Energy
Australian Resources Research Centre
26 Dick Perry Avenue, Technology Park, Kensington, Perth, WA 6151, Australia
PO Box 1130, Bentley, WA 6102, Australia
Telephone: (08) 6436 8500 • Facsimile: (08) 6436 8555 • ABN 41 687 119 230

Our Ref: 08/308

Committee Secretary
Senate Select Committee on Fuel and Energy
Department of the Senate
PO Box 6100
Parliament House
Canberra ACT 2600
Australia

29 August 2008

The Committee Secretary

RE: CSIRO's Submission to the Inquiry into the Impact of Higher Petroleum, Diesel and Gas Prices and Several Related Matters.

We thank you for the opportunity to comment on the inquiry into the impact of higher petroleum, diesel and gas prices and several related matters. Our attached comments are written with an understanding that CSIRO is actively undertaking research on issues of relevance to Australia and the region.

CSIRO's research in partnership with the Future Fuels Forum indicates that there is significant uncertainty about the future price of oil. However, modelling conducted by CSIRO and others indicates that prices sustained above US$60/bbl may be likely.

In response to sustained high oil prices and the introduction of an emission trading scheme, our modelling projects that a much more diverse fuel mix will evolve. Whilst the introduction of emissions trading alone is not expected to substantially increase the price of fuels, Australia will need to develop new, low emission technologies to realise the sustainable introduction of alternative fuels.

CSIRO has the capability and is committed to ensure that Australia possess the technology to lead the adoption of an affordable and sustainable energy strategy for the region.

Should you require any further information regarding our submission, please do not hesitate to contact me or Mr Peter King (the main submission contact).

Yours sincerely

Dr Beverly Ronalds
Group Executive, CSIRO Energy

CSIRO Submission 08/308

Inquiry into the Impact of Higher Petroleum, Diesel and Gas Prices and Several Related Matters

Enquiries should be addressed to:
Mr Peter King
Senior Adviser
CSIRO Government Relations
PO BOX 225
Dickson ACT 2602
Australia
Ph: (02) 6276 6361
Email: PeterG.King@csiro.au

Main submission Author:
Mr Paul Graham
Energy Futures Theme Leader
Energy Transformed Flagship
PO Box 330
Newcastle NSW 2300
Australia
Ph: (02) 4960 6061
Email: Paul.Graham@csiro.au

Contents

Overview 3
Summary 3
1. The impact of higher petroleum, diesel and gas prices and an emissions trading scheme: 3
2. The role of alternative fuels: 4
3. The domestic oil/gas exploration and refinement industry: 4
1. Outlook for oil and impact of changes in petrol and diesel prices 5
1.1 An alternative view of the future oil price 6
1.2 Impact of emission trading on petroleum product prices 7
1.3 Impacts on fuel users 8
1.4 Impact of emission trading on employment 9
2. The role of alternative fuels 10
2.1 The role of biofuels 11
2.2 The role of electrification 13
2.3 Synthetic fuels from natural gas and coal 14
2.4 The role of natural gas 15
3. Australian oil and gas exploration and refinement industry 16
3.1 Oil exploration and refinement 16
3.2 Gas exploration and refinement 16
References 18

Overview

This document represents CSIRO's views on a number of the issues raised in the Senate Select Committee on Fuel and Energy Terms of Reference. CSIRO has only addressed those issues which are within its scope of research. In relation to the Terms of Reference of the Senate Select Committee on Fuel and Energy we are able to comment on the uncertainty in the outlook for oil prices and its impact on fuel prices in Australia (item a), the price and employment impacts of emission trading (item d), the role of alternative fuels (item g) and the outlook for domestic oil and gas exploration and refinement (item h).

This submission draws on the following existing and past CSIRO research programs and expertise:

- Alternative energy and transport futures
- Advanced battery technologies and hybrid electric drivetrain optimisation
- Thermochemical and enzymatic lignocellulosic ethanol production
- Enhanced oil and gas production
- Synthetic fuels and gas separation
- Assessment of Australian biomass feedstocks and their suitability for alternative energy conversion technologies
- Oil and gas exploration including subsea and well technologies

Summary

1. The impact of higher petroleum, diesel and gas prices and an emissions trading scheme:

- In relation to oil prices, CSIRO's research in partnership with the Future Fuels Forum indicates that there is significant uncertainty about the future price of oil. Whilst current oil prices are high enough to encourage significant investment in new oil field production, it is not clear for how long new oil production will be sufficient to offset the decline in production at some existing oil fields. If a global production peak is reached in the near term and alternative fuels do not rapidly fill the gap, fuel prices may need to increase by several dollars a litre in order to ration demand in Australia.

- The introduction of emissions trading is not expected to substantially increase the price of fuels. The present government's Green Paper indicates that consumers may be shielded from the price of carbon until around 2013. Emission permit prices of A$40 and A$100/tCO_2e translate to petroleum fuel price increases of A$0.10 and A$0.25 per litre, respectively. It may take a decade or more for carbon prices to reach these levels, and the overall impact is less than that of oil price movements over the past four years.

- At very high fuel costs, many people (particularly low income groups) and businesses will choose to substantially reduce their use of transport below their present levels, making the development of affordable public transport and more accessible community resources important. From an economy-wide perspective, increased costs of oil-based fuels will filter through the economy, increasing the cost of all goods and services. Research indicates that sustained oil prices of around US$100/bbl would reduce economic growth by around 3 percent.

