**SENATE RURAL AND REGIONAL AFFAIRS**
**AND TRANSPORT COMMITTEE**

# INQUIRY INTO AUSTRALIA'S FUTURE OIL SUPPLY AND ALTERNATIVE TRANSPORT FUELS

**SUBMISSION BY**

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**PERSONAL BACKGROUND**

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**Associate, Institute of Sustainability & Technology Policy**
**Murdoch University W.A.**

Brian is an executive member of the Australian Association for the Study of Peak Oil founded in 2005.

He is a member of the Board of International Advisers to the Oil Depletion Analysis Centre (ODAC), a branch of the London-based Association for the Study of Peak Oil and Gas (ASPO).

He was a member of the WA Minister for Planning and Infrastructure's Transport Energy Strategy Committee in 2003-04.

He is a member of the Sustainable Transport Coalition of W.A. that has a major focus on oil supply futures, transport and land use planning.

He worked for the Water Authority of W.A. and its predecessors for 34 years until his retirement in 1993.

He completed his career managing the operation and maintenance of Perth's water sources, both surface and groundwater.

During the 1980s he represented the Water Authority on national committees on water quality issues and for 8 years was a member of the National Health and Medical Research Council's Water Quality Committee.

His family has been farming in the Avon Valley east of Perth since the early 1830s.

In the late 1970s he was inspired by the work of Nicholas Georgescu-Roegen and Howard T. Odum on economics, environment and energy, with a focus on petroleum issues. Thereafter he widened his understanding of ecological economics and related issues, complemented by his employment in the water industry that was confronting conditions where water resource and environmental constraints to its operations became its central focus.

On retirement he took these issues up publicly and in 1995 wrote a book, *The Decline of the Age of Oil.* He has campaigned on these issues ever since.

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## SUMMARY AND RECOMMENDATIONS

*It is certain that cheap and available oil will become more and more scarce as the demand for it grows. It is also certain that the cost of preparing too early is nowhere near the cost of not being ready on time.*

Alannah MacTiernan, W.A. Minister for Planning and Infrastructure, in her speech opening the W.A. Sustainable Transport Coalition's "Oil: Living With Less" Conference, August 2004

### Section 1. Introduction

*Cheap petroleum products dominate transport fuels and there are no alternatives emerging* to match their performance, including remaining petroleum products. The long-term response must be to progressively reduce the role of contemporary transport, reversing 200 years of development. This structural change will take TIME and the sooner we start adapting the better.

The pioneering work on all-inclusive *community and stakeholder dialogue* to find solutions to complex problems and used in the Department of Planning and Infrastructure in Western Australia gives a lead that needs extending and developing everywhere.

**Recommendation:** *Processes for inclusive community and stakeholder dialogue based on democratic participation with attention to social justice* ***are essential*** *for a successful transition to a world 'beyond oil'.*

### Section 3. Energy Quality and Economics

*A dialogue is urgently needed* between neo classical economics and ecological economics to give energy its due place in the discipline. There is an urgent need for studies to determine and make public the embodied energy in goods and services, including for energy sources themselves, their energy profit ratio. *A dialogue to raise the standard of such studies is needed.* Such information is vital to make the right choices for the future.

**Recommendation:** *That research is promoted to assess the embodied energy in important goods and services in Australia, and the energy profit ratios of energy sources with the results made public.*

### Section 4. World Oil

*The "pessimists", such as the Association for the Study of Peak Oil, are winning the debate* on the timing of peak oil production against the "optimists"—more strictly a plateau. Production comes from ageing giant oilfields and exceeds the discovery rate. New discovery is limited and in hostile, expensive and politically unstable locations. Production outside the former Soviet Union (FSU) and the Middle East has plateaued. Russia has reached the limits of oil export capacity that limits its future. Published reserve data and performance lacks transparency and cannot be trusted, especially in the FSU and Middle East. It is a source of market uncertainty.

**Recommendation:** *That Australia require mandatory transparent reporting by companies of field-by-field reserves and production data, and subject these to public audit for original oil-in-place, the ultimate recoverable and cumulative production.*

Such a requirement is unlikely to cause too much difficulty for companies operating in Australia. But it will set an example for the world to emulate.

