Inquiry into Australia's future oil supply and alternative transport fuels

Senate Rural and Regional Affairs and Transport References Committee

CSIRO submission

February 2006

Contact: Dr Cedric Griffiths, CSIRO
26 Dick Perry Avenue
Kensington WA 6151
Phone: 08 6436 8500
Email: Cedric.Griffiths@csiro.au

ABARE	Australian Bureau of Agricultural and Resource Economics
APPEA	Australian Petroleum Production and Exploration Association Limited
AUV	Autonomous Underwater Vehicle
BHP	BHP Billiton
BRS	Bureau of Rural Sciences
CNG	Compressed Natural Gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CtL	Coal to Liquids
EEZ	Exclusive Economic Zone
EM	Electromagnetics
GA	Geoscience Australia
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GtL	Gas to Liquids
IOR	Improved Oil Recovery
LPG	Liquefied Petroleum Gas
LNG	Liquefied Natural Gas
MEOR	Microbially Enhanced Oil Recovery
NWS	North West Shelf
OECD	Organisation for Economic Cooperation and Development
PF2	Platform Free Fields
PJ	Petajoules
R&D	Research and Development
ULP	Unleaded Petrol
USGS	United States Geological Survey

Inquiry into Australia's future oil supply and alternative transport fuels

Senate Rural and Regional Affairs and Transport References Committee

Executive Summary

Overview

CSIRO's submission is based around the importance of a partnership of Government and industry funded research and development (R&D) for securing the future of Australia's transport fuel supply in a global environment of uncertainty.

- Australia is likely to rely on oil as its principal transport fuel for the foreseeable future.
- The security and reliability of Australia's oil supply are of growing concern, particularly in the context of increasing world reliance on the Middle East for oil and the growing demand from developing economies such as China, and India..
- The ability of Australia to purchase any short-fall in indigenous liquid hydrocarbons could be threatened if countries (e.g. USA, China) lock-in supplies with long-term contracts. A potential option is to develop strategic relationships with countries with excess capacity where Australian technology can contribute to exploration, appraisal and development in return for long-term supply guarantees.
- Australian oil reserves are under-explored. There is a need for ongoing assessment of Australia's oil prospects (especially in frontier basins), improved exploration techniques, and maximising recoveries from existing fields. All of these have a significant R&D dimension, unique to Australia, which CSIRO is addressing.
- Australian refining capacity will be insufficient to handle the anticipated growth in demand by 2012. There is, therefore, a need to investigate alternatives to conventional onshore refining.
- In addition to further oil exploration and research, there is a strong need to investigate alternative transport fuels including natural gas, biofuels, conversion of coal to liquids, and hydrogen.
- Research is also needed into techniques for reducing Australian transport fuel demand.
- Australia's rich endowment in natural gas provides enormous opportunity to supplement declining indigenous oil reserves with liquid fuels derived from gas condensate in the short term, as well as from gas to liquids (GtL).
- Important opportunities for Australian GtL R&D exist in niche areas such as offshore supplies. CSIRO has work in progress.
- Conversion of coal to liquids (CtL) is also being investigated as an alternative fuel source (in the medium term). R&D is required to optimise this for Australian coals.
- Both GtL and CtL processing will produce significant increase in greenhouse gas emissions, which will require mitigation by methods such as gas sequestration. CSIRO is a research leader in this area.
- Biofuels currently represent less than 0.5% of the transport fuel mix, but could potentially represent a more significant fraction. Feasibility studies in terms of the potential for increased production and adoption as well as possible impacts on the environment, the Australian economy and world commodity markets are needed. CSIRO has research in progress.
- Substantial levels of biofuel production in Australia (i.e. greater than 2-5% of transport fuel usage) would be increasingly viable given some combination of the following:
  - oil supplies are strongly restricted and/or prices remain above US$60 in the long term;
  - world grain and sugar markets remain oversupplied with depressed prices; and
  - technological advances further reduce the cost and raise the efficiency of the biofuel production process (in particular technology associated with ligno-cellulose to ethanol/methanol conversion).
- Hydrogen is a possible long-term candidate as an alternative transport fuel source. However, a low greenhouse emissions source is required, and there are issues with distribution and storage within vehicles.. R&D

to solve these issues is being actively pursued in Australia and overseas.

Recommendations

We recommend that the Commonwealth Government, in partnership with State Governments, industry and research bodies such as CSIRO, address the issue of Australia's future oil supply and alternative transport fuels by investing in and developing the following areas.

1. Improve the perception of Australia's prospectivity for oil and gas in order to encourage national and international investment. This should include developing new appropriate technologies for evaluating undiscovered resource potential as well as ensuring adequate pre-competitive data provision in deeper waters.
2. Encourage industry to explore in Australia rather than overseas, and maximise the extraction of oil from existing fields, by:
    a. investing in R&D into improved frontier and brownfield exploration technologies to improve direct identification of oil in the subsurface (as discussed in the body of the paper);
    b. investing in R&D to improve production and recovery technologies.
3. Encourage the development of a future supply of alternative fuels through investment in R&D into the various technical issues concerning the future supply of alternative fuels. This may include:
    a. Gas to liquids – developing opportunities for Australia through R&D in niche areas such as offshore supplies, as well as addressing issues of greenhouse gas emissions.
    b. Coal to liquids - developing opportunities for Australia through R&D focussing on the exploitation of our unique and vast coal reserves, as well as addressing issues of greenhouse gas emissions.
    c. Biofuels – investigating the potential for increased production and adoption, and possible impacts on the environment, the Australian economy and world commodity.
    d. Hydrogen – identifying a low greenhouse emissions source, and developing technologies to address current issues with distribution and storage within vehicles.
4. In parallel with the supply-side R&D, invest in R&D into the social, economic and technical drivers for transport fuel demand and identifying viable strategies for demand reduction.

CSIRO's Role and Relevance

CSIRO has a wide range of research capabilities directed at maintaining an internationally competitive and sustainable Australian energy industry, including maximising Australia's self sufficiency in transport fuels. It has internationally renowned and inter-disciplinary expertise in a variety of relevant areas such as: exploration; field appraisal and development; oil, gas and coal production and processing; renewable energy sources such as biofuels; greenhouse gas mitigation; environmental monitoring and sustainability; and socio-economic drivers for energy supply and demand.

CSIRO has been developing new tools, technologies and frameworks to improve Australia's assessment and management of the economic, social and environmental implications of Australia's transport energy demand. CSIRO's research is firmly grounded in close partnerships with industry, government, university and community groups.