- In recent research, CSIRO found that achieving a rapid transition to sustainability via emission trading and related mechanisms would have little or no impact on national employment, with projected increases in employment of 2.5 to 3.3 million jobs over the next two decades. However, achieving the transition will require a massive mobilisation of skills and training – both to equip new workers and to enable appropriate changes in practices.

2. The role of alternative fuels:

- In the next ten years, CSIRO modelling projects that diesel, electricity, liquefied petroleum gas (LPG) and natural gas (particularly in freight) will all increase their share of the transport fuel market. These fuels all have some existing production and distribution infrastructure. However, they will also require some new infrastructure.
- Natural gas is recognised by many countries as the bridging fuel for the next decade. 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.

3. The domestic oil/gas exploration and refinement industry:

- Geologic research and new technologies are needed to maximise Australia's oil self sufficiency by reducing exploration risk in frontier basins and generating reserve growth of existing fields. New technologies are needed to effectively monetise Australia's vast natural gas off the Northwest Shelf and other petroleum/gas provinces. Integrated geologic and engineering research is needed to diversify Australia's domestic gas supplies by increasing production of coal seam methane and the development of tight gas resources.

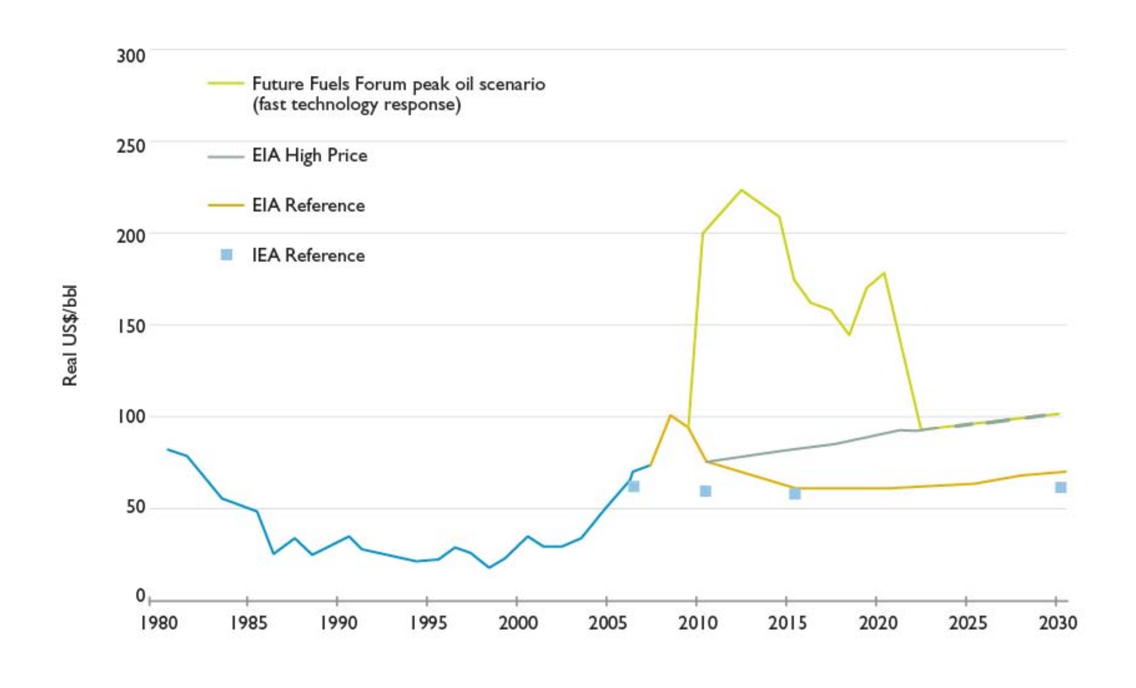
1. Outlook for oil and impact of changes in petrol and diesel prices

CSIRO conducts an Energy Futures research theme which recently partnered with the transport industry to form the Future Fuels Forum.

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 goal of the Forum was to identify plausible scenarios for the future of transport fuels in Australia. The Forum included 18 industry, community and government organisations with an interest in transport. The Forum completed its process in July 2008 making its findings available to the general public with the publication of *Fuel for thought* (see Attachment A). This publication was also accompanied by a technical report: *Modelling of the future of transport fuels in Australia*.

The Future Fuels Forum considered the outlook for oil prices (CSIRO and Future Fuels Forum, 2008). They found that 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 average annual price in their reference, or business as usual, cases (e.g. EIA 2008a, EIA 2008b, IEA 2007) (Figure 1). Note, all prices are discussed in real or current dollar terms.

Figure 1: Historical and projected average annual oil prices.



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).

1.1 An alternative view of the future oil 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 growth in China and India is not abating 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 $100/bbl by 2030 (Figure 1).

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, where the petrol price per litre varies from A$1.86 in Latvia to A$2.54 in the United Kingdom to A$2.85 in Scandinavia.

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, and 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.

