Fuel for thought

The future of transport fuels: challenges and opportunities

Future Fuels Forum
June 2008
Disclaimer

The results and analyses contained in this report are based on a number of technical, circumstantial or otherwise specified assumptions and parameters. The user must make its own assessment of the suitability for its use of the information or material contained in or generated from the report. To the extent permitted by law, CSIRO and the participating organisations exclude all liability to any party for expenses, losses, damages and costs arising directly or indirectly from using this report. The views expressed in this report do not necessarily represent the views of any single or all participating organisations.

Acknowledgments

The Future Fuels Forum extends its sincere thanks to John Wright, Director CSIRO Energy Transformed Flagship, for his guidance and support throughout the project.

Project Team

Chairman: Oleg Morozow, RPS Ecos
Project Leader: Paul Graham, CSIRO
Editor: Vanessa Wallace, Savance Communications
Modelling: Paul Graham, CSIRO; Luke Reedman, CSIRO; Franzi Poldy, CSIRO
Additional Facilitation: Mary Maher, Mary Maher and Associates
Communications: Linley Davis, CSIRO
Design: Curzon Creative Services

Future Fuels Forum Delegates


Enquiries should be directed to:

Paul Graham
Theme Leader Energy Futures
CSIRO Energy Transformed Flagship
PO Box 330, Newcastle, NSW 2300 Australia
Telephone: +61 2 4960 6061
Paul.Graham@csiro.au
Fuel for thought
The future of transport fuels: challenges and opportunities

Future Fuels Forum
June 2008
Securing access to affordable and sustainable fuel underpins Australia’s economy and our way of life. But our world is changing. The primary centres for economic growth are shifting; fuel costs are rising and many countries are ramping up efforts to address climate change. The result: ensuring we use the right fuels in the future will be crucial for the sustainability of our planet.

We have been bombarded with information on peak oil, alternative fuels and fuel and greenhouse gas-saving vehicle technologies. All have implications for fuel prices, the environment, global warming and, ultimately, the structure of our society. But how do we decide between the options?

As representatives from Australia’s transport stakeholders we welcomed the opportunity to participate in the CSIRO-led Future Fuels Forum to consider Australia’s fuel choices.

Our goal has been to identify plausible scenarios for the future of transport fuels in Australia, subject them to techno-economic modelling and assessment, and then examine their implications. In doing so, we have not made recommendations for specific investments or government policy; instead we have sought to present a cogent view of the broad spectrum of elements to be considered for assessment of Australia’s future fuel options.

CSIRO alone is responsible for the robustness of the quantitative modelling conducted and the views contained in this report do not necessarily represent the views of any single, or all, participating organisations. However, we, after sometimes robust and far-reaching debate, do agree that Australia will have to change its transport fuel mix. Such change will take considerable time, resources and the participation of all stakeholders.

History shows that when acting alone, neither government, industry, community or individuals can provide the definitive answers. We hope that the successful conclusion of this collaborative project, and the contents of this report will assist in advancing the debate on our transport fuel needs by providing strategic input to decision-makers in industry and government on what options will need their careful consideration and further research.

Prepared jointly by Future Fuels Forum delegates

June 2008
# Table of contents

**Executive summary** 10  
The future will demand change 12  
  Paying heed to our vulnerability 12  
  A new era: expected changes in price and availability of oil products 13  
  A challenge and an opportunity 18  

Social impacts of changing Australia’s transport fuel mix 21  
  Possible economic impacts 21  
  Impact of additional transport sector policies 23  

The role of consumers and industry in shaping a response 25  
  Uncertain times ahead 25  
  New industry fuel supply chains 26  

The role of government in shaping a response 29  
  Picking winners versus market-based instruments 30  
  A balancing act 31  
  Integrating responses 32  

The role of technology and travel preferences 33  
  Australia’s travel preferences 33  
  Fuel and vehicle technology 35  

The role of cities 38  

References 41  

Abbreviations 43
| Figure 1: | Greenhouse gas emissions in Australia by sector. | 13 |
| Figure 2: | Real daily oil prices since 2004. | 14 |
| Figure 3: | History and projections of future average annual international oil prices. | 15 |
| Figure 4: | Potential future petrol prices under alternate international oil market conditions. | 16 |
| Figure 5: | New vehicle sales in Australia (FCAI, 2008). | 16 |
| Figure 6: | Proportional targets and relative contributions of the electricity and transport sectors given a 60% below 2000 levels by 2050 emission target and EIA high oil price. | 17 |
| Figure 7: | Proportional targets and relative contributions of the electricity and transport sectors given a 95% below 2000 levels by 2050 emission target and EIA high oil price. | 18 |
| Figure 8: | Value of Australian crude oil and refinery products exports and imports (left hand axis) and share of crude and refinery products in the value of total Australian imports (right hand axis). | 19 |
| Figure 9: | Possible cost of weekly fuel bill in 2018 for medium passenger vehicle under alternative international oil market conditions. | 22 |
| Figure 10: | Greenhouse gas emissions by policy measure to 2050: 60% below 2000 level emission target by 2050 and EIA high oil price scenario. | 22 |
| Figure 11: | Average cost of passenger road vehicle travel by policy measure: 60% below 2000 level emission target by 2050 and EIA high oil price scenario. | 24 |
| Figure 12: | Average cost of freight road vehicle travel by policy measure: 60% below 2000 level emission target by 2050 and EIA high oil price scenario. | 24 |
| Figure 13: | Projected increasing electrification of road transport vehicles: EIA high oil price and 60% below 2000 emission target scenario. | 27 |
| Figure 14: | Differences in types of biofuel feedstocks. | 27 |
| Figure 15: | Comparison of price impacts for different rates of post-peak oil decline in oil supplies and slow, moderate and fast technology and infrastructure responses. | 30 |
| Figure 16: | Greenhouse gas emissions under 60% below 2000 levels by 2050 emission trading target and four different international oil market conditions. | 31 |
| Figure 17: | Comparison of greenhouse gas emissions under current social and cultural preferences and changed social and cultural preferences that support reduced travel/fuel use: 60% below 2000 levels emission target in place. | 34 |
| Figure 18: | Projected level of transport fuel consumption in response to different rates of decline in oil supply (associated with a peak oil event) and different rates of technological/infrastructure responses. | 35 |
| Figure 19: | Consumption of transport fuels under slow decline in oil supply, fast technology response, fuel cell cars available and 60% below 2000 levels by 2050 emission target scenario. | 36 |
Executive summary

The Future Fuels Forum was formed in November 2007 in recognition that the transport sector is facing serious challenges from pressures to reduce greenhouse gas emissions and increasingly constrained international oil supplies.

The Forum’s purpose in light of these challenges was to explore scenarios, conduct quantitative modelling and share ideas as a group so as to inform policy and investment decision making within their own organisations and within the broader Australian community through the publication of this report.

The discussion in this report is supported by modelling that was conducted by CSIRO on behalf of the Future Fuels Forum. A more in-depth technical discussion of the modelling has been published separately in *Modelling of the future of transport fuels in Australia*. There, the reader may scrutinise the various assumptions, sensitivity analysis and methodologies used to arrive at the various quantitative projections herein.