### Section 5. World Natural Gas

*Natural gas production is in decline in North America and imminent in Europe—46 per cent of world consumption*. UK production is in rapid decline. *See Appendix 3.* Russia and the Middle East dominate reserves*. Due to the high cost of transporting natural there will be a series of regional natural gas peaks rather than a world peak*. A boom in LNG development for export is occurring. *Natural gas prices will rise.*

**Recommendation:** *That more attention needs to be given to the long-term economic risks of exporting LNG to the USA and its ability to pay for these given the acute supply crises occuring in both US oil and gas.*

### Section 6. Australian Oil and Gas

Australian oil production comes from declining small fields with future discovery uncertain and may be mostly from deep water offshore. Imports are increasing and vulnerable to disruption for a small player like Australia. Natural gas is more plentiful, but most is offshore from the

North West coast and distant from local markets. But it can be a potential transition transport fuel for a much less transport intensive future. Little attention is being given to this role.

**Recommendation:** *That a 30-year strategy for domestic Australian oil and natural gas supply be developed focusing on a priority role for natural gas as a transport fuel as against other uses and export as LNG. To be concurrent with similar demand management strategies—see further recommendations below. To be reviewed every five years.*

**Recommendation:** *That royalties and tax concessions for the upstream oil and gas industry be reviewed. Any further tax concessions and subsidies to the industry to have a lower priority than introduction of demand management initiatives to reduce consumption of oil and gas as these will be of more immediate benefit.*

## Section 7. Effectiveness of Transport Fuels

*There are no transport fuels in sight that can replace petroleum products* as we now use them. Therefore the prime response to 'peak oil' must be demand management—to reduce the scale and extent of fuel driven transport at all levels from the local to the global. *This will take several decades to achieve.* This must have immediate high priority regardless of when the global peak of world oil production is expected to occur. Biofuels such as ethanol and biodiesel cannot replace petrol and diesel on any scale because of supply conflicts with grain for food. The present World Trade Organisation (WTO) strategy on trade implies the endless growth of cheap transport, an era about to end.

**Recommendation:** *That a 30-year broadly based transport demand management strategy be prepared for petroleum-based transport fuels to reduce their consumption at a rate consistent with the likely declining availability of these fuels.*

**Recommendation:** *That biofuels for transport should not be promoted or subsidised except possibly for biodiesel on a limited farm scale for local use.*

**Recommendation:** *Explore using LNG as a transition fuel for trucks and locomotives in lieu of diesel. The alternative of gas-to-liquids is likely to have an inferior net energy yield.*

**Recommendation:** *The WTO strategic direction on free trade is becoming obsolete. Australia should promote reform to reverse the strategy towards a transition that focuses on greater local production of goods and services and reduced long-distance trade*.

## Section 8: Agriculture and the Food Chain

*Modern agriculture is the use of land to convert petroleum into food*, a description that particularly applies to Australia with its poor soils and rainfall. *The first priority for remaining cheap oil and gas must be for food production while a sustained effort is made to reduce world population to levels not dependent on these fuels.* The major energy inputs to the food chain occur post-farms, with significant inputs for transport, processing, packaging and retail.

**Recommendation:** *Governments should sponsor NOW embodied energy studies of the food chain from farm inputs to homes so that the priority areas for reducing energy inputs can be defined for energy demand management. A high priority is likely to be reducing and even eliminating the need for car travel to and from large centralised super markets.*

**Recommendation:** *In the transition period such localisation strategies for the food chain must be balanced against maintaining appropriate food exports until the countries and regions absolutely dependent on food imports have reduced their populations to levels of sustainable food self-sufficiency.*

**Recommendation:** These strategies should incorporate revitalisation of rural and local communities and the tackling of land degradation.

## Section 9. Road and Rail Transport

*Car-dependence has increased personal travel costs* in our cities at the expense of much cheaper public transport, cycling and walking. Crash, pollution and congestion costs are huge. The provision of other services suffers as a consequence. Urban sprawl is promoted that separates residences from workplaces forcing long commuter journeys, especially in the outer suburbs where public transport is poor. Funding from taxes favours roads. Local production can reduce the need for freight transport that also needs to shift to more energy efficient rail as far as possible. Road freight does not cover the cost of 'externalities'. Perverse taxes and charges reinforce these impacts.