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

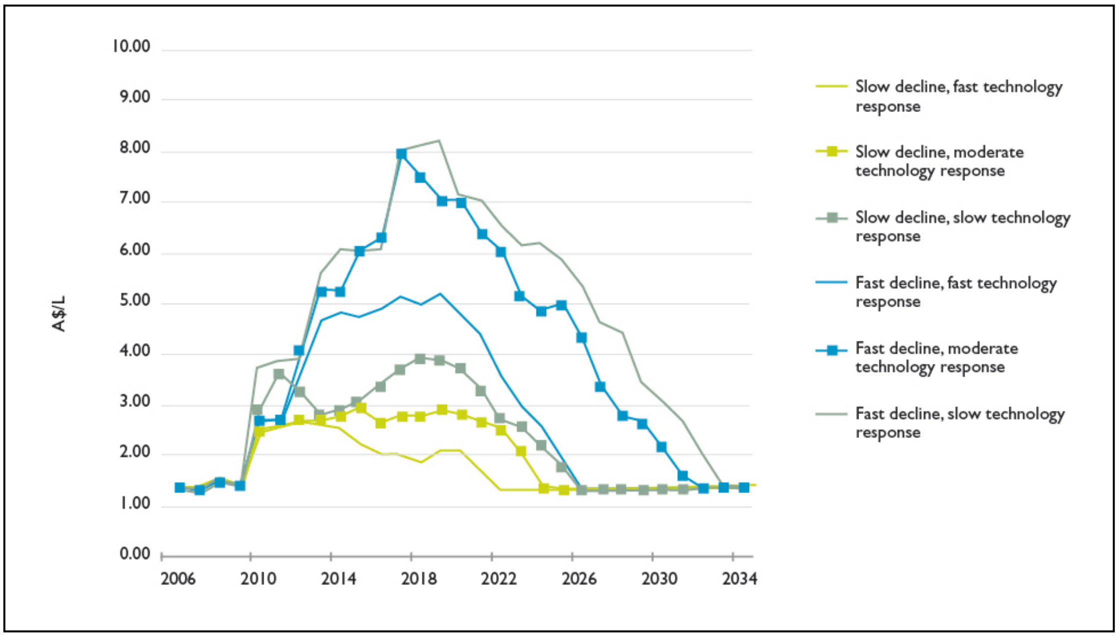
All three oil price paths discussed are shown in Figure 1: steady oil prices associated with both of the IEA and the US EIA reference cases, the US EIA high oil price case and a projection of oil prices associated with a near-term peak in oil production.

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 paths 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 1.

The resulting range of petrol prices for alternative peak oil scenarios modelled by CSIRO for the Future Fuels Forum are between A$2 to as high as A$8 per litre by 2018 (Figure 2).

Figure 2: Comparison of petrol price changes for different rates of oil production decline and slow, moderate and fast technology and infrastructure responses.



In relation to oil prices, CSIRO's research in partnership with the Future Fuels Forum indicates that there is significant uncertainty about the future price of oil. Whilst current oil prices are high enough to encourage significant investment in new oil field production, it is not clear for how long new oil production will be sufficient to offset the decline in production at some existing oil fields. If a global production peak is reached in the near term and alternative fuels do not rapidly fill the gap, fuel prices may need to increase by several dollars a litre in order to ration demand in Australia.

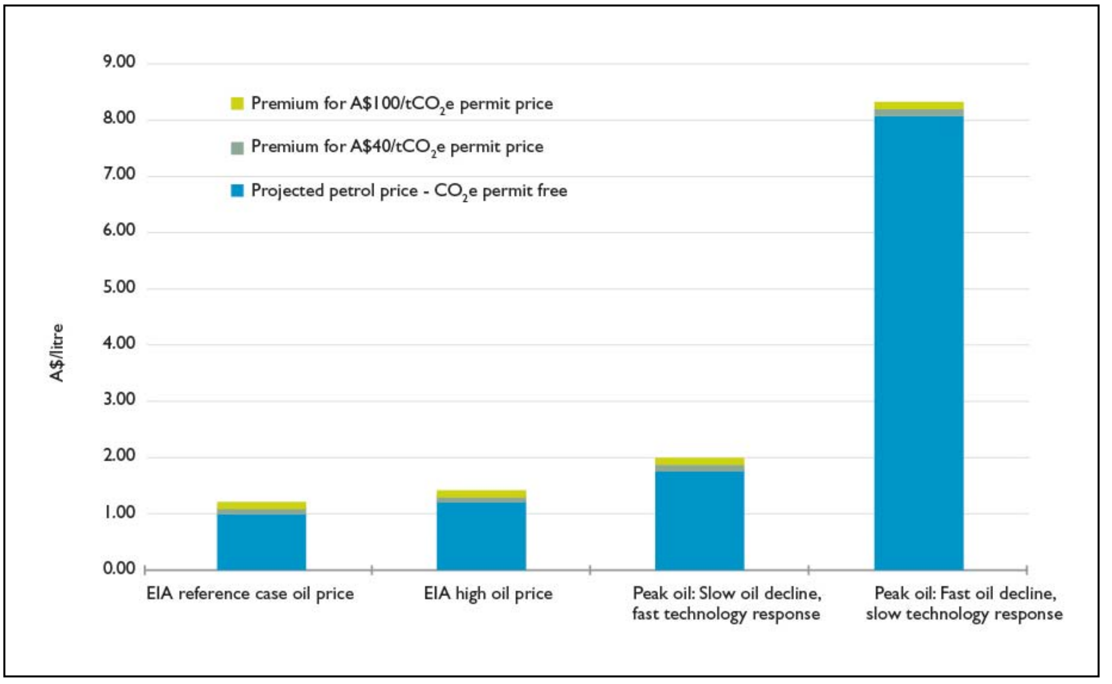
1.2 Impact of emission trading on petroleum product prices

Irrespective of the range of cost increases experienced as a result of tighter international oil markets, the cost of petroleum products could also increase with the introduction of emission trading in Australia. Current government policy is to introduce emission trading in 2010. Assuming transport fuel is included in the scheme, passenger and freight road users are to be shielded from carbon prices via offsetting excise rates decreases until 2013 and 2011, respectively.