Introduction

Transport is a vital element of any country's economy and one of the most important issues that will influence future Australian transport in the short to medium term is the sustainability of our oil-based economy. This has been highlighted in recent times in two ways. Firstly, the rapid rise in the price of oil has caused Australia to consider the security of its oil supplies. A recent report by the Bureau of Transport and Regional Economics, under the title "*Is the World Running Out of Oil?*" noted that the volume of oil discovered globally every five years has been decreasing since the mid 1960s. The same report demonstrated that a world peak in oil production may be currently occurring or will do so in the near future. If true, this would create a seller's market of unprecedented proportions, with significant implications for both supply and cost.

Burgeoning demand in developing nations puts increasing pressure on oil companies to extract more from the world's oil wells. It is becoming increasingly evident that this total reliance on greater output and continual new discoveries may not be realistic. Despite oil company forecasts of rising production to meet continually rising demand, it would be imprudent not to prepare for the possibility of shortening supplies in the future and accompanying price rises. The situation may also arise where increasing oil consumption becomes too costly in non-monetary terms, including environmental and social factors. It should be stressed, however, that we believe oil will remain the dominant component of the global transport fuel mix for the next 30 years.

Transport, which is almost totally dependent on oil, creates about 15% of Australia's greenhouse gas emissions. This proportion is low in comparison to the 27% figure for the United States, although only because our emissions from other sources (principally power generation) are so high.

Three quarters of Australia's oil use is consumed in transport, roughly half by cars and a quarter by commercial vehicles. We are not self-sufficient (we import 22% of our requirements now) and in the future it is likely we will have to rely increasingly on imported oil - ABARE projections indicate that we will be importing over 50% of our oil by 2030. This is likely to result in a commensurate detrimental effect on our balance of trade together with other risks of dependence. In addition, transportation is forecast to take an increasing share of oil consumption over the next 20 years.

Australia is one of the world's largest international suppliers of natural gas and the world's largest per capita user of automotive LPG. However, there are only small numbers of vehicles on Australia's roads using compressed natural gas (CNG) or liquefied natural gas (LNG). Increased up-take of natural gas (either in a gaseous form, as a liquid fuel or, in the longer term, hydrogen) has strong potential to play a significant role in Australia's future strategy for transport fuels.

Today's motor vehicles are much more fuel efficient than even a decade ago, yet the average Australian car consumes no less fuel than a decade ago because of rising sales of larger passenger vehicles. Rising fuel costs are a disincentive to buy larger vehicles, but sudden increases can cause social distress.

CSIRO is in a position to make a significant contribution to any long-term national plan that seeks to address the above issues in a variety of ways. We can assist in the identification of the issues and associated uncertainties (both current and future); we can provide technological expertise to address issues of fuel supply and consumption; and we have expertise that would be valuable in developing a balanced portfolio of management strategies. Such a portfolio could include maximising indigenous oil supply, developing alternative fuels and higher efficiency vehicles to supplement oil, and placing a higher value on improving energy efficiency and reducing consumption through provision of alternatives to vehicular travel.

Projections of oil production and demand in Australia and globally and the implications for availability and pricing of transport fuels in Australia

Considerations

Australian GDP has been growing at around 3% per year for the past five years. Australian growth in productivity is somewhat less (about 2% per year). It is thus reasonable to expect the need for energy to double in 35 years or sooner if these rates are maintained, unless rising fuel costs or improved efficiency dampen demand growth.

Current transport fuel supplies are shown in Figure 1. The projections beyond 2012 assume an even doubling of all fuel demand, i.e. there is no change of product mix. We also assume no increase in domestic refining capacity.

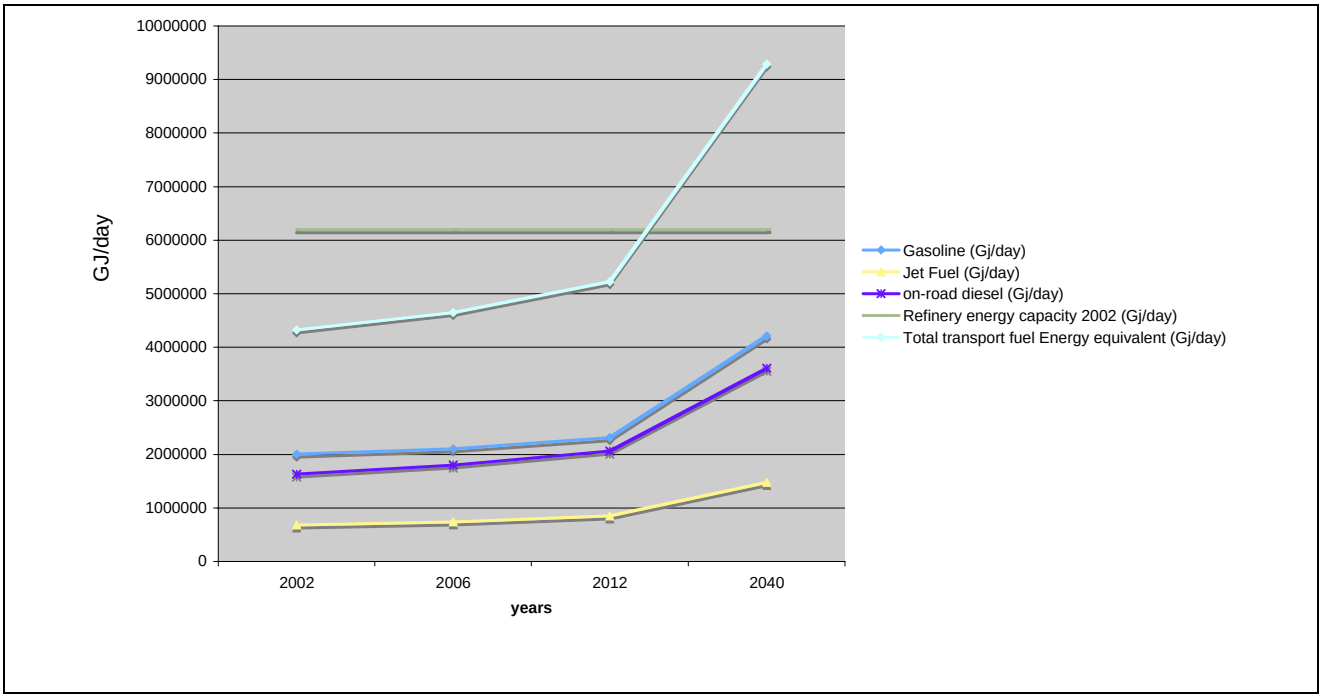

Figure 1: Australian and New Zealand transport fuels forecast in energy terms – 2002 to 2040 AD (Data from ABARE).