The Future Fuels Forum identified a number of key risks, opportunities and challenges for the future of transport fuels in Australia.

### Increasing cost of oil and the need to reduce greenhouse gas emissions will drive change

Australia’s transport fuel mix will substantially change in response to the increasing cost of oil and the need to reduce greenhouse gas emissions. There are as many challenges as there are options for transforming our transport fuel mix. As a result, it is important that debate, planning and investment in industry, government and the community accelerate.

### Our fuel mix will be more diverse

Modelling indicated Australians are projected to be using a much more diverse fuel mix in road, rail, air and sea passenger and freight travel.

In the next ten years it is projected that electricity, liquefied petroleum gas (LPG) and natural gas (particularly in freight) will be the first fuels to expand their use, particularly if there is an abrupt decline in the availability of international oil supplies.

Only these among the non-conventional fuels have the capacity to expand their availability into the transport market in a relatively short time frame due to existing production and distribution infrastructure. However, even these fuels will take considerable time to be fully commercialised.

Longer term, beyond 2020, advanced biofuels that limit competition with food production and synthetic fuels derived from gas and coal (using carbon capture and storage) are also expected to come into use once production infrastructure has had sufficient time to scale up. The extent of their use will depend on primary fuel prices and government greenhouse gas emission targets.

### The price of oil-based fuel products will increase

Owing to changes in international oil markets and to a lesser extent carbon pricing, further substantial increases in the price of oil-based fuel products (petrol and diesel) are considered plausible, although very uncertain in their timing and extent.

Modelling projected that if international oil supply continues to grow steadily, petrol and diesel prices will experience only a slight rise on present levels. However, if there is a near-term peak in international oil production resulting in declining future oil supplies, petrol prices could increase to between A$2 and as much as A$8 per litre by 2018.

### The transport sector will make a modest contribution to reducing greenhouse gas emissions

The introduction of emission trading alone is unlikely to radically change the transport sector. Even a A$100/tpCO₂e permit price will only increase the cost of fuel by around A$0.25/L, which is significantly less than the impact of oil price movements in the past four years.

Nevertheless, the modelling indicates there will be a steady shift toward low emission fuels and vehicles.
Australia will be forced to manage its response to reducing greenhouse gas emissions and the risk of increasing costly and scarce oil supply simultaneously rather than sequentially.

Australia is more vulnerable to changing market circumstances than some other countries due to its relatively high vehicle use, the relatively high fuel consumption by vehicles in its fleet, its 97 per cent reliance on oil-based fuels for transport and declining domestic reserves of conventional oil.

Any increase in transport costs will adversely impact low income Australians for who transport accounts for a higher proportional share of household income. This impact will be more acutely felt by those living on the urban fringe or in regional areas where average kilometres travelled per day is higher.

Oil price increases will affect weekly fuel bills, increasing from A$40 in 2007 to between A$50 and as high as A$220 per week in real terms by 2018 for a medium passenger vehicle. The high end of this range will only occur if international oil supplies abruptly decline and fuel and vehicle manufacturers are unable to quickly ramp up alternative supplies and technologies. Oil price movements in 2008 have already shifted costs toward the lower end of this range although it remains to be seen whether this represents short term market volatility or a sustained shift.

Any oil price increases will also flow through freight costs to most other items in the economy adding, for example, up to 31 cents to a loaf of bread. However, in the long term (beyond 2030) the modelling projects passenger and freight transport costs can be expected to be similar or lower than today with the adoption of new fuels and technology.

There is likely to be only moderate preparation by individuals and businesses in relation to the possible decline in oil supplies due to the uncertainty surrounding such an event.

On the other hand, the social impacts are potentially high. As a result, there is an argument for greater government intervention in the transport sector.

In designing new policies, the government will need to consider the risks attached to both market-based policies, on the one hand that emphasise decision making driven by market forces and industry development policies on the other that require the government to ‘pick winners’.

Governments will also need to consider the interdependencies between different sectors and different policy goals.

In the event of a decline in international oil supplies technology alone will not be sufficient to meet the fuel supply gap. Reduced travel across freight and passenger transport will be necessary.

If international oil supply declines slowly then modest reduction in travel of less than five per cent is sufficient. However, if reduction in oil supply is rapid and alternative fuel vehicles are slow to become available then passenger and freight travel may be reduced by up to 40 per cent.

Reduction in travel of this magnitude can be expected to have significant social and economic impacts, but these were not quantified in this study. Literature, however, indicates at least a three per cent decrease in GDP.

Transport intensive activities such as tourism and mining would be most vulnerable. Early action to accelerate the availability of non-oil based alternative fuels and less fuel intensive modes of travel is key in avoiding impacts in the high end of this range.

The choices Australians make about the size of their vehicle, how much they need to travel and in what mode (e.g. public versus private passenger transport) are likely to be equally as important as the fuel and technology choices that they make in reducing greenhouse gas emissions and their vulnerability to the impacts of higher prices for oil products.

This is important because of the uncertainty that still remains over which future technologies and fuels will proceed to be commercially available at reasonable cost.

The modelling projected that a greater shift toward public transport and lighter vehicles, and increased use of rail and sea freight could reduce kilometres travelled by 30 per cent and greenhouse gas emissions by 17 per cent.
The future will demand change

Paying heed to our vulnerability

Transport is the life blood of the Australian economy and thirty years on from the oil crisis of the 1970s and 80s, Australians are accustomed to drawing on bountiful oil supplies and fuel costs occupying only a modest proportion of household and business budgets.

Transport in Australia, as in much of the world, is highly dependent on petroleum-based fuels, with alternatives accounting for only three per cent of total fuel consumption. As a result, fuel production and distribution infrastructures are substantially geared towards delivering petroleum-based fuels. About 41 per cent of final energy consumption is used in the transport sector and the demand for transport energy is growing at about 2.4 per cent per year. The vast majority of domestic passenger and freight trips are undertaken in road vehicles, which account for 75 per cent of transport fuel use. Air transport is the second highest user at 16 per cent and water and rail transport make up the residual (4 and 2 per cent respectively).

Our domestic production of oil, which has helped to shield Australia from the balance of payments impacts of increasing international oil prices, is expected to decline (notwithstanding the potential use of oil shale reserves). Despite this, Australia’s dependency on petroleum fuels continues. Until recently, alternative fuels have not been competitively priced; oil products remain readily available on the international market and the life expectancy of fuel production and distribution infrastructure is long.

---

1 Final energy consumption refers to energy consumed as, for example, petrol or electricity and its amount is net of energy losses in the conversion and refining processes required to deliver the final energy product.
Since 2004, however, one of the most publicly discussed economic phenomena has been the dramatic rise in the global price of oil that, in turn, has translated into rising domestic fuel costs.

At the same time, Australians are increasingly looking to improve the sustainability of transport use. The high level of car ownership in Australia has meant that transport accounts for 14 per cent of Australia’s total national greenhouse gas emissions (roughly equivalent to emissions from agriculture). Road travel contributes 89 per cent of total transport greenhouse gas emissions. Aviation, rail and shipping account for approximately 6, 3 and 2 per cent respectively.