Modelling conducted for the Future Fuels Forum projects that the price of emission permits can be expected to begin at around A$25-40/t$CO_2$e, increasing to A$70-100/tCO_2e for a 60 per cent emission cut by 2050 target and A$200-300/t$CO_2$e by 2050 if Australia chooses to pursue near-zero emission targets within the emissions trading scheme.

When the carbon price is eventually passed through to consumers, emission permit prices of A$40 and A$100/tCO_2e translate to petroleum fuel price increases of A$0.10 and A$0.25 per litre, respectively. While significant, as shown in Figure 3, the impact of emission permit prices is substantially less than the potential changes in oil prices.

Figure 3: Potential future petrol prices under alternate international oil and carbon market conditions.



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. Since 2004 Australians have not radically shifted to low emission vehicles. The most significant shift has been toward a greater portion of small and medium sized vehicles in total vehicle sales.

The introduction of emissions trading is not expected to substantially increase the price of fuels. The present government's Green Paper indicates that consumers may be shielded from the price of carbon until around 2013. Emission permit prices of A$40 and A$100/tCO_2e translate to petroleum fuel price increases of A$0.10 and A$0.25 per litre, respectively. It may take a decade or more for carbon prices to reach these levels, and the overall impact is less than that of oil price movements over the past four years.

1.3 Impacts on fuel users

If fuel prices do rise, those with low incomes will be most vulnerable as spending on fuel represents a greater proportion of their disposable income. In addition, this group tends to have fewer resources to invest in alternative fuels or more efficient vehicles. Regional communities and those located on the urban fringes will also be disproportionately impacted owing to their higher fuel use, higher fuel prices relative to cities and fewer options for reducing motor vehicle travel.

In regard to the projected price paths already discussed (Figure 1), if 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).

If there is a near-term peak in oil production, fuel costs for the same class of vehicle and travelling patterns are forecast at between A$50 and A$220 a week (assuming no reduction in kilometres travelled). 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.

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.

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 an economy-wide perspective, increased costs of oil-based fuels will filter through the economy, increasing the cost of all goods and services. There is very little economic modelling of the potential impact of high fuel prices in Australia publicly available. Energy Futures Forum (2006) found that sustained oil prices of around US$100/bbl would reduce economic growth by around 3 percent in the year that price was reached relative to a reference case where oil prices in the same year had returned to their long term average of around US$35/bbl.

At very high fuel costs, many people (particularly low income groups) and businesses will choose to substantially reduce their use of transport below their present levels, making the development of affordable public transport and more accessible community resources important. From an economy-wide perspective, increased costs of oil-based fuels will filter through the economy, increasing the cost of all goods and services. Research indicates that sustained oil prices of around US$100/bbl would reduce economic growth by around 3 percent.

1.4 Impact of emission trading on employment

CSIRO recently examined the expected impact of emission trading on employment in Hatfield-Dodds et al. (2008). The report came to the following conclusions:

- Achieving a rapid transition to sustainability would have little or no impact on national employment, with projected increases in employment of 2.5 to 3.3 million jobs over the next two decades.
- Employment in sectors with high potential environmental impacts will also grow strongly, with projected increases of more than 10% over ten years. This will add 230,000 to 340,000 new jobs – in addition to normal employment turnover – in the transport, construction, and agriculture, manufacturing and mining sectors. Employment in construction and transport sectors is projected to grow significantly faster than the national average.
- Achieving the transition to a low carbon sustainable economy will require a massive mobilisation of skills and training – both to equip new workers and to

enable appropriate changes in practices by the three million workers already employed in these key sectors influencing our environmental footprint. Current approaches do not appear sufficient for meeting these challenges.