From energy density considerations alone (although we recognise that greenhouse gas and pollutant issues must also be considered), the volumes of various transport fuels likely to be required under projected transport energy demand scenarios for 2012 and 2040 are displayed in Figure 2. For instance, if all of the required transport fuel was to be provided from petrol then around 100 GL would be needed each year in

2040. Nearly 400 GL of liquid hydrogen would be needed to provide the same energy. Figure 2 also provides an indication of the relative volumes that would need to be transported via pipelines, tankers and refineries for the different options. A typical ocean-going shuttle tanker holds around 0.5 GL. It is predicted that the lowest volume (highest energy density) transport fuels likely to supply the energy required in 2012 are diesel and petrol (less than 100 GL/year) followed by LPG, LNG, and ethanol (less than 150 GL/year). Around 400 GL/year of liquid hydrogen are likely to be required and around 2 tcf (85000 GL) of sales gas (raw gas).

Once Australian refinery capacity is exceeded, Australia will need to import the balance of refined product, regardless of the domestic supply volume. Although securing indigenous oil supply provides one clear solution in the short-term, refining capacity is also a vital issue to be addressed in terms of transport fuel security.

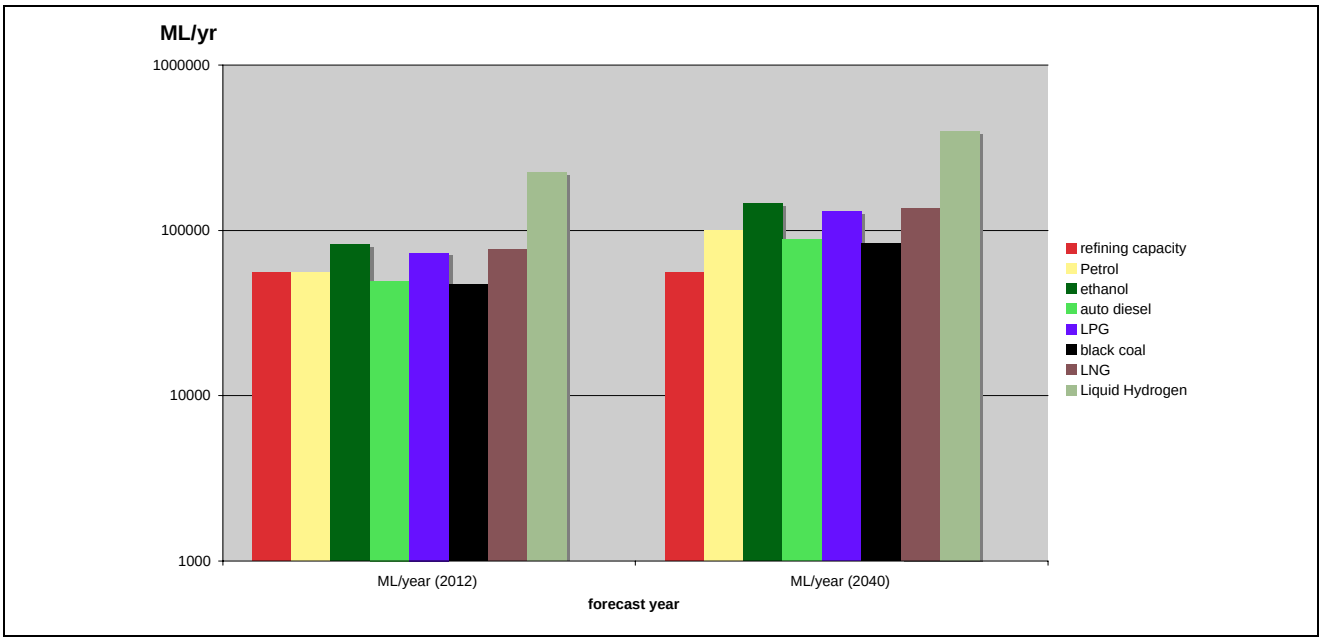

Figure 2: Relative volumes required to supply project transport fuel energy needs in 2012 (2000 PJ) and 2040 (3400 PJ).

From this data it is clear that:

- the demand for transport energy is due to exceed Australian refining capacity within the next five years;
- it is possible to satisfy a future increased energy demand using a mix of fuel types;
- not all *potentially* useful fuel types are equally practicable in the volumes that would be required.

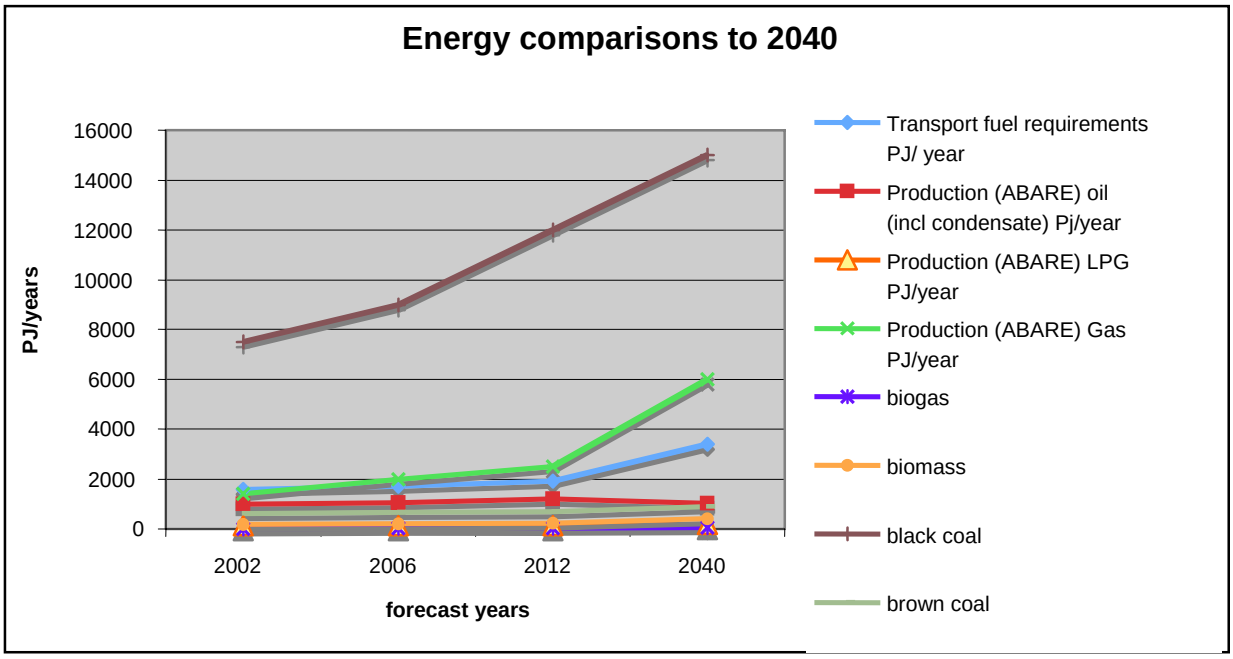

Figure 3: ABARE projections for production of several fuel types compared to Australian transport fuel demand over the next 35 years. (units are PJ).