A new era: expected changes in price and availability of oil products

Market volatility

The international oil market is very volatile with the price per barrel increasing and decreasing several tens of dollars in any given year (see Figure 2). For example, the annual average for 2007 was US$70 per barrel (bbl), despite reaching US$99/bbl on some trading days. At the time of writing this report, the oil price has reached beyond US$130/bbl.

During the 1990s, the average oil price was US$28/bbl. Today there appears to be consensus that the continued tightening in the balance of international demand and supply will see oil prices remain at levels above US$60/bbl.2

While there may be a degree of consensus that US$60/bbl is the lowest average oil price likely to be seen in the future, there is much debate on the extent to which the projected long-term average price per barrel might rise above that level.

Modelling completed for the Future Fuels Forum acknowledged a range of possible price outcomes without assigning a probability to them.

---

2 All prices presented in the report are in real terms with a base year of 2006.
‘Steady as she goes’

At least two energy agencies – the International Energy Agency (IEA) and the US Energy Information Administration (EIA) – forecast US$60 to US$70/bbl as the long term price in their reference, or business as usual, cases (e.g. EIA, 2008 and IEA, 2007) (Figure 3).

These projections assume that high oil prices are temporary and will return to lower levels as new oil supply will eventually be brought into the market to meet growing demand. This same assumption has been applied to each revised edition of projections for several years, despite continued increases in the price of oil since 2003. Recent announcements suggest the IEA may diverge from this view for the first time in its November 2008 update by recognising an extended tightening in supply (King and Fritsch, 2008).

If prices remain at an annual average of around US$70/bbl in the long term, it is projected that Australian consumers can expect to pay around A$1.10 per litre for petroleum-based transport fuels (ignoring the levying of carbon taxes and assuming US/A$ exchange rates remain at the level witnessed during January to June 2008 and the real value of fuel excise continues to decline).

A new baseline price

The US EIA and other agencies also acknowledge the possibility of prices well above the US$60/bbl level for sustained periods in the future.

These forecasts refer to specific structural factors that differentiate the present from the past, including the perception that China and India have permanently shifted demand higher and the growing awareness that growth in global oil supply might become constrained in the next five to ten years. These forecasts fall into two categories.

One category assumes that a tightening demand and supply balance will put upward pressure on the price but oil supply will continue to expand. An example of this is the US EIA high oil price case which sees the oil price rise to US$100/bbl by 2030 (Figure 3).

At around US$100/bbl the price of petroleum-based fuel is projected to be around A$1.50 per litre. This is still below prices presently paid in many European countries.

The second category assumes that the nature of the oil supply constraint is far more serious and that global oil production is nearing the point where it will reach a peak and begin to decline, with the result that growing demand cannot be met. Peak oil is the term used to describe this event.

Information is limited on what oil prices might be associated with a peak in global oil production in the near term (2008 to 2013). Modelling undertaken for the Future Fuels Forum projected prices in the range of A$2 to as high as A$8 per litre by 2018 for petroleum-based fuel products in Australia, depending on how rapidly alternative fuels and vehicles become available and what share of diminishing global oil supplies Australia will have access to.
Peak oil is the point in time when oil production reaches its maximum annual rate, after which the annual production rate declines each year.

While the term is currently used to describe a possible peak in total world oil production, in practice a succession of peaks have already occurred in different oil-producing regions throughout the world. Growth in global oil supplies has been sustained by expansions in supply from new oil fields. Eventually the rate of production decline at mature oil fields exceeds the rate of expansion at new oil fields and total world oil production will have peaked.

The person most associated with this term is geologist M. K. Hubbert who correctly predicted United States oil production would peak in the early 1970s.

High prices associated with a peak oil event would be expected to be sustained for several years until alternative non-oil based fuel becomes available or demand for fuel contracts.

All three oil price paths discussed are shown in Figure 3: steady oil prices associated with both of the IEA and the US EIA reference cases, the US EIA high oil price case and a projection of oil prices associated with a near-term peak in oil production.

The projection of oil prices associated with a near-term peak in oil production is derived from CSIRO modelling of a scenario explored by the Future Fuels Forum where alternative fuel technology is made available at a relatively fast rate. Once the alternative fuel technology has been adopted, available oil supplies can keep pace with demand for oil products and the price path reverts, by design, to the US EIA high oil price case.

In sensitivity testing of the modelling, when alternative fuels and technologies were assumed to be not readily available or the rate of decline in availability of oil-based fuels in Australia was more rapid, this projected oil price profile climbs several hundreds of dollars a barrel higher and extends by up to a decade longer than the path shown in Figure 3.

Figure 3: History and projections of future average annual international oil prices.
Impact of emission trading

Irrespective of the range of cost increases experienced as a result of tighter international oil markets, the cost of petroleum products will increase with the introduction of emission trading in Australia in 2010 (assuming transport fuel is included in the scheme).

Modelling conducted for the Future Fuels Forum projects that the price of emission permits can be expected to begin at around A$25-40/tCO₂ₑ, increasing to A$70-100/tCO₂ₑ for a 60 per cent emission cut by 2050 target and A$200-300/tCO₂ₑ by 2050 if Australia chooses to pursue near-zero emission targets within the emission trading scheme.

Figure 4: Potential future petrol prices under alternate international oil market conditions.

Figure 5: New vehicle sales in Australia (FCAI, 2008).
Emission permit prices of A$40 and A$100/tCO\textsubscript{2}e translate to petroleum fuel price increases of A$0.10 and A$0.25 per litre, respectively. While significant, as shown in Figure 4, the impact of emission permit prices is proportionally less than the potential changes in oil prices. Historically, Australians experienced greater petrol price increases in the four year period 2005 to 2008 than is expected to result from future carbon prices. March 2005 was the last time petrol was less than A$1.00 per litre. Between 2000 and 2004 the cost of petrol fluctuated between A$0.80 and $0.90 per litre. During this period Australians did not radically shift to low emission vehicles. The most significant shift has been toward a greater portion of small and medium sized vehicles in total vehicle sales.

Given this historical perspective it is not surprising that the modelling projected the transport sector will make a less than proportional contribution to any emission target (Figure 6 and Figure 7). The expected modest increase in fuel prices (offset, to some extent, by increasing incomes) leads to a similar modest acceleration toward lowering transport sector emissions.

In contrast, it is expected that the electricity sector will make a higher than proportional contribution, partly through the increased use of electricity in transport via plug-in electric vehicles. Greenhouse gas emission permit prices in the ranges discussed will at least double the wholesale cost of electricity\textsuperscript{3} in the short to medium term, which in contrast to the transport sector, makes a wide variety of zero and near-zero emission electricity generation technologies viable in the near term.

\textsuperscript{3}This translates to only a one third increase in household retail electricity prices since the electricity component of electricity rates is only a third of the total, the major part of the balance being transmission and distribution costs.
The timing of possible international oil market events (higher oil product prices and/or constrained supply) is uncertain.

While the finite nature of oil reserves is generally accepted, not all commentators subscribe to the view that international oil production is nearing a peak. The uncertainty around these events is a significant challenge for both Australia and the international community.

Without diminishing the challenge presented by higher oil prices, there are several potentially positive outcomes emerging as opportunities over the longer term.