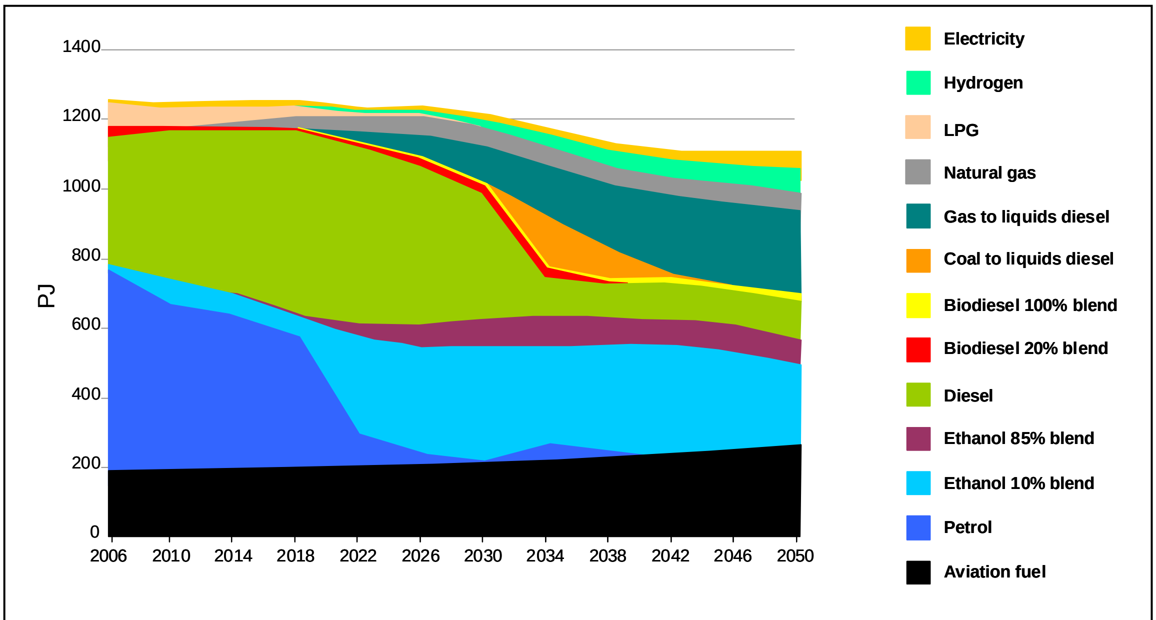
In recent research, CSIRO found that achieving a rapid transition to sustainability via emission trading and related mechanisms would have little or no impact on national employment, with projected increases in employment of 2.5 to 3.3 million jobs over the next two decades. However, achieving the transition will require a massive mobilisation of skills and training – both to equip new workers and to enable appropriate changes in practices.

2. The role of alternative fuels

Modelling conducted by CSIRO projects that a much more diverse fuel mix will evolve in response to the likely outcome that oil prices will be sustained above US$60/bbl and emission trading will be introduced. The initial response to these market forces is projected to result in greater uptake of diesel fuel, natural gas (mainly by the articulated truck fleet in the form of LNG) and electricity via hybrid or fully electric vehicles. Longer term, the response is expected to include synthetic gas and coal liquids and advanced biofuels that limit competition with the food market.

Figure 4 shows an indicative outcome for a scenario where oil prices rise to around US$130/bbl, the government's present greenhouse gas emissions target of 60% below 2000 levels is implemented and fuel cell vehicles are cost competitive. A more diverse range of scenarios are reported in Graham et al. (2008). The discussion below indicates some of the assumptions and uncertainties in these projections.

Figure 4: Consumption of transport fuels under a scenario with EIA's (2007) high oil price case, fast technology response, fuel cell cars available and 60% below 2000 levels by 2050 emission target.



In the next ten years, CSIRO modelling projects that diesel, electricity, liquefied petroleum gas (LPG) and natural gas (particularly in freight) will all increase their share of the transport fuel market. These fuels all have some existing production and distribution infrastructure. However, they will also require some new infrastructure.

2.1 The role of biofuels

2.1.1 Feedstocks and new technologies for biofuel production

CSIRO has a significant research stream assessing the amount of Australian biomass feedstocks and their suitability for alternative biofuel energy conversion technologies. In regard to the question of how much biofuel Australia could produce O'Connell et al. (2007) find that:

- Conversion of export fractions of wheat could theoretically have supplied upper limits of 11-22% of Australia's current petrol usage as ethanol (after adjusting for different energy content of fuels)
- Conversion of domestic waste oil, tallow exports and oilseed exports could have theoretically provided upper limits of 4-8% of Australia current diesel usage as biodiesel.
- If a national E10 target were set it could force the import of wheat in drought years since the above percentages only represent upper limits.
- Using second generation technologies based on lignocellulosic feedstocks for ethanol or from new trees and crops for biodiesel, upper estimates for biofuels production could replace between 10-140% of our current petrol usage. The high uncertainty is due to lack of knowledge on ecologically sustainable and economically feasible production of lignocellulose feedstocks.

Second generation biofuel conversion technologies have recently been reviewed by Warden and Haritos (2007). They can be divided into two broad categories – thermochemical and enzymatic, although different combinations of the two technologies can be used to produce particular fuels. Most conversion processes involve some manner of pre-treatment step which facilitates the actual chemical conversion to a biofuel. Most processes are also feedstock-dependent, meaning they need to be modified to provide a consistent conversion rate if the feedstock changes.

Most processes claim to be competitive with oil at around US$40 - 60 per barrel.

There are several different types of liquid and gaseous fuels that can be produced from lignocellulosic sources, each with advantages and disadvantages relating to certain characteristics including their utility, cost/ease of production, public image, energy content, compatibility with existing processes and infrastructure, and yield per tonne of feedstock. There are significant efforts in the USA and Europe towards the development and commercialisation of second generation biofuels industries. There is considerable support being provided by the US Department of Energy in the USA.

In general, Europe is more focussed upon thermochemical conversion methods, whereas the USA has focussed more upon enzymatic conversion processes. There is no clear "best practice" or "best fuel" at this point in time, although most effort is currently being put towards the production of ethanol.