**Recommendation:** *Cease funding of freeways and road tunnels in cities and restructure financing to give priority to public transport walking and cycling built around core electric rail transit.*

**Recommendation:** *Integrate land use planning with transport with a focus on quality higher density development and good services, minimising oil dependence, localising employment and enhancing urban living.*

**Recommendation:** *Require transport impact studies for ALL significant developments to reduce petroleum fuel consumption that keeps pace with declining oil supply*.

**Recommendation:** *Use democratic dialogue processes as outlined in Section 1 to implement these strategies, including where job changes occur due to reduced car use*.

**Recommendation**: *Concurrently, with dialogue processes, review perverse tax and charges regimes that work against the above reform strategies and progressively implement reforms to consistently reinforce the new direction.*

## Section 10. China and India

*China, and to a lesser extent India*, are undergoing unprecedented urban and industrial development, including cars. *China is the main driver of oil consumption growth*. Chinese demand for minerals is responsible for the commodities-driven economic boom in Australia. This development in China is at the expense of agricultural land that is compromising grain production. Water shortages are aggravating the situation. *Soon China may be forced to import grain at a rate the world cannot meet.* The Western industrial economic model is not an option for China. There are serious consequences for Australia not being addressed by governments, business and economists.

**Recommendation:** *Governments and the community must investigate urgently the unsustainable nature of Chinese and Indian economic development and enter into a dialogue on the consequences and how to respond.*

## Section 11. Greenhouse Gas Emissions and Climate Change

The Australian Bureau of Agricultural and Resource Economics (ABARE) released a report in January 2006 for the inaugural meeting of the Asia Pacific Partnership on Clean Development and Climate (APPCDC) responding to the six countries growing emissions of Greenhouse gases. The report projected these countries business-as-usual fossil fuel scenarios to 2050 as well as reduced ones for demand management and sequestering of carbon dioxide. *ABARE did not address AT ALL the issue of the impending decline in world oil production, or other resource constraints.* Under the best scenario all six countries significantly increased their oil consumption to 2050 that implied world consumption in 2050 two and a half times that predicted by the Association for the Study of Peak Oil and Gas (ASPO).

**Recommendation:** *That all governments insist that reports make informed reference to the debate on the imminent peaking of oil production where the subject is relevant to the report.*

The Intergovernmental Panel on Climate Change (IPCC) published in 2000 an update of its 40 scenarios for fossil fuel production from 1990 to 2100. These scenarios are the basis for projections of possible greenhouse gas emissions from burning fossil fuels under a range of circumstances. For oil and gas these range from five times current use in 2100 to near zero. *The IPCC does not attach probabilities to these scenarios.* The ASPO estimates for oil and gas are based on probability estimates and are at the bottom of the IPCC scenarios. IPCC is currently reviewing its scenario package through 2007 and will include a discussion on their probabilities.

**Recommendation:** *That the Federal government initiate a public critique of the 40 IPCC scenario probabilities as part of the current IPCC scenario review.*

**Recommendation:** *That strategies responding to anthropomorphic climate change from fossil fuel consumption be merged with those responding to the impending decline in oil production.*

**Senate Rural and Regional Affairs and Transport Committee**

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## 1. INTRODUCTION

**Ride the Whirlpool**

*"I have seized on the metaphor of the boat in the whirlpool to emphasise the point that the chaos into which we are moving is a natural thing, far more natural than linear stability and order. We ride the whirlpool in many forms in nature, and we evolve personally and socially to do so. The individuals and organisations that will be successful in this will be the ones that unleash the creative genius of their people. This is the essence of modern leadership."*

Lieutenant General Dr John Sanderson, AC ex-Governor of Western Australia
on his choice of name for the book of his speeches while Governor, *UWA Press 2005.*

The decline of cheap oil will be the climax of the fossil fuel age, given the role of petroleum and petrochemicals in our civilisation. It is the greatest adaptive challenge that *homosapiens* has ever faced. Everyone will undergo a cultural transformation, have to make major concessions and give up old ways of living for new ones in an incredibly short time frame. The experience will appear to be chaotic with perpetual change. But as our ex-Governor says this is a natural thing and can be a powerful and creative experience with the right leadership.