Firstly, as a result of Australia’s abundance of alternative energy sources, Australia could emerge in the long run as a country with a high level of transport fuel energy security and improved terms of trade.

In 2006-07, imports of crude oil and refinery products accounted for approximately 10 per cent of the value of all Australian imports (Figure 8). The value of net imports of crude oil and refinery products to Australia in 2006-07 was A$11 billion.

On a calendar year basis ABARE (2008a) reports that amount has already risen to A$14.5 billion in 2007. With the outlook for domestic crude oil and petroleum product production expected to be flat or declining (ABARE, 2008b) and international oil prices continuing to rise throughout 2008, the net value of imports can be expected to be even higher in 2008.

A second opportunity is that many of the actions seeking to reduce the impact of higher oil prices, such as more efficient vehicles and greater use of mass transport, also reduce greenhouse gas emissions.

It could also be reasonably expected that new industries (for example, biofuels production) will emerge in Australia, bringing with them associated trade and employment benefits.

Depending on the severity of the events, changes in the international oil market could be particularly challenging for the economy.

The Energy Futures Forum (2006) estimated that a sustained annual average oil price of around US$100/bbl would reduce GDP by around 3.1 per cent (relative to the more benign case of a gradual reduction in oil prices to historical levels). The reduction in GDP from a peak oil event could be expected to be even greater.

Except in the case where oil prices rise slowly and steadily, it is unlikely Australia can completely avoid these impacts.

**Figure 7:** Proportional targets and relative contributions of the electricity and transport sectors given a 95% below 2000 levels by 2050 emission target and EIA high oil price.
The future will demand change

In the more likely case of higher oil prices emerging abruptly, Australia can only seek to minimise rather than eliminate all impacts. To do so requires preparing in earnest now.

Preparation that could assist in minimising the impact of sustained higher petroleum product prices or oil shortages could include the following, some of which were specifically modelled by the Future Fuels Forum to determine their efficacy in reducing impacts.

**Research, demonstration and development of more efficient processes for producing alternative fuels**

The modelling conducted for the Forum indicates that when oil-product alternatives, such as ethanol, biodiesel and synthetic liquid fuels from natural gas and coal (with carbon capture and storage) became available the prices of oil-product based fuels are restored to levels more consistent with today’s prices following a peak oil event.

Without alternative fuels, reduced travel with the associated economic and lifestyle impacts are more likely to occur.

Cost effective availability of alternative fuels also reduces the cost of reaching national emission abatement targets. For example, if biodiesel could be cost-effectively produced from algae in large volumes, the modelling indicates a reduction in the price of CO₂ permis by around A$5 to A$15/tCO₂ under the present government’s proposed emission target.

**Increased rates of investment from industry and government in alternative fuel infrastructure**

In some cases, existing infrastructure need not be modified. For example, synthetic fuels and low blend biofuels can use existing liquid fuel distribution infrastructure.

Some development is required for gaseous fuels and electricity for electric vehicles but a substantial part of the main distribution infrastructure already exists.

The greater challenge would appear to be the fuel production facilities that involve significant risk – an issue that is discussed further below. In the event of peak oil, price impacts are found to be twice as high in scenarios where fuel and vehicle infrastructure was slow to respond (Figure 15).

**Consumers choosing more efficient mass transport modes and vehicles for their travel needs**

The Forum constructed scenarios that assumed varying degrees of uptake of mass transport and light vehicles. In these scenarios, fuel needs and greenhouse gas emissions are reduced by around a third and a fifth respectively, relative to the case where current consumer preferences are maintained.

In relation to vehicle engine efficiency, the model was generally free to choose the economically efficient
level of uptake of higher efficiency diesel and hybrids (both involve increased engine costs). In the majority of cases, the widespread uptake of more efficient vehicles becomes economically viable during the next decade. There is considerable uncertainty around this projection as cost is only one of many factors taken into account by vehicle purchasers.

City planning and information programs that support cultural and lifestyle choices to maintain access in the community for less kilometres travelled

City design and cultural change were outside the scope of modelling capabilities available to the Future Fuels Forum but were widely acknowledged for their potential contribution to reducing the severity of impacts from higher cost fuel. Specific measures around city planning and lifestyles are discussed in the following section, “The Role of Cities”.

Social impacts of changing Australia’s transport fuel mix

Whether it is in response to constrained oil supply or the price signals associated with emission trading, Australia will need to change its transport fuel mix.

While such change is viewed by many as desirable, it will come at a cost and governments will need to consider to what degree they will assist vulnerable groups. No matter what the level of changes in price, a critical challenge will be maintaining equity since the price changes will affect all, irrespective of their resources and capacity to adapt.

Possible economic impacts

Those with low incomes will be most vulnerable to rising fuel costs as spending on fuel represents a greater proportion of their disposable income. In addition, there is a tendency for this group to own less fuel efficient vehicles and have fewer resources to invest in alternative fuel or more efficient vehicles. Regional communities and those located on the urban fringes will also be disproportionately impacted owing to their higher fuel use and fewer options for reducing motor vehicle travel.

In the modelling conducted for the Forum, when oil prices remain between $US70 and $US100/bbl, the weekly cost of fuel for a medium-sized petrol vehicle (around 1200 to 1500 kilograms) travelling an average 15,000 kilometres per year can be expected to remain similar to, or slightly more than, 2007 levels (A$40 per week) in real terms as fuel increases will be offset by declining real excise levels (fuel excise has not been indexed since 2001).

In scenarios where a near-term peak in oil production was explored, fuel costs for the same class of vehicle and travelling patterns are forecast at between A$50 and A$220 a week. The high end of this range will only occur if international oil supplies abruptly decline and fuel and
vehicle manufacturers are unable to quickly ramp up the infrastructure and technology required to support the introduction of alternative fuels. Oil price movements in 2008 have already shifted costs toward the lower end of this range, although it remains to be seen whether this represents market volatility or a sustained shift.

A similar calculation is not presented for freight travel, since outcomes will vary depending on the eligibility of business for various rebates and benefits. However, the order of magnitude of changes will be broadly the same.

It could be reasonably expected that, at very high levels of fuel costs, many people (particularly low income groups) and businesses will choose to substantially reduce their use of transport below their present levels rather than pay the additional fuel costs associated with an extreme peak oil event.

From a community perspective, if such an event occurs affordable public transport and the development of more accessible community resources will be important in ameliorating the impact of the loss of access to affordable private transport.

**Figure 9:** Possible cost of weekly fuel bill in 2018 for medium passenger vehicle under alternative international oil market conditions.

**Figure 10:** Greenhouse gas emissions by policy measure to 2050: 60% below 2000 level emission target by 2050 and EIA high oil price scenario.
Demographic and economic changes in Australia that have led to lower household occupancy rates, fewer local shopping centres and higher vehicle ownership will also make this task challenging.

From a market perspective, increased costs of oil-based fuels will filter through the economy, increasing the cost of all goods and services. The mining and metal manufacturing sectors are among the highest users of transport as an input to production. Transport is not a large portion of tourism and recreation in national accounts, but only because transport is often provided by the end-user.