2.1.2 Food versus fuel

Increased food prices in recent years has 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.

2.1.3 Biofuel research

Algae are the fastest growing biomass. Research is focussing on whether these should be grown in open ponds or in vertical rotating facilities to maximise carbon dioxide consumption and light exposure leading to maximum growth. Some algae (e.g. *Botryococcus*) can produce non lipid biofuels much closer to conventional petroleum. Some research may need to be undertaken to genetically engineer these algae and/or maximise their growth and oil yield. Other research may be required in process engineering, drying algae and extraction of oil.

There are large overseas research programs on enzymatic production of ethanol from waste cellulose. There is an opportunity for Australia to use its indigenous genetic stock to develop specific enzymes that can be patented. Research is underway in assessing the terrestrial biomass in Australia most suitable for ethanol production which does not interfere with food production (e.g. grasses) on marginal land. Further research may be necessary on using lignin to produce biofuel. Biofuel can be produced from terrestrial plant lipids which are present in non food crops but these plant (e.g. *Jatropha*) species are noxious weeds and would need to be considered for introduction with some care.

Further research is also required on the depletion of carbon from soils when biomass is not recycled but used as transport fuels. Carbon capture by soils as humus may be one method to fix carbon dioxide.

2.1.4 Projections of biofuel use in Australia

CSIRO modelling assumed that biodiesel from algae and lignocellulosic ethanol would not be available until 2015 and 2020, respectively, although demonstration trials can be expected prior to this.

Based on these assumptions ten percent blends of ethanol and petrol are expected to continue to be used and expand slightly in the short term. Both ten percent and eighty five percent blends of ethanol fuel are expected to receive a significant boost around 2020 following the availability of new ethanol supplies from lignocellulosic production.

Biodiesel consumption is projected to remain steady into the future reflecting the assumed limited volumes available at a competitive price. Algae based biodiesel is assumed to be technically feasible by 2015 but its cost competitiveness is uncertain. As a result, CSIRO has explored a scenario where algae based biodiesel is cost competitive in order to understand its potential.

Under the assumption of low cost biodiesel from algae, CSIRO modelling projects that biodiesel from algae will be taken up in very large volumes and eventually dominate the diesel vehicle market. The fuel is initially taken up as a 20 percent blend with oil based diesel so that it can be used in the current vehicle stock. However, its use in higher blends is also favoured after there has been sufficient time to build up the stock of high blend capable vehicles.

The availability of low cost biodiesel would encourage greater use of diesel vehicles in general at the expense of the market share of petrol and natural gas. The use of higher efficiency diesel vehicles together with the low emission intensity of biodiesel from algae was projected to result in additional emission savings relative to the case where it is not taken up of 10MtCO_2e by 2050.

2.2 The role of electrification

Electricity is expected to steadily expand its role as a transport fuel increasing from the 8PJ currently (which is consumed exclusively by rail transport) to 149PJ or 41TWh (where the road transport mode is the dominant electricity user). Note, this estimate of electricity consumption only includes that drawn from the grid, not that generated in the vehicle via any other means. The uptake of electric and hybrid electric vehicles appears to be the cause of the projected reduction in LPG usage in Figure 4 and some other scenarios explored. In this context, electricity can be seen as a potential competitor to LPG as a way of reducing travel costs. On the other hand it is possible that LPG hybrids could be offered to consumers stemming the projected decline in LPG usage over the longer term.

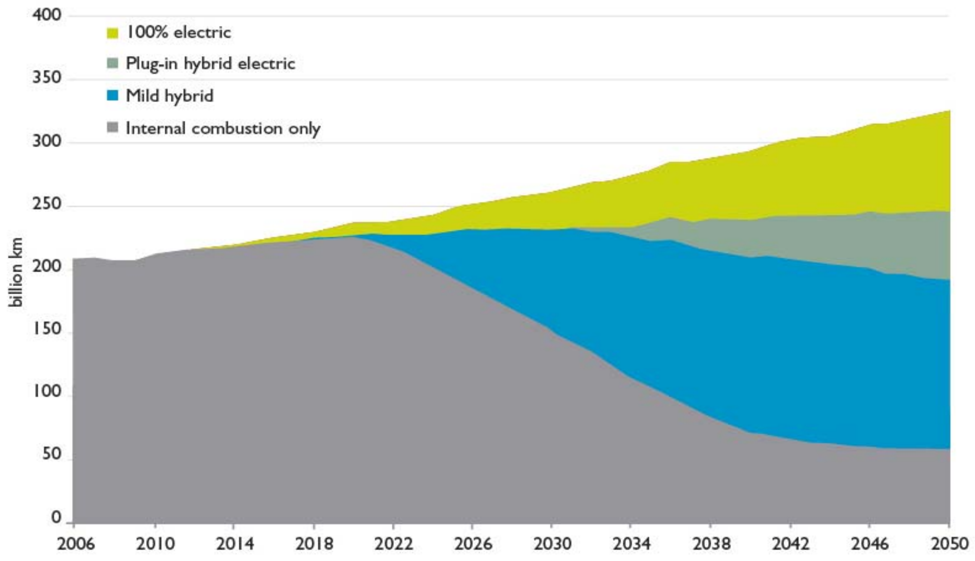
The emergence of the partial electrification of the road transport sector is shown in greater detail in Figure 5. It shows that by 2050 plug-in hybrid electric and full electric vehicles will account for around a third of the road vehicle fleet. Mild hybrids which generate their electricity on board rather than drawing on the electricity grid are projected to account for another 50 percent of the fleet leaving internal combustion only vehicles responsible for just one sixth of vehicle kilometres travelled.