Positive change can only occur rapidly *if everyone* can participate in an informed way and respect the views of others, be confident that there is all-round fairness, and if government and other authorities are genuinely committed to embracing the outcomes of the process. The magnitude, multiplicity and complexity of the changes means no one can know in advance what a satisfactory outcome will be—an important conclusion from complex system theory. Satisfactory outcomes can only emerge through active democratic participation that weaves citizens more deeply into decision-making. Participative democratic processes are essential for success.

This approach has been successfully used in Western Australia by the Department of Planning and Infrastructure on the initiative of the Minister, Alannah Mactiernan, to progress a range of complex planning and transport issues, including ones where there are many conflicting interests. The following principles apply:

- Government must genuinely listen to divergent voices.
- Stakeholders are to listen to others in the same way.
- Governments must ensure the engagement is reflective of the community—that the aspirations of special interest groups are calibrated against a broad cross section of the community.
- Governments to be open with the process of engagement and with its sharing of information.
- Governments to be genuinely committed to embracing the outcomes of the process.
- Establish continuous feedback links with participants to ensure the broader community stays engaged.
- Leadership must reflect and implement these principles.

This process has been successfully used in Western Australia at local and regional levels and in the lead up to the *Network City* plan for the Perth Region (**WAPC 2004)**. A highlight was the *Dialogue with the City Forum* in 2003 where 1,400 people participated in an interactive forum, eight people at a table each with a facilitator for face-to-face deliberation and a networked computer. The computers enabled common themes to be collected and broadcast to the forum in real time. The outcome provided the basis for the development of the draft *Network City* Plan in 2004. A more comprehensive exposition on the principles involved is in the book *Gaian Democracies* **(Madron & Jopling 2003).**

The process fosters attitudes of cooperating for the common good, while retaining the beneficial sides of competition. Cooperation and competition processes in human affairs complement each other. They are not mutually exclusive.

**Developed further, this pioneering approach can be a powerful tool for coping with the changes arising from declining oil supply, indeed the only way.**

Finding out what the problems are and how they interact, what options there are, what needs to be 'done' and how to do it can only arise from such participatory processes. The Recommendations in my submission will have few specific 'solutions' to issues raised, rather they will point to broad issues that need addressing in the way described above. Many of the problem areas have already been analysed and described in great detail, there is already a great deal of factual information.

## 2. SUBMISSION STRUCTURE

The submission will cover a wide arrange of topics with some of the more important issues explained in depth in eight Appendices. This will enable readers to cover the issues briefly and grasp the essence of the arguments without being submerged in too much detail.

**The submission will address the following issues.**

- The necessity for inclusive, democratic and socially just practices for implementing adaptation and change strategies, with an emphasis on the need to simultaneously integrate cooperation and competition—as discussed above.
- Outline an ecological economics critique of economics focusing on the energy cost of producing energy as a central theme. Introducing the concept of energy profit ratio.
- Outline the position of the Association for Peak Oil and Gas (ASPO) on the future of oil production and compare its views with the position of one more optimistic viewpoint.
- Discuss the imminent peaking of North American and European natural gas production.
- Outline the Australian position on oil and natural gas supply in this global context.
- Compare transport fuel options from an ecological economics viewpoint, concluding that the scope for alternative fuels to match the performance of petroleum products are limited.
- *Industrial agriculture is a way of converting petroleum into food*—the food chain and population issues.
- The consequences for urban areas and development and the need for reform of transport infrastructure financing, the tax system and current government subsidies.
- China's urban/industrial development is at the expense of agricultural land and grain production. It is unsustainable in the near term. Implications for Australia and the world.
- Outline the need to merge policies responding to the peaking of cheap oil and climate change arising from human-induced greenhouse gas emissions. Critiques of ABARE's report 06-1 for the Asia Pacific Partnership on Clean Development and Climate, and of the Intergovernmental Panel on Climate Change scenarios for oil and natural gas consumption to 2100.

