic transport future.

Conclusion

Ultra-clean diesel fuel and advanced diesel and diesel electric hybrid technology offers the most cost-effective near to mid term transport solution for the developed world to achieve:

- Lower toxic emissions
- Lower greenhouse emissions
- Greater efficiency of energy use
- Less dependence on foreign oil imports
- Affordable transport

Natural gas and GTL technology have a significant role to play in the diesel transport pathway by introducing GTL diesel to the marketplace. Developing remote gas fields for this market could also underpin the infrastructure necessary to bring more natural gas to markets where CNG can be used in niche urban transport applications.

Australia has already had success with its remote northwest gas developments and in marketing LNG as a clean fuel for power generation and distribution in the Asian region. There is no doubt that Australia has the skills and resources required to be equally successful in the fast-developing global GTL industry. As a leading GTL company, Sasol Chevron is confident that Australia will become a major player in the industry and that, as a result, substantial economic benefits will flow from our industry to the Australian people.

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