Of course, hybrid electric vehicles are already being sold in Australia. However, they are not yet a large enough portion of the fleet to appear in Figure 5. The existing fleet of hybrids will not be visible on Figure 5 until they reach around 50,000 vehicles. In effect Figure 5 only shows the point where hybrids and electric vehicles are expected to be taken up in earnest by the mainstream consumer.

Another feature of the projection is that fully electric vehicles tend to precede mainstream uptake of hybrid electric vehicles. This follows from the assumption that a purely electric vehicle will have fewer additional component costs and is only available to the light vehicle market and therefore not necessarily competing with hybrids.

The projected increasing electrification of the transport sector must of course be supported by increasing electricity production. This is automatically accounted for in the modelling CSIRO conducted. CSIRO projects that the introduction of emission trading will eventually transform the electricity sector so that electricity drawn down from the grid into vehicles is low emission. At present, that is not the case.

Figure 5: Projected increasing electrification of road transport vehicles: Assuming the EIA high oil price projection and a 60% below 2000 levels emission target by 2050.



CSIRO modelling projects that the next decade will largely see the uptake of wind and natural gas combined cycle plants for electricity generation. This is not surprising since they are the two current lowest cost low emission plant. However, once CO_2 capture and storage (CCS) and other renewable energy technologies (such as hot fractured rocks, biomass, solar thermal and solar photovoltaics) are available at a competitive cost from around 2020, these very low emission technologies begin to be deployed.

2.3 Synthetic fuels from natural gas and coal

Technology is currently available for both gas and coal to liquid fuel production. Implementation requires a large capital outlay and then the assets are long-lived. As a result such investments are subject to a high degree of risk that the price of oil will not remain high enough throughout the life of the plant to recover the initial outlay. The current inflated price of infrastructure raw materials such as steel is also contributing to project risk.

Another concern is that synthetic fuel production emits greenhouse gases and therefore the ready availability of CO_2 capture and storage technology (not expected until around 2020) is a potential pre-requisite for the more emission intensive processes involved.

For these reasons it is projected that no immediate plants will proceed in Australia and potential investors will continue to fund research to bring down the cost of the plants to reduce the up-front costs, whilst at the same time monitoring the price of oil to determine if a favourable trend continues.

A key area of research is improving the efficiency of the conversion process. Given Australia has a large amount of remote offshore gas, research has also been concerned with how to covert this gas to synthetic fuels at the remote location. Research in relation to coal to liquids production is needed into effects of mineral matter in prospect coals to understand their role in catalysts poisoning and production of environmental hazardous materials. New processes to address issues identified need to be piloted before being adopted in development plants before full scale deployment in large scale plants.

In terms of the relative competitive position of gas versus coal to liquids, coal to liquids diesel with CO_2 capture and storage tends to be favoured if 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.

2.4 The role of natural gas

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

However, even if domestic natural gas prices were to rise to levels consistent with oil, that would take some time to filter through and in the long term natural gas still has the advantage of being a slightly lower carbon content transport fuel.

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

CSIRO modelling has indicated as much as an additional 200PJ per annum of natural gas could be required for the Australian transport sector by 2020 in the extreme case where global oil production declines. If oil supply is unconstrained around 40PJ of natural gas are projected to be consumed per annum. Current use of natural gas in Australian transport is less than 2 PJ per annum.

Natural gas is recognised by many countries as the bridging fuel for the next decade. 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.

3. Australian oil and gas exploration and refinement industry

3.1 Oil exploration and refinement

There was close to a 40% fall in Australia's crude oil production between 2000 and 2004 although production has stabilised in the last few years. From being a country that was close to self sufficiency in oil, Australia now imports a significant amount of oil to meet domestic demand. There is an urgent need to find new oil accumulations to replace reserves in old oil fields as they are depleted.

Additional reserves can come from reserve growth of existing fields or from the discovery of new fields. Reserve growth occurs by the development of better geologic understanding of reservoirs and their compartmentalisation and by enhanced recovery methods that allow a greater percentage of the in-place oil to be recovered. Research on reservoir geometries, subtle trapping mechanisms, and improved recovery methods could lengthen the life of Australia's mature oil fields, particularly in the Gippsland basin.

Continued production of oil in Australia at current levels is, however, dependant on finding new oil fields. There are a number of geologic basins around Australia, particularly in the offshore areas, that remain unexplored for oil. Many of these basins have sediment thicknesses and rock types that may be favourable for major oil accumulations.

Australia is relatively unexplored for oil and gas compared to some other parts of the world. There have only been about 6,600 exploration and appraisal wells drilled on the continent. By contrast, there has been over 500,000 exploration wells alone drilled in the United States, a country of similar size.

Due to the remote nature of many of Australia's basins and the deepwater offshore, oil exploration is expensive. Exploration risk is also high in Australia with less than 50% of exploration wells drilled for oil and gas being successful – compared with ~80% in West Africa. Appropriate research can substantially reduce exploration risk. In the U. S. A. exploration success has increased from about 20% to over 50% in the last 25 years despite the fact that it is a very mature area for exploration.