## 3. ENERGY QUALITY AND ECONOMIC EFFECTIVENESS

**Neo classical economics** regards energy as *'just another commodity'.* By contrast energy occupies a central place in the more recent discipline of ecological economics. Economic systems theory must be consistent with the first and second laws thermodynamics[1]. Appendix 1 (14 p.) discusses the relevant issues—these are summarised below.

- *The 'economy' is a sub-system embedded in the environment* and draws high quality material and energy sustenance from it, discharging wastes and low quality energy to the environment. Energy cannot be recycled—a consequence arising from the second law of thermodynamics.
- *Energy drives the energy industry*. Some commercial energy must be used to extract and convert energy sources from nature into useful forms. *The critical issue is 'how much'.* Energy Profit Ratio (EPR) is one measure of energy quality and a pivotal index for assessing the economic performance of fuels. Both the direct and indirect energy inputs embodied in goods and services must be included in the denominator.

$$EPR = \frac{\text{energy output}}{\text{energy input}}$$

- *Energy sources have different qualities* that affect their usefulness and economic performance, as measured by gross domestic product per unit energy input (GDP/E). We are never likely to have coal-fired aeroplanes. GDP is a deficient index of welfare.
- *The different end-uses of energy sources* also affect their quality and contribution to GDP/E. In the USA oil is 1.6 to 2.7 times more effective economically than the direct use of coal, and electricity 2.7 to 14.3 more effective. Similar relations apply for Europe and Japan.
- For the USA 72 per cent of the increase in the GDP/E ratio since 1920 can be explained by change of fuel type—the shift to oil and electricity. Another 24 per cent can be explained by changes in direct use of energy by households—fuel for vehicles and heating.
- *Technology development* is about using energy sources effectively—and consumes energy in the process.
- *Government, financial and other services* are significant users of commercial energy.
- *Given these factors* there are direct but complex relations between energy consumption, money, economic activity and inflation, and the quality, availability and types of energy.

Most of the world's oil production is refined into petroleum products for transport. In this role it is superior to any alternative fuels and has mostly had a particularly high EPR. Remaining oil production will have reduced economic performance as the best deposits from the past are depleted and the cost of discovery and extraction increases in both dollar and energy terms. Alternative transport fuels cannot match the historical performance of petroleum products.

*Figure 1* shows the variation in EPR for Louisiana USA oil and natural gas over the production life cycle. Note that the highest EPR's occur in the middle of the production cycle. In the early years both the volume and economic effectiveness of the output is expanding. In the final years the reverse is the case. Similar relationships would apply for other petroleum provinces, but not necessarily the simple profile for Louisiana. *This relationship should be borne in mind in the subsequent discussion below.*

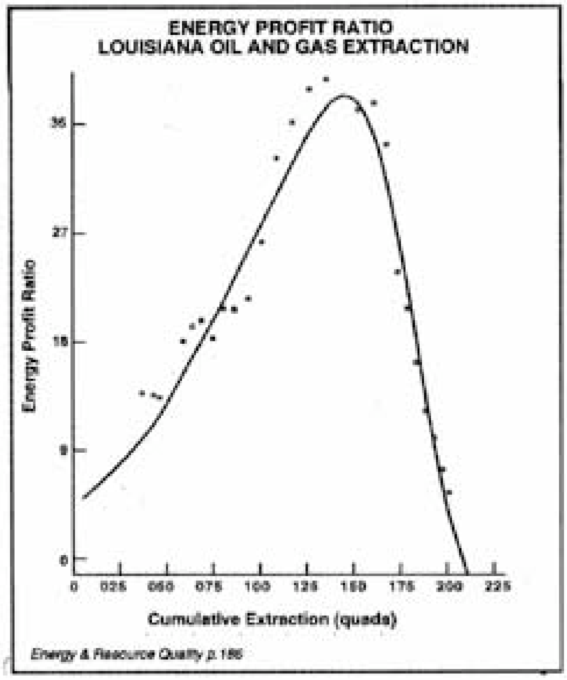
## 4. IS WORLD OIL PRODUCTION ABOUT TO PEAK?