Transport of food to retail outlets accounts for between one and six per cent of the cost of grocery items (ABS, 2005). The use of transport in food production further exposes this sector to changes in transport costs. For example, moderate increases in the price of oil might add between one and two cents to a loaf of bread. However, the more substantial increases associated with peak oil scenarios were projected to add between 8 and 31 cents per loaf of bread.

Note, transport is only a small component of the services sector that accounts for around 70 per cent of Australia’s GDP. However, this sector may be indirectly impacted by reductions in discretionary household expenditure and travel.

Impact of additional transport sector policies

The list of current government policies that impact on transport is long and spans all levels of government. Included are land use regulations, fringe benefits tax, information programs, public transport infrastructure expenditure, research and development expenditure, vehicle registration and many more.

Beside these existing interventions, governments may choose to introduce additional policies designed to encourage deeper cuts in transport related greenhouse gas emissions or to further encourage readiness for less secure international supplies of oil. These might be termed “complementary policies”, since they complement existing government policies or market forces to achieve a common goal.

To understand better how such policies could contribute to more secure and sustainable transport fuels, the Forum chose to explore the impact of four such complementary policies on technology uptake, greenhouse gas emissions and the cost of transport.

The policies were selected on the basis of the variety of policy levers used, the relative ease with which they could be modelled, and their ability to explore different types of incentive effects. The policies were not selected on the basis of their desirability.

It must also be noted that these policies are not being recommended by the Forum and that no comparative analysis against other policy options was undertaken. Additional analysis would be necessary to understand the wider impacts, in particular the social equity implications of these and other measures.

The four complementary measures modelled are:

- Accelerated scrapping of road vehicles 15 years or older
- Increasing the rate of fuel excise by a factor of 5 over 40 years
- Mandatory improvements in vehicle fuel efficiency
- A $2000 subsidy for low emission and alternative fuel vehicles

Increasing the rate of fuel excise was the most effective in achieving a marked additional reduction in fuel use and emissions over the long term, relative to the case where no complementary policy measures are in place.

The modelling found that the policy of compulsory scrapping of 15 year old vehicles is most effective in driving a rapid decline in greenhouse gas emissions and fuel consumption in the next decade. However, for all the complementary policies, other than increasing excise, the modelling highlighted a significant rebound effect that, if not overcome, could render the policies ineffective in achieving some policy goals.

The rebound effect occurs when policies that initially accelerate the uptake of more efficient and low emission technologies have the opposite effect in the longer term. Such an effect occurs because early uptake of low-emission, high-efficiency technology reduces the impact of price signals that might have encouraged further technological change in the long term.

Given the mixed results for complementary policies in achieving improved energy security and greenhouse gas reduction, their benefits will need to be carefully weighed against their impact on costs.

4 In practice this means vehicles older than 15 years are not registered rather than forced to be scrapped.
The modelling found that increasing excise and introducing compulsory scrapping of older vehicles increases the cost of passenger vehicle travel by 2.7 and 3.7 per cent respectively by 2018. Such policies are also regressive as they impose a higher than proportionate additional cost on lower income groups.

The increasing excise and compulsory scrapping scenarios also initially lead to higher costs for freight transport. However, in contrast to passenger transport, freight costs are lower in the long term due to an increasing uptake of electricity as a fuel (particularly rigid trucks) and liquefied natural gas (articulated trucks).

Subsidies for low emission vehicles and compulsory fuel efficiency standards could benefit lower income groups as they decrease the cost of travel relative to the expected outcome without such measures in place.

In the case of mandatory fuel standards the cost of passenger vehicle travel is three per cent lower by 2018. For the low emission vehicle subsidy policy, the cost of travel does not immediately fall but, as low emission vehicles become more affordable over the longer term, accelerated uptake occurs and this policy becomes the second most effective measure in reducing private passenger transport costs.

For freight transport mandatory improvement in fuel efficiency consistently delivers lower transport costs per kilometre. The low emission vehicle subsidy does not reduce travel costs for freight as much as it does for passenger vehicles, due to the relatively higher cost of freight road vehicles relative to passenger road vehicles.

**Figure 11:** Average cost of passenger road vehicle travel by policy measure: 60% below 2000 level emission target by 2050 and EIA high oil price scenario.

**Figure 12:** Average cost of freight road vehicle travel by policy measure: 60% below 2000 level emission target by 2050 and EIA high oil price scenario.
The role of consumers and industry in shaping a response

While industry, government and consumers are often well versed in what actions might be required to prepare Australia for less secure but more sustainable transport fuels, deciding when these actions should occur is less clear.

Underpinning this uncertainty is the timing and extent of future oil price rises.

Uncertain times ahead

As discussed previously, many believe that within the next five years the global annual rate of oil production will peak. However, many others believe that further exploration and investment in oil production and refining infrastructure, particularly in the Middle East where most remaining reserves of oil reside, will see oil prices fall and level out in the near future (see US EIA price forecasts).

Debate around carbon pricing is just as polarised. While Australians can be confident that a price signal will be introduced from 2010, the rate of greenhouse gas reduction required and the subsequent CO₂e permit price to be passed on to consumers is still being debated. International negotiations on what the global community will be able to collectively agree to as a global greenhouse gas reduction target are also incomplete.

A critical unresolved aspect of these negotiations is the sharing of responsibility for that target between countries. In particular, the debate centres on the degree to which responsibility lies with developed nations in being responsible for most accumulated emissions to date and having the greatest wealth with which to fund mitigation activities, or with developing nations, which are expected to be responsible for the majority of emissions in the future but with a lower per capita wealth position.
As a result of this uncertainty with both international oil and domestic CO₂e permit prices, those consumers and industries taking immediate preparatory action to lower their exposure risk incur a loss if policy or events emerge slowly. The loss is greater the more substantial the investment and the longer the lead time in bringing it to fruition.

Traditionally, lead times for actions such as bringing a new fuel to large scale commercial production or implementing new city design principles are decades long. On the other hand the potential losses from not acting are also high, including, for example, loss of mobility for the consumer and loss of market share for industry. Studies have shown that the time taken for a new technology or practice to grow from 10 to 90 per cent market share is on average 40 years but can be shorter if the new technology fits well with existing infrastructure.

These insights about the level of uncertainty faced by industry are evident in the modelling conducted for the Future Fuels Forum. For example, natural gas fuelled vehicles can be observed in some scenarios as achieving a market share of 15 per cent and coal to liquids with carbon capture and storage expanding to provide 20 per cent of all transport fuel by 2050.

In other scenarios these two fuels play a minor (<5 per cent) role in vehicle and fuel markets.

Faced with balancing the risks of action and inaction, economic theory suggests it is likely that both consumers and industry will choose to put a greater weight on the loss from investing too soon. This is because both receive immediate negative feedback from preparatory actions. Industry experiences a fast response to unrealised returns on investment via company valuations. Consumers experience an immediate impact on their budget when purchasing a more expensive vehicle. This is an economically rational response – when the future outcome of an investment is uncertain there is always a strong incentive to wait for extra information that might reduce the uncertainty of the investment. So, in effect, the time required to fully realise an action (such as an investment in new vehicle manufacturing) can largely consist of simply waiting for market conditions to be fully revealed.