CSIRO's integrated research on the nature of Australia's petroleum systems and their unique geologic setting aims to reduce exploration risk in Australia. New CSIRO technologies, such as nanosensors and geophysical imaging suitable for Australia's environment and geology will also aid in the discovery of Australia's undiscovered oil resources.

3.2 Gas exploration and refinement

Australia is rich in natural gas resources. Much of this gas lies on the Northwest Shelf and has only recently become of economic interest as the global demand for natural gas increases and costs of global trade in the commodity have fallen. If that gas is to successfully compete in the global marketplace it must be extracted and transported in a cost competitive fashion as several other nations that have substantially larger reserves (for example, Qatar and Saudi Arabia) are also entering the global market.

CSIRO's research on technologies such as platform-free fields and gas-to-liquid conversion appropriate for Australia's gas accumulations will help ensure our gas resources are monetised.

Ironically, despite the fact that Australia has vast gas reserves, much of the nation's conventional gas lies well removed from urban centres and there is concern about domestic gas supplies. The recent Veranus incident in Western Australia, for example, pointed out the vulnerability of domestic supplies that are heavily dependant on a few sources of supply.

The future of domestic gas supplies may be best served by diversification of supply from sources such as coal seam methane and tight gas in addition to conventional gas fields. Research is needed to find appropriate technologies to optimally produce gas from Australia's extensive subsurface coal seams. CSIRO, for example, is conducting research on microbial enhancement of gas recovery from coals.

Natural gas that is tightly bound in rocks with low porosity and permeability are referred to as "tight gas". There are a number of geologic basins close to urban centres in Australia that may contain significant amounts of tight gas but these are currently poorly understood. In North America tight gas already makes up over 15% of natural gas production. Transfer of tight gas technologies from North America combined with research to adapt those technologies to Australia's unique geologic settings should substantially diversify the nation's domestic gas supplies.

Geologic research and new technologies are needed to maximise Australia's oil self sufficiency by reducing exploration risk in frontier basins and generating reserve growth of existing fields. New technologies are needed to effectively monetise Australia's vast natural gas off the Northwest Shelf and other petroleum/gas provinces. Integrated geologic and engineering research is needed to diversify Australia's domestic gas supplies by increasing production of coal seam methane and the development of tight gas resources.

References

Batten, D. and O'Connell, D. 2007. Biofuels in Australia: some economic and policy issues. RIRDC Pub No. 07/177.
http://www.rirdc.gov.au/reports/BBE/07-177.pdf

CSIRO and Future Fuels Forum (2008), Fuel for thought: The future of transport fuels: challenges and opportunities, CSIRO, Canberra,
http://www.csiro.au/science/FutureFuelsForum.html.

EIA (Energy Information Administration) 2007, Annual Energy Outlook 2008: with projection to 2030, Energy Information Administration,
http://www.eia.doe.gov/oiaf/archive/aeo07/index.html

EIA (Energy Information Administration) 2008a, Annual Energy Outlook 2008 (Revised Early Release), Energy Information Administration
http://www.eia.doe.gov/oiaf/aeo/

EIA (Energy Information Administration) 2008b, Short-term Energy Outlook, Energy Information Administration
http://www.eia.doe.gov/emeu/steo/pub/contents.html

Energy Futures Forum 2006, The Heat Is On: the Future of Energy in Australia, CSIRO,
http://www.csiro.au/science/EnergyFuturesForum.html

IEA (International Energy Agency) 2007, World Energy Outlook 2007, International Energy Agency
http://www.worldenergyoutlook.org/2007.asp

Graham, P., Reedman, L. and Poldy, F. 2008, Modelling of the Future of Transport in Australia, CSIRO
http://www.csiro.au/science/FutureFuelsForum.html

Hatfield-Dodds, S., G. Turner, H. Schandl and T. Doss, 2008, Growing the green collar economy: Skills and labour challenges in reducing our greenhouse emissions and national environmental footprint. Report to the Dusseldorp Skills Forum, June 2008. CSIRO, Canberra.
http://www.csiro.au/resources/GreenCollarReport.html

King, N. and Fritsch, P. 2008, Energy Watchdog Warns of Oil-Production Crunch, The Wall Street Journal, May 22 2008, pgA1,
http://online.wsj.com/article/SB121139527250011387.html?mod=hps_us_whats_news

O'Connell, D., D. Batten, M. O'Connor, B. May, J. Raison, B. Keating, T. Beer, A. Braid, V. Haritos, C. Begley, M. Poole, P. Poulton, S. Graham, M. Dunlop, T. Grant, P. Campbell and D. Lamb (2007), Biofuels in Australia – Issues and Prospects: A Report for the Rural Industries Research and Development Corporation (RIRDC: Canberra), May.
http://www.rirdc.gov.au/reports/EFM/BiofuelsSummaryWEB_READY.pdf

Warden A. and Haritos, V. 2008, Future Biofuels for Australia–Issues and opportunities for conversion of second generation lignocellulosics. A Report for the Rural Industries Research and Development Corporation (RIRDC: Canberra)
http://www.rirdc.gov.au/reports/BBE/08-117.pdf