The anticipated increase in transport fuel requirements (Figure 3) can be met from a variety of indigenous sources, without relying on imports. Each has its advantages and disadvantages, not least in the relative contribution to greenhouse gases. Some options are outlined below.

- Locate new oil reserves (frontier and 'brownfield' exploration)
- Extract more oil and gas from existing reservoirs (improved/enhanced recovery)
- Produce condensates/LPG from existing and new wet gas fields
- Convert abundant domestic methane to liquids (diesel, petrol, methanol) and/or hydrogen
- Produce biofuels from sugar cane and/or other sources
- Convert coal to fuels (liquids, hydrogen)
- Convert the transport fleet to electric power – provide electricity from a variety of distributed and/or stationary sources

Several of these options are discussed in the following sections.

Potential for new sources of oil and alternative transport fuels

Locate new oil and gas reserves

Undiscovered hydrocarbon resources are defined as the quantities of oil and gas that have yet to be discovered in the sandstone and limestone deposits kilometres underground in onshore and offshore sedimentary basins such as Bass Strait, Onshore and Offshore Canning Basins, Officer Basin, Cooper/Eromanga Basins and the Great Australian Bight. The volume of undiscovered resources in Australian basins have been extremely difficult to identify for a number of years for a variety of reasons.

Low drilling rates in frontier basins constitute one key reason. The lack of drill holes has resulted in a lack of data about what our actual resources are. In order for frontier exploration to occur, three factors need to be present – geological prospects, a promising fiscal regime, and stable political conditons. The combination of these factors needs to at least match that offered in available overseas areas. If an area has lower perceived prospects, or higher political risk and/or a severe tax regime, then companies are unlikely to take the significant financial risk in drilling new areas. In Australia exploration expenditure and drilling activity has waned since the early 1980's in real terms (Figure 4). Most of the largest oil companies quoted on the Australian stock exchange spend an increasing percentage of their exploration dollars offshore.

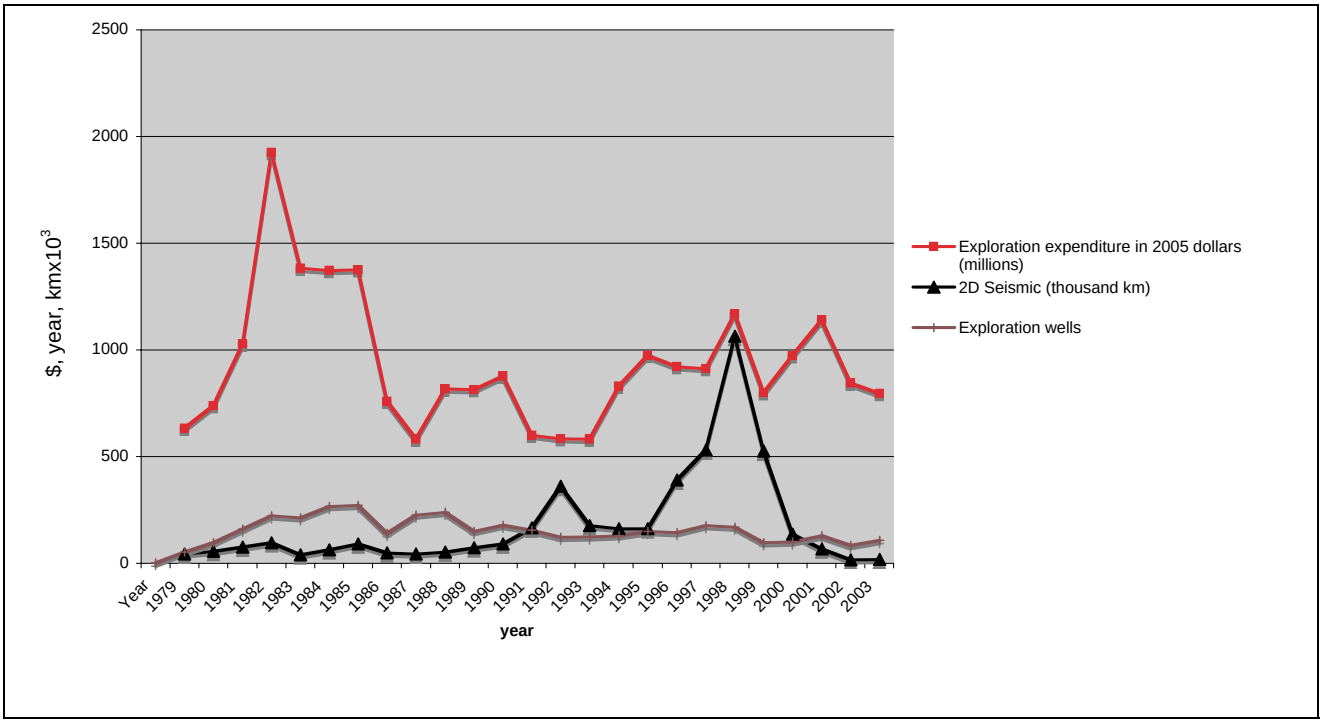

Figure 4: Exploration expenditure (2005 dollars) and drilling activity in Australia since 1979.

'Wildcat' drilling success rates worldwide are still at around 10%, whereas in Australian many companies are quoting 30% to 40% success rates. This essentially indicates that companies in Australia are not taking the same risks that they would elsewhere and are, in consequence, not making the big discoveries in new areas that would turn around the perception of prospectivity. This is borne out by the level of exploration drilling in Australia being relatively low compared with other regions in the world. By the end of 2003, around 8640 exploration and development wells had been drilled in Australia's onshore and offshore areas. Australia has about 16 million square kilometres of sedimentary basins. By comparison over 60 000 wells have been drilled in the Gulf of Mexico - an area smaller than the Carnarvon Basin off the north-west coast of Australia. It is clear, therefore, that Australia is largely unexplored and has significant potential for new discoveries.

How much is there really left to discover?

It has been many years since a comprehensive, independent analysis of undiscovered resources has been carried out over all Australian basins. Technologies have moved on considerably in this time. A recent published assessment of the most prospective basins on the NW Shelf is show in Table 1. This table compares different undiscovered resource assessments for some NWS basins by USGS, BRS and Geoscience Australia.