This does not preclude some parts of industry and some consumers, perhaps with less risk averse attitudes, from making immediate investment. The challenge for governments is how to reduce, or spread, the risks so that the risk profile improves for the majority.

New industry fuel supply chains

Industry (and to a lesser extent consumers) will also need to grapple with more diverse and unfamiliar fuel supply chains.

Some fuel and technology options for Australia could see sections of industry working together that would not presently identify as having significant links. The potential convergence of industries is likely to create challenges that have not yet received full consideration by all stakeholders involved.

Electricity and transport

Vehicles relying on electricity as the main or part source of fuel could be on the market within five years as built-for-purpose models (these vehicles are currently available as retrofitted conventional vehicles; for example, an electric version of the Hyundai Getz).

Modelling for the Future Fuels Forum indicates plug-in electric vehicles (with or without an internal combustion engine for longer range driving) could account for up to two thirds of kilometres travelled in Australia by 2050.

Such an option provides a near-zero emission road vehicle, provided that emission trading decarbonises electricity generation.

If zero and near-zero emission electricity generation technologies such as CO₂ capture and storage and hot fractured rocks fail to deliver the expected level of greenhouse gas abatement to the electricity sector; this will have a consequential negative impact on the ability of electricity fuel to reduce transport sector emissions.

Irrespective of its capacity to deliver lower emission levels, the low cost of electricity relative to other transport fuels means it is likely to play a part in transport over the longer term. Electricity generators will need to factor this into their daily load curves and demand growth forecasts.

Fuel and food markets

Increased food prices in recent years have focussed attention on biofuels as a potential contributor to that phenomenon. However, it has also become clear that biofuel demand for agricultural feedstocks is only
one of several factors driving food prices. Food prices have also been affected by higher transport and farm production costs due to higher oil prices, droughts, a global draw down in food stocks over several years, increased demand from growing economies like China and India and general market trading volatility.

While farmers welcome increased agricultural prices, concerns exist over the potential for the livestock industry to experience increases in feed prices (feed grain has yet to be used by the Australian biofuels industry). Consumers may also be negatively impacted by increasing food costs but actual impacts to date have been very regional and food product specific (Batten and O’Connell, 2007). Current production of biofuel in Australia does not compete with food production because of its small size and because it primarily uses waste or food co-production feedstocks.

At the global level, there are concerns that developed countries will out-compete poorer countries for their share of agricultural production. Diverting agricultural production from food provision in developing countries to biofuel production for developed countries may exacerbate the currently poorer standards of living in developing countries.

Second generation biofuels using such feedstock as algae and lignocellulosic parts of biomass, which are potentially available in larger volumes than food crops without significant changes in land use, are expected to reduce the pressure biofuel production places on the food market. However, such biofuels still require research, development and demonstration to realise their potential.

Our modelling assumed that these sources of biofuels would be unavailable until 2015 to 2020, although demonstration trials can be expected prior to this.

**Figure 13:** Projected increasing electrification of road transport vehicles: EIA high oil price and 60% below 2000 emission target scenario.

**Figure 14:** Difference in types of biofuel feedstocks.

<table>
<thead>
<tr>
<th></th>
<th>Current feedstocks</th>
<th>Future feedstocks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples</strong></td>
<td>Canola, sugar cane</td>
<td>Algae, wood and crop waste</td>
</tr>
<tr>
<td><strong>Food market interaction</strong></td>
<td>Competes for feedstocks</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Technical and economic viability</strong></td>
<td>Now</td>
<td>5 - 10 years</td>
</tr>
</tbody>
</table>
Domestic and international natural gas markets

Natural gas is recognised by many countries as the bridging fuel for the next decade, as there will be a delay before several less technically developed low emission electricity generation plants can be progressively commercialised.

The price of Australian gas exported in the form of liquefied natural gas (LNG) has traditionally been tied to international oil prices, and hence in recent years the price realised for this gas has been rising.

In contrast, domestic natural gas on the eastern seaboard remains relatively cheap compared to global gas prices, largely due to substantial natural gas resources being tied to a domestic pipeline infrastructure rather than to export markets. However, in recent years there has been heightened speculation that this traditional gap between domestic and international natural gas prices may close with the development of LNG export facilities near to the eastern states’ natural gas pipeline. Indeed, the price of domestic natural gas in Western Australia has been rising due to the competing demands of LNG projects able to sell at international natural gas prices.

Given this, the potential for natural gas to expand into the domestic transport market without putting further upward pressure on prices would seem unlikely.

Even if domestic natural gas prices were to rise to levels consistent with oil, natural gas still has the advantage of being a slightly lower carbon content transport fuel.

In this context, domestic natural gas use in transport and other sectors may still demand a significant and potentially growing share of total Australian gas production, particularly in road freight.

Modelling indicated as much as an additional 200PJ per annum of natural gas could be required for the Australian transport sector by 2020 relative to the approximate 900PJ currently used in manufacturing processes and electricity generation. Current use of natural gas in Australian transport is less than 2PJ.
The role of government in shaping a response

However governments must balance multiple policy objectives. As a result, additional policies may be considered that support other goals such as reducing the cost of transport, encouraging a more diverse fuel mix to improve Australia’s fuel security and accelerating research and development to share costs more evenly between public, private, current and future fuel consumers.

Governments at all levels already have a variety of policies that seek to address these and other goals. In considering whether to ramp up their level of intervention or direct involvement in the transport sector, consideration must be given to what extent industry and the community can be expected to succeed in reaching the desired goals on their own accord under current policy settings.

As discussed in the previous section, given the risks faced by industry and consumers when considering investing in alternative fuels, the required size of those investments and their irreversibility, it is likely that Australian individuals and companies will only undertake limited preparatory action for an alternative fuel future.

Governments could consider providing more in-depth analysis of the future outlook for fuels to industry and the community. However, such analysis could only highlight and marginally reduce the uncertainty rather than completely remove it.

Another strategy could be to rely on offshore technology entrepreneurs to act sooner and make technology available to Australia, but there is no certainty they will invest any sooner than their counterparts in Australia.

It follows from the level of investment risk and the size of the potential social impacts that there is a justifiable argument for increased Australian government intervention to either directly invest or increase the attractiveness of private investments in reducing Australia’s fuel vulnerability.
Without greater government action now it is unlikely that Australia will be prepared if it needs to abruptly change the transport system (such as in the case of a near-term peak in global oil production). The question for government is the extent to which its role is to take actions to address such an uncertain future.

While many might accept an argument for greater government intervention, translating that argument into policy actions that are efficient and equitable is challenging.

Figure 15: Comparison of price impacts for different rates of post-peak oil decline in oil supplies and slow, moderate and fast technology and infrastructure responses.

Picking winners versus market-based instruments

If government takes the view that it should not pick winners, funds it has available to assist investment must be spread across many fuels, technologies and programs. Ideally, this funding would be sufficient to provide strong support for a wide range of alternatives to reach sufficient scale. However, if competing priorities leads to limited allocations of funding, evenly allocating those limited funds to many prospective technologies or programs could mean that none reach the scale required to substantially reduce vulnerability to changing events.