Australia has probably used only a relatively small proportion of its overall petroleum endowment. This is a big advantage that sets us apart from the traditional major OECD petroleum players, including the UK and USA, both of which have sharply declining production (Figure 5).

Proven and probable reserves figures published by ABARE and GA in 2003 suggest that Australia has remaining about 13 years supply of oil and condensate, 4 years LPG, and 70 years of methane at anticipated 2012 demand levels (if transport fuels were solely supplied by each of those fuels alone). If domestic exploration can be encouraged to the level of the most optimistic USGS 2000 estimates for resources discovery and production, then 35 years of oil and condensate and an additional 70 years of gas may be available at 2012 demand levels.

Table 1: Comparison of Australia's petroleum assessment by BRS and USGS and GA

Oil (x 10^6 Barrels; Gigalitres)

Basin	P-95%		P-Mean		P-5%	
Bonaparte (BRS-1998)	182	29	491	78	1195	190
Bonaparte (USGS-2000)	383	61	1286	205	2605	414
Bonaparte (GA 2001)	74.5	11.8	334.7	53.2	683.4	108.7
Browse (BRS-1998)	40	6	342	54	1079	172
Browse (USGS-2000)	229	36	1055	168	2606	414
Browse (GA 2002)	0	0	46	7.3	150	23.9
Carnarvon (BRS-1998)	252	40	585	93	1101	175
Carnarvon (USGS-2000)	862	137	2380	378	4052	644
Carnarvon (GA - 2005) P-90, P-Mean, P-10	27	4	167	27	354	56
Gippsland (BRS-1998)	94	15	189	30	302	488
Gippsland (USGS-2000)	103	16	309	49	583	98

Condensate (x 10^6 Barrels; Gigalitres)

Basin	P-95%		P-Mean		P-5%	
Bonaparte (BRS-1998)						
Bonaparte (USGS-2000)	245	39	1080	172	2395	381
Bonaparte (GA 2001)	17.2	2.7	116.1	18.4	321.2	51.1
Browse (BRS-1998)						
Browse (USGS-2000)	211	34	934	148	2205	351
Browse (GA 2002)	17.2	2.7	116.1	18.4	321.2	51.1
Carnarvon (BRS-1998)						
Carnarvon (USGS-2000)	1215	193	3682	585	6523	1037
Carnarvon (GA - 2005) P-90, P-Mean, P-10	0	0	26	4	77	12
Gippsland (BRS-1998)						
Gippsland (USGS-2000)	72	11	339	54	747	119

Source: APPEA Journal 2001 - "Understanding Australia's petroleum resources future production trends and the role of the frontiers", T.G. Powell, Oil & Gas Resources 2005 – Geoscience Australia

Note that there can be an order of magnitude difference between the P95 and P5 estimates (indicating the degree of uncertainty), but also up to five times difference between P50 estimates from different studies (indicating the different assumptions and purposes). P50 (P-mean in the table above), is the average predicted value from a risk assessment. The P95 value should be exceeded 95% of the time, whereas the P5 value should only be exceeded 5% of the time.

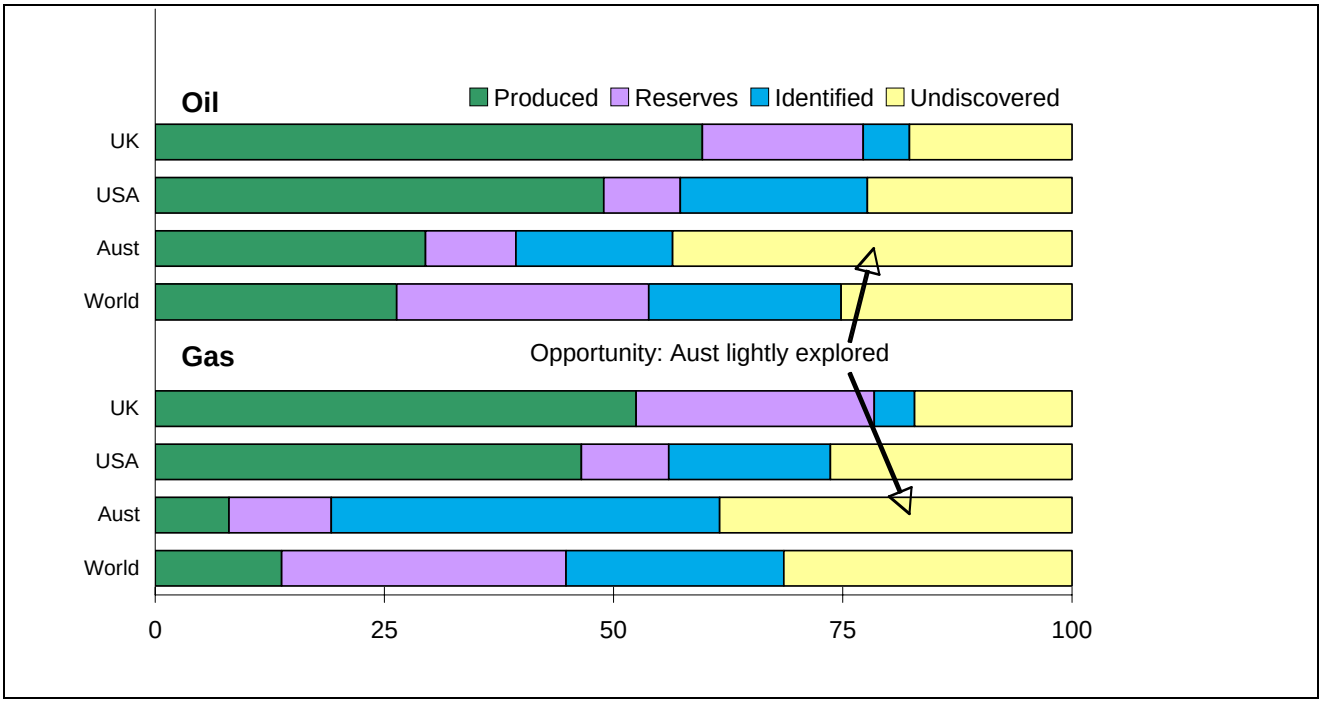

Figure 5: Comparison of the recoverable oil and gas resources (%) for Australia and the rest of the world.

This graph combines oil and condensates. (Source USGS)

Frontier Exploration

Exploration in Australian frontier areas presents significant technical challenges for oil companies.