If, on the other hand, funds are made available to a small subset of possible responses then they are more likely to reach a substantial scale. Thus the decision to ‘pick winners’ would seem to pay off if it is believed the scale and pace of change needed is great.

As the modelling indicates, if government could be successful in improving the response rates of consumers and industry to declining oil supplies then, if that event occurs, cost impacts might be halved.

On the other hand the ‘winners’ picked by government might fail on technical or other grounds and not achieve their intended goal. A wider portfolio of investments selected by competing market forces could result in a greater likelihood of a ‘winner’ or ‘winners’ emerging in the long run. If the scale and pace of change needed is limited, a policy of picking ‘winners’ would lead to the view in hindsight that government budgets were not well spent or policy interventions unduly raised the cost of transport.
A balancing act

There are many potential objectives for society that cut across the transport fuels sector.

These include regional development associated with, for example, the development of a biofuels industry to support higher demand for agricultural output and the potential location of processing facilities in regional areas.

Another objective is greenhouse gas reduction. Enhanced fuel security is also important, either in terms of ensuring physical availability of transport fuels in Australia or avoiding the financial impact of high costs of oil.

Other objectives include improving local air quality, increasing exports, strengthening of local communities and improving travel safety.

Many of these objectives, if pursued without consideration of each other, can have unintended negative consequences. For example, a government policy to expand the biofuels industry could negatively impact upon consumers through higher food prices or, if not handled correctly, could contribute to deforestation. Conversely, promoting the development or use of biofuel feedstocks that limit pressure on food-based feedstock may lead to the satisfactory achievement of several goals.

Another potential negative impact of government intervention is that, in pursuing higher exports of natural gas, Australia’s ability to significantly increase the proportion of natural gas and synthetic diesel in its transport fuel mix may be diminished.

The lack of familiarity in using many alternative fuel vehicles could also bring inherent safety risks.

On the positive side, some objectives such as greenhouse gas reduction and energy security are mutually supportive. As can be seen in Figure 16, responding to a near-term peak in international oil supply would achieve significant abatement in addition to any emission trading scheme.

The combined effect of responding to both transport fuel security and emission trading is greater in terms of greenhouse gas reduction achieved.

Actions targeting energy efficiency in transport (via alternative engines, vehicles and modes) would likely contribute to objectives of reducing both oil supply vulnerability and the cost of travel.

Similarly, air quality could improve while meeting other objectives of greenhouse gas reduction and reduced oil dependency, which improves health and city amenity. From first principles, greater use of electricity and gaseous fuels, such as hydrogen, LPG and natural gas, can be expected to both promote reduced greenhouse gas emissions and improve local air quality.

Figure 16: Greenhouse gas emissions under 60% below 2000 levels by 2050 emission trading target and four different international oil market conditions.
Using a more diverse mix of transport fuels and engine technologies in Australia is likely to lead to the development of new industries and foster, so-called, ‘green collar’ job creation. However, after factoring in likely reductions in other employment associated with production and distribution of the current fuel mix, the modelling conducted by the Forum could not calculate whether these new industries lead to an overall positive net employment.

**Integrating responses**

Whilst the challenges are national ones, the major responsibility for urban transport is currently with the State governments. Rapidly addressing the issues identified will require the federal system of government to work cooperatively.

Examples of current areas of co-intervention impacting upon transport across at least two levels of government include:

- Road funding – Federal, State and Local
- Vehicle registration – Federal and State
- City infrastructure – Federal, State and Local
- Fuel excise rates – Federal and State
- Rail, sea and aviation infrastructure – Federal, State and Local
- Industry development fuel research expenditure – Federal and State

Clearly, all levels of government have significant leverage to impact on a variety of aspects of the transport and fuel supply end use chain. If these different levels of government all seek to intervene with different goals there is likely to be a variety of unintended consequences (some positive, some negative) as outlined in our discussion above.
The role of technology and travel preferences

Australia’s travel preferences

The choices Australians make about how often, how far and in what mode they travel (public versus private passenger transport) and what size vehicle they need to own are likely to be equally as important as the fuel and technology choices they make in attempting to reduce greenhouse gas emissions and manage their vulnerability to the impacts of higher prices for oil products.

This is particularly important given that high levels of uncertainty remain as to which technologies and fuels will become commercially available at a reasonable cost.

Modelling for the Future Fuels Forum projected that a greater shift toward public transport, rail and sea freight and lighter vehicles could, by 2050, reduce kilometres travelled by 30 per cent and greenhouse gas emissions by 17 per cent.

This is demonstrated in Figure 17 where the only difference in emission outcomes for two scenarios is the degree to which social choices support a slower rate of growth in demand for transport.

Note: The modelling could only determine the magnitude of changes to social and cultural preferences for transport, not their likelihood or how such changes could be achieved.

There is potential for even greater greenhouse gas emission reductions when considering other societal choices that impact the frequency and length of travel.

These include:

- The design of cities including housing density, location of transport hubs relative to community facilities and the general level of investment in transport infrastructure (this is discussed in more detail in the following section titled “The Role of Cities”)
- Work arrangements, including where individuals work and the timing of travel to and from the workplace
• Substitutes for private motorised transport not already considered in the modelling, such as walking and cycling.

There are a variety of views about how rapidly Australia could see changes in preferences for transport. Such views are not resolved in this report as a comprehensive study of such social drivers for change is beyond the report’s scope. Further research is required to determine their potential for changing future patterns of transport activity.

The report, however, does find that a shift toward a lower level of transport demand would be greatly accelerated by a high oil price. In the event of a very high oil price, such as those associated with a peak oil event, transport demand could decline for up to five years.

If international oil supply declines slowly, a modest reduction in demand of less than five per cent might occur. However, if the reduction in oil supply is rapid and alternative fuel vehicles are slow to become available, road travel and freight may be reduced by up to 40 per cent with a subsequent 30 per cent reduction in total transport fuel consumption (Figure 18). Freight transport tends to contribute a slightly higher proportion of this reduced demand. This is because in freight transport, fuel is a much higher proportion of total transport costs.

Reduction in travel of this magnitude can be expected to have significant social and economic impacts. Quantification of such impacts was outside the scope of this report.

Transport intensive activities such as tourism and mining are expected to be most vulnerable. Early action to accelerate the availability of non-oil based alternative fuels and less fuel intensive modes of travel is crucial to avoiding impacts in the high end of the range explored in the modelling.

**Figure 17:** Comparison of greenhouse gas emissions under current social and cultural preferences and changed social and cultural preferences that support reduced travel/fuel use: 60% below 2000 levels emission target in place.
The modelling indicates that there is a wide variety of fuel and vehicle technologies that could emerge under different drivers. The modelling was able to provide the most detail in relation to road transport. The modelling also examined the rail, shipping and aviation sectors, however, the examination of potential technological developments was not as detailed. This is recognised as a limitation of the modelling framework applied and is due partly to the shipping and aviation sectors not participating in the project and partly to the smaller contribution of these sectors to fuel use and resultant greenhouse gas emissions.

In relation to road transport, common to all scenarios is a greater use of electricity and hybridised energy systems, biofuels, gaseous fuels, such as a liquefied petroleum gas and natural gas, and synthetic diesel fuels from natural gas and coal (with carbon capture and storage).