- Experience from the Otway Basin, in common with many other places around the world, has shown that low-cost two dimensional (2D) seismic exploration is inadequate for identifying potentially economic reservoirs in the subsurface, especially where, as is the Australian case, the fields are relatively small and in complex structural settings. Three dimensional (3D) seismic is considered essential. Marine 3D seismic surveys are now common and relatively low cost. However Australia has large areas of desert underlain by potential oil fields. Desert 3D seismic is relatively expensive, especially in remote areas such as the Canning and Officer Basins where there is little or no infrastructure. An opportunity exists for investment in both infrastructure (roads, water, telecoms) and new technology (lower-cost desert 3D seismic and electromagnetics (EM), low-cost drilling technology) with potential long-term advantages for the community.
- The central Tasmanian Basin has potential reserves but technical challenges in imaging these reservoirs. Research to address this issue could potentially open up a new oil province.
- Large offshore frontier basins, such as exist along the southern margin of Australia (Southern Margin), may benefit from sustained research into combined seismic and Electro-magnetic (EM) inverse methods, particularly submarine towed array technology, to improve the likelihood of correctly imaging oil-filled, as opposed to brine-filled, traps. Any technology that can reduce the risk in this physically and geologically challenging area would be beneficial to transport fuel supply in the short-to-medium term.
- Autonomous Underwater Vehicle (AUV) technology is considered to be the key to economic viability of many new developments in both exploration and development of frontier, remote, deep water, areas of

the Australian Exclusive Economic Zone (EEZ). Research and development of sensor and manipulator packages for both overseas and Australian AUV's will speed their adoption by companies.

- CSIRO Wealth from Oceans Flagship's *Platform Free Fields* research programme aims to provide enabling technologies for lower risk deep/remote offshore field development. This research is likely to result in more of the Australian EEZ to be considered commercially viable.
- Direct identification of source rock maturity and richness from seismic and EM would assist exploitation in high-grade areas of the Southern Margin and reduce potential risks. Further investment would help bring this technology to the stage where companies are likely to adopt it.
- Research into more sophisticated basin analyses is urgently needed to refine the estimates of undiscovered resource potential for all Australian basins. South Australia is the only State that has put significant effort into this area in recent years. There are now many advanced technologies that could be brought to bear, including those from CSIRO and organisations in Canada and China. This work is not currently supported in Australia. It is not sufficient to rely on United States Geological Survey estimates of four of the more mature Australian basins.

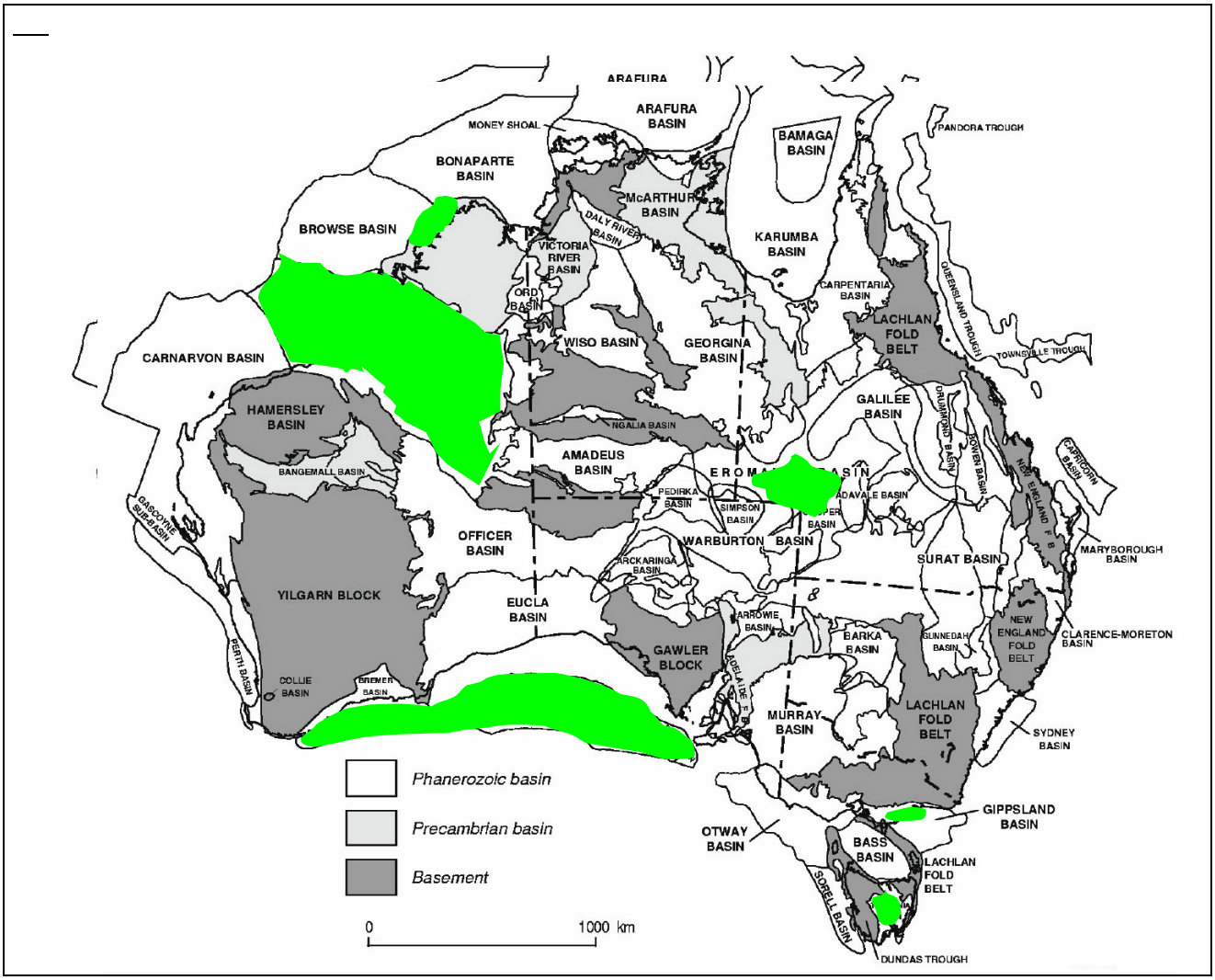

Figure 6: Australian basins where there exist the potential for significant new oil reserves (marked in green)

Brownfield Exploration

In more mature basins, where many drill holes and producing fields exist, smaller fields become commercially viable close to existing infrastructure. Encouraging exploration for such fields is worthwhile for several reasons:

1. as production from the initial large fields plateau, there exists spare capacity in production facilities and pipelines that can be filled by new discoveries close to infrastructure;
2. decommissioning infrastructure is delayed;
3. local geological knowledge from existing field development is utilised before the teams disperse;
4. the technical challenges are different to those in frontier areas, often large seismic and well data-sets exist but of varying quality and vintage. Resources are necessary to re-evaluate and re-process 30 year-old data;
5. new stratigraphic understanding needs to be added to re-processed data and, as the targets are often smaller and less obvious than the original field image, more sophisticated analyses are necessary;
6. more research is needed into hydrodynamic variation in mature basins caused by drawdown from the main fields and pressure maintenance in satellite fields;
7. many satellite fields discovered in brownfield exploration are stratigraphic traps which require more sophisticated seismic processing and interpretation. Investment in such technologies is likely to benefit the community at large.

Improved oil recovery technology

The estimates of 'proven and probable' oil in place presented above assume varying (often unspecified) recovery efficiencies. Oil companies typically expect to extract less than 40% of the oil originally in place in Australian reservoirs. The Norwegian government has initiated a $1.5 billion research and development programme involving oil companies, research institutes, universities and service companies, with the aim of increasing recovery percentages in Norwegian fields to 70%, nearly doubling reserves in existing fields. Such an 'Improved Oil Recovery' (IOR) programme is recognised as having enormous advantages for the state apart from the prolonged revenue stream. An Australian-funded IOR research programme linked to this effort, but addressing Australian issues, would have the possibility not only of prolonging the revenue stream to the state and companies, but also helping to secure indigenous transport fuel supplies. The technologies developed by such a programme for Australian reservoirs may also be applied elsewhere and form the basis of new service industries.

Microbially Enhanced Oil Recovery

This technology has the potential to not only make oil fields with heavier or more bio-degraded oil more commercially attractive, but also to address by-passed pay in fields with lighter oil. Finding bacteria adapted for Australian field conditions, developing efficient utilisation strategies, and supporting deployment are all technically challenging issues, and beyond the short-term interest of most oil companies operating in Australia. Expanded investment in this area of research could have benefits for the exploitation of many reservoirs.

Potential Alternative Transport Fuels

Biofuels

The Australian Government Biofuels Taskforce in August 2005 supported the 350 million litre (ML) target for ethanol by 2010. After several years of debate about the pros and cons of ethanol, this is considered to be a significant advancement towards an alternative to total dependence on oil. Investigation of environmental, economic and social considerations would be highly beneficial in developing this source of alternative transport fuel. For example, there have been community concerns in the past about potential damage by ethanol of car engines (and voiding of warranties), which need to be addressed in order for this alternative fuel source to gain wide acceptance. Information on the website of the Federal Chamber of Automotive Industries has gone some way to alleviating this concern. Nevertheless, an analysis of community attitudes could be of some value.

It is worth noting that 350 ML is less than one percent of Australia's oil consumption, which is unlikely to significantly affect the overall Australian reliance on oil as a transport fuel. The proposal is to use ethanol to mix with unleaded petrol (ULP) on a 1:10 basis, known as E10. It is considered, that if E10 is to be made acceptable to the majority of motorists, there should be an opportunity for significantly more ethanol to be available. Given this, a plan for increasing ethanol production beyond 350 ML, could have some benefits.

The Biofuels Taskforce also examined biodiesel. Australia is likely to produce 500 ML of biodiesel by 2007, representing less than 4% of Australia's diesel production. Innovative schemes for the production of biofuels (both ethanol and biodiesel) would greatly assist the development of the biofuel industry beyond supplying niche fuel additives through a series of small and fragmented operations. Australia has one of the world's highest ratios of land area to population. Research is needed to ascertain what crops are most suitable for use as feedstock for biofuels and whether crops grown for biofuels could contribute to solving Australia's salinity problems.

CSIRO recognises the potential for biomass based transport fuels to contribute to Australia's future transport fuels mix, but also recognises that the ultimate significance of this contribution remains subject to considerable uncertainty in economic, environmental and technological terms. Where it has appropriate expertise, CSIRO is seeking to develop and deploy scientific knowledge to help address these uncertainties – often in partnership with other government or industry initiatives. Examples of specific recent and current activities include:

- CSIRO's participation in the "350ML Biofuels" report in 2003 (with ABARE and BTRE);
- CSIRO's participation in the PM's Biofuels Taskforce in 2005;
- Conduct of environmental assessments (greenhouse gas and energy balance) for various industry based biofuel proposals;
- Assessment of biofuel impacts on air quality (limited studies to date, but proposals are before government agencies to expand this work in line with the recommendations of PM's Biofuels Taskforce);
- Exploring options for alternative biomass feedstocks (e.g., maize, sweet sorghum) to complement sugar or grain industry based ethanol production;
- Broad scale analyses of the potential for biofuels to be produced from woody biomass with associated benefits in terms of dryland salinity control / remediation;
- Re-optimisation of sugar industry harvesting and transport operations in relation to proposed ethanol and/or electricity co-generation activities.

Looking forward, CSIRO's Energy Transformed Flagship is currently engaged in a scoping study to identify the R&D likely to be needed to underpin Australia's future transport fuel needs. Biofuels will be included in

this scoping study, due for completion mid 2006 and the results will be important in shaping future CSIRO investment.

Alternative Liquid Fuels - Gas to Liquid (GtL) and Coal to Liquid (CtL)

The process of creating synthetic liquid fuels involves the conversion of feedstock to a mixture of carbon monoxide and hydrogen (syngas) which can be further processed to form synfuel – mainly diesel. A range of feedstock can be gasified to form syngas, with natural gas and coal being discussed widely. Gasification of biomass is also being considered as a possibility.

The production of synfuel from natural gas now appears to be economic – at least in places where the price of natural gas is low. Thus, for example, several plants are being constructed in Qatar (where the gas price is reputed to be US$ 0.5/Gj) and will be on line in 2006. These plants are large and located on-shore. Roughly 600 million scf of gas is converted to 70-75,000 barrel per day.

The experience gained in building and operating these plants is expected to lead to significant decreases in capital expenditure and the annual costs of operation. Conventional wisdom, based on estimates from a few years ago, is that GtL would become economic when oil prices reach US$32/barrel. However,Australia can do little at present to improve this process. Work would be required on an industrial scale to compete, with competition from several large companies that have a significant experience in this area.

Although Australia has large reserves of natural gas, most of the fields are off-shore and the gas is considered 'stranded'. This broad definition covers gas that cannot be brought ashore economically using present technology. If such gas could be converted into a product that could easily be brought ashore, the economic benefits would be significant.

At the same time Australia and several other countries have off-shore hydrocarbon reserves that involve both oil and gas. Associated gas cannot be flared and must be re-injected into the well – at significant capital and operational expenditure. There would be immediate advantages to convert the gas into a fuel that could be brought ashore with the oil.

The difficulty with such conversions lies with size. It may be possible to use conventional GtL technology but the footprint of the plant and associated processes is very large indeed. What is needed is a smaller simplified plant that can convert the gas.