Given uncertainty about the cost of fuel cell vehicles, a specific sensitivity case examined the role of hydrogen if the technology proves cost effective. In that case, hydrogen was conservatively projected to power 28 per cent of road transport kilometres.

The Forum acknowledges that there are other fuels that could play a role in the future. These could include, for example, use of exotic weeds to produce biofuels and other synthetic fuels, such as methanol and dimethyl ether. The potential uptake of such fuels was not modelled, as available data was generally of poor quality.

Many of the modelled engine technologies and fuels are at varying stages of research, demonstration and development and are yet to be commercially demonstrated. A significant risk is the timing of the introduction of such fuels and technologies to the marketplace and whether their cost of production will be above current assumptions.

An example of potential fuel and technology uptake is presented in Figure 19. In the short-term, when faced with very high petroleum-based fuel...
product prices, the market will favour electricity and gaseous fuels, since these are the only fuels that can be brought forward in a short time frame.

However, even these fuels will take up to five years to penetrate a significant portion of the market. The delay relates to the time required for vehicle manufacturers to make alternative fuel vehicles their production focus and for existing fuel distribution facilities to ramp up to meet the required volumes.

Longer term, beyond 2020, the share of biofuels and synthetic fuels tends to increase, initially as blends in the 10 to 20 per cent range as manufacturers and distributors take advantage of existing liquid fuel supply infrastructure and the dominance of petrol and diesel-ready vehicles. However, it is also expected that vehicles ready to take a higher blend of biofuels could also be taken up, particularly if future biofuel costs are low relative to traditional petroleum-based fuels.

Concerning synthetic fuels, coal to liquids diesel with CO₂ capture and storage tends to be favoured, providing the price of carbon emission permits are low. This outcome becomes more likely if the price of Australian domestic natural gas rises relative to other energy prices. However, when carbon emission permit prices are high and natural gas prices change proportionally to that of other energy prices, natural gas tends to be the favoured feedstock for synthetic diesel production.

With regards to freight transport, the current cost advantage and high fuel efficiency associated with using liquefied natural gas is particularly attractive for articulated trucks, although international demand for LNG poses some uncertainty on the future price of natural gas in Australia.

The modelling also forecasts smaller rigid trucks as being capable of the same degree of electrical hybridisation and uptake of alternative fuels as passenger cars.

Biofuels and synthetic fuels can be expected to be included in the transport mix for air, rail and sea transport, while increasing electrification can be expected in rail transport. The shipping industry is also expected to shift from bunker oil to a greater use of diesel, with resultant fuel and emissions savings (International Marine Organization, 2008).

When road vehicle engine technologies are considered, varying degrees of electrification from mild through to plug-in and fully electric vehicles are expected to occur. Mild hybrids might include, for example, an advanced start/stop facility for city traffic conditions involving a more powerful electrical starting motor but would rely solely on an internal combustion engine at all times for driving.

Deeper levels of electrical hybridisation would involve different ways of integrating an electric motor for increasing amounts of driving time using the efficient electric engine. Plug-in hybrids would allow some of the production of electricity to come from the main grid rather than the internal combustion engine.
A fully electric engine would rely solely on the grid to produce the electricity needed to drive the electric engine requiring a significant amount of on-board storage or reduced driving range.

The modelling projects the widespread uptake of hybrid electric vehicles late next decade. Sensitivity analysis suggests the timing could be substantially brought forward with the provision of subsidies.

Fuel cell vehicles could also emerge during the period between 2010 and 2020 if cost targets can be met. Fuel cell vehicles provide a longer range than battery powered electric vehicles (around 400-500km compared to 100km for batteries). However, currently electric vehicles are lower cost.

Irrespective of the scenarios, the modelling forecasts an increasing electrical hybridisation of road vehicles. Driven in large part by the rapid and substantial petroleum price increase in the past five years and the increasing global desire to reduce greenhouse gas emissions, prototypes of these technologies have gained sufficient consumer uptake to assure most forecasters that hybrid electric vehicles will reach a price point that is economically viable for mainstream consumers.
Congestion is an increasing challenge for commuters and for the economy. The cost of travel is another concern. If fuel costs continue to rise, it is anticipated to have a greater than average financial impact on households in outer-suburban locations, whose occupants typically travel further and have few transport options other than the private motor vehicle.

The question of how to design better transport patterns and land use in Australian cities is an increasingly contested topic of public debate.

Specific areas of debate include the current and future locations of transport infrastructure, the overall level of investment, the value for money in public transport, the appropriateness of charges for road infrastructure development and use, the share of government resources supporting each mode (including road, rail, air and sea and non-motorised categories either on road or walking), the appropriateness of policies that affect decisions on where people live and in what density and the general rules for participating in travel (for example, road speeds).

Part of the reason these topics remain so contested is that the costs and benefits of changes to city design tend to take many years to be realised. Housing stock density is slow to change, there is commonly strong local resistance to densification policies, public budgets for expanding more energy efficient modes of transport are constrained by competing priorities, construction can be delayed by the need to consult and gain the support of those affected, and governments have only limited control over culture which is by its nature resistant to change.

The wide variety of urban environments often also means that measures that successfully improve transport in one area will not always deliver the same outcome elsewhere.

The role of cities

Australia is one of the most urbanised countries in the world.

Our major cities have experienced significant population growth which, in addition to low private transport costs and a preference for larger houses, has led to an expansion around our city boundaries.
6 The role of cities

Strategies for improving the ability of cities to respond to significant fuel price rises include:

• Expanding the provision of high quality integrated public transport including the targeted extension of rail services and reconfiguring urban transport networks so that local suburban and circumferential bus services link to rail services. Note, bus services that are capable of using existing road space are likely to provide the fastest response

• Planning for higher urban residential and activity densities and more local services

• Expanding cycle ways and pedestrian infrastructure

• Improved integration of public and non-motorised transport modes

If governments and communities acknowledge the possibility that the dominant form of transport (that is, the private motorised vehicle) could undergo a sharp decline in affordability in the near future due to a peak in global oil production, there would be greater potential to engage on improving public transport and city planning.
References


ABARE (Australian Bureau of Agricultural and Resource Economics) 2008a, Australian Commodities, March quarter, 08.1, ABARE, Canberra.


CSIRO 2008, Modelling of the Future of Transport Fuels in Australia, CSIRO.

Batten, D. and O’Connell, D. 2007, Biofuels in Australia: some economic and policy issues. RIRDC Pub No. 07/177.


Abbreviations

**ABARE**  
Australian Bureau of Agricultural and Resource Economics

**ABS**  
Australian Bureau of Statistics

**bbl**  
barrel

**CO₂**  
carbon dioxide

**CSIRO**  
Commonwealth Scientific and Industrial Research Organisation

**EIA**  
Energy Information Administration (US)

**GDP**  
gross domestic product

**FCAI**  
Federal Chamber of Automotive Industries

**IEA**  
International Energy Agency

**km**  
kilometres

**LNG**  
liquefied natural gas

**LPG**  
liquefied petroleum gas

**PJ**  
petajoules

**tCO₂e**  
tonnes of carbon dioxide equivalent
Your CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.