One possibility is the conversion of gas to methanol (BHP built a pilot plant to check feasibility). However, the demand for methanol and the large alternative sources in the Caribbean do not allow satisfactory economics.

As a result, CSIRO has been investigating smaller more flexible gas to liquid conversion and we are developing a new process based on methane pyrolysis. With the advantages of smaller footprint and production of synthetic gasoline rather than diesel, the process has unique advantages in Australia, and offers excellent prospects for associated gas across the world.

The situation with the production of synfuel from coal (CtL) is a somewhat different. The key issue here is, . compared to natural gas, the process produces more greenhouse gas emissions., However, the reserves of coal are much larger than the reserves of gas, particularly in America. It seems highly probable that CtL processes will be optimised in America. In this case, the research needs must be focused on adjusting processes to meet the use of Australian coals. CSIRO is already active in this field, working with coal gasification and clean up of syngas prepared from Australian coals. Once syngas is produced and cleaned, the conversion to synfuel will follow the same line as GtL. As a result, additional in-depth research is unlikely to be required.

LPG and others

Australia is the largest per capita user of transport Liquefied Petroleum Gas (LPG) . LPG can be sourced from petroleum refining and from natural gas processing. Current use of LPG is 3 million tons a year - 80% from natural gas, 20% from refineries. LPG from refineries in Australia is unlikely to increase unless there is a marked increase in the size of refineries. This is unlikely to happen while we can import fuel from places like Singapore, as at present. If the Australian oil supply becomes more scarce, then it will be more difficult to source LPG from oil. Thus one would need to look to the gas fields to produce LPG. However, the difficulty with this is that the supply of LPG from gas fields depends on how "wet" or "dry" the gas is. It is possible to estimate present LPG reserves, but not what they would be in the future.

Very little is known about the possibilities of methanol and its derivatives as possible Australian alternative transport fuels. It is known that dimethyl ether prepared from methanol is an excellent diesel replacement fuel, but will require a distribution network and special storage tanks on vehicles, rather similar to LPG tanks. Methanol itself is not popular in the community. The energy density is low and there is no distribution network. Nevertheless, methanol is an attractive feedstock for fuel cell vehicles.

Conclusions

- Australia is likely to rely on oil as its principal transport fuel for the foreseeable future, although security and reliability of supply are of growing concern particularly in the context of increasing world reliance on the Middle East for oil and the growing demand from developing economies such as China, and India.
- The ability of Australia to purchase any short-fall in indigenous liquid hydrocarbons could be threatened if countries (e.g. USA, China) lock-in supplies with long-term contracts. A potential option is to develop strategic relationships with countries with excess capacity where Australian technology can contribute to exploration, appraisal and development in return for long-term supply guarantees.
- Australian refining capacity will be insufficient to handle the anticipated growth in demand by 2012. There is, therefore, a need to investigate alternatives to conventional onshore refining.
- Australian oil reserves are under-explored. There is a need for ongoing assessment of Australia's oil prospects (especially in frontier basins), improved exploration techniques, and maximising recoveries from existing fields. All of these have a significant R&D dimension unique to Australia, which CSIRO is addressing.
- In addition to further oil exploration and research, there is a strong need to investigate alternative transport fuels including natural gas, biofuels, conversion of coal to liquids, and hydrogen.
- Research is also needed into a techniques for reducing Australian transport fuel demand.
- Australia's rich endowment in natural gas provides enormous opportunity to supplement declining indigenous oil reserves with liquid fuels derived from gas condensate in the short term as well as from gas to liquids (GtL).
- Important opportunities for Australian GtL R&D exist in niche areas such as offshore supplies. CSIRO has work in progress.
- Conversion of coal to liquids (CtL) is also being investigated as an alternative fuel source (in the medium term). R&D is required to optimise this for Australian coals.
- Both GtL and CtL processing will produce significant increase in greenhouse gas emissions, which will require mitigation by methods such as gas sequestration. CSIRO is a research leader in this area.
- Biofuels currently represent less than 0.5% of the transport fuel mix, but could potentially represent a more significant fraction. Feasibility studies in terms of the potential for increased production and adoption as well as possible impacts on the environment, the Australian economy and world commodity markets are needed. CSIRO has research in progress.
- Substantial levels of biofuel production in Australia (i.e. greater than 2-5% of transport fuel usage) would be increasingly viable given some combination of the following:
  - oil supplies are strongly restricted and/or prices remain above US$60 in the long term;
  - world grain and sugar markets remain oversupplied with depressed prices; and
  - technological advances further reduce the cost and raise the efficiency of the biofuel production process (in particular technology associated with ligno-cellulose to ethanol/methanol conversion).
- Hydrogen is a possible long-term candidate as an alternative transport fuel source. However, a low greenhouse emissions source is required, and there are issues with distribution and storage within vehicles.. R&D to solve these issues is being actively pursued in Australia and overseas.

- An approximate timetable can be anticipated:

  Crude oil derived fuels – continued importance but decreasing in relative terms from ca 2020

  GtL 2015 – 2050

  CtL 2015 - 2100

  Alternatives – 2020 onward (Biofuels may have an earlier start)

Recommendations

We recommend that the Commonwealth Government, in partnership with State Governments, industry and research bodies such as CSIRO, address the issue of Australia's future oil supply and alternative transport fuels by investing in and developing the following areas.

1. Improve the perception of Australia's prospectivity for oil and gas in order to encourage national and international investment. This should include developing new appropriate technologies for evaluating undiscovered resource potential as well as ensuring adequate pre-competitive data provision in deeper waters.
2. Encourage industry to explore in Australia rather than overseas, and maximise the extraction of oil from existing fields, by:
   a. investing in R&D into improved frontier and brownfield exploration technologies to improve direct identification of oil in the subsurface (as discussed in the body of the paper);
   b. investing in R&D to improve production and recovery technologies.
3. Encourage the development of a future supply of alternative fuels through investment in R&D into the various technical issues concerning the future supply of alternative fuels. This may include:
   c. Gas to liquids – developing opportunities for Australia through R&D in niche areas such as offshore supplies, as well as addressing issues of greenhouse gas emissions.
   d. Coal to liquids - developing opportunities for Australia through R&D focussing on the exploitation of our unique and vast coal reserves, as well as addressing issues of greenhouse gas emissions.
   e. Biofuels – investigating the potential for increased production and adoption, and possible impacts on the environment, the Australian economy and world commodity.
   f. Hydrogen – identifying a low greenhouse emissions source, and developing technologies to address current issues with distribution and storage within vehicles.
4. In parallel with the supply-side R&D, invest in R&D into the social, economic and technical drivers for transport fuel demand and identifying viable strategies for demand reduction.