This topic raises its head periodically. Surging consumption over the last three years, driven mainly by China, has caused demand to press against supply for the first time since the 1970s, forcing up oil prices. Debate on the timing of peak oil production has gathered pace since the mid-1990s, initiated mainly by the work of two retired petroleum geologists, Colin Campbell and

[1] The first law of thermodynamics says energy can neither be created nor destroyed but may be transformed from one state to another. The second law says: without compensating change elsewhere, heat can only flow from a hotter body to a colder body, introducing the concept of irreversible processes

Jean Laherrére. In the 1990s they had privileged access to Geneva-based Petroconsultants' extensive database on oilfield exploration, development and performance in the 1990s, the only one for countries outside of North America. Their initial work was published by Petroconsultants, and subsequently in many books, magazines and industry journals.

**Figure 1**
**Louisiana USA EPR Profile**




By 2001 rising interest led to the formation of the mainly European-based Association for the Study of Peak Oil and Gas (ASPO) and comprised petroleum industry professionals, academics and other interested people, including Campbell and Laherrére. In late 2001 ASPO formed its research arm, the Oil Depletion Analysis Centre (ODAC), and has held annual conferences since 2002. It publishes a monthly Newsletter and its members are extensively involved in conferences, media and publicity on peak oil (**ASPO 2005).**

People often ask; *"are we running out of oil".* This is the wrong question. In the absence of political and other disturbing factors, production from petroleum provinces rises to a peak and then declines as continued oil extraction becomes progressively more difficult. In these circumstances the peak usually occurs when about half the ultimately extractable oil has been produced. The crucial question is; *"when is production going to peak and decline begin".* Ultimately production ceases when it is no longer economic to continue pumping—but there will still be large amounts of oil left in the oilfields. Some heavy viscous oil and that derived from solid hydrocarbons, such as Canadian tar sands, have different production profiles.

ASPO is the leading *'pessimist'* school—holding that the world peak may only be 5-10 years away. There are *'optimists'* who say this may be 20-30 years away. I will outline the essential features of the ASPO school and their rationale, and describe key differences with the 'optimist' school and why I think this perspective is not valid.

## 4.1 The ASPO viewpoint

Below is a summary of the ASPO model for past and expected future oil discovery and production, (**ASPO 2005).** ASPO defines *regular oil* as the majority of oil that is produced easily and relatively cheaply from oil fields in favourable locations. *Non-regular* oil comes from a variety of difficult-to-produce and expensive sources such as heavy oil (very viscous and solid hydrocarbons), from deep water offshore, in polar regions (e.g. Alaska), as well as liquids extracted from natural gas (NGL). *Table 1 shows ASPO's past and expected future production for regular and non-regular oil.*

Table 2 shows ASPO's expected production rate in million barrels per day for the major *regular oil* producing regions to 2050, plus expected ultimate production in gigabarrels, and as well for the categories of *non-regular oil*. ASPO's expectations for the peak years are shown.

**Table 1**
**ASPO Future Production by Category**
**Gigabarrels Gb**

| **Regular Oil Gb** | | | | |
|---|---|---|---|---|
| | **To 2004** | **Future** | | **Total** |
| | Known Fields | | New | |
| | | 758 | 123 | |
| | **968** | **882** | | **1850** |
| **Non-Regular Oil Gb** | | | | |
| Heavy Oil | | | | 151 |
| Deep Water | | | | 69 |
| Polar | | | | 52 |
| NGL | | | | 276 |
| **Total** | **106** | **444** | | **550** |
| **All Liquids Gb** | | | | |
| **Total** | **1074** | **1326** | | **2400** |

**Table 2**
**ASPO Future Production 2005 to 2050**
**Million barrels/day and Gigabarrels**

| **Regular Oil** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Region** | **2005** | **2010** | **2015** | **2020** | **2050** | **Total Gb** | **Peak Year** |
| US-48 | 3.6 | 2.8 | 2.2 | 1.7 | 0.4 | 200 | 1971 |
| Europe | 5.2 | 3.6 | 2.5 | 1.7 | 0.2 | 75 | 2000 |
| Russia | 9.2 | 8.4 | 6.8 | 5.5 | 1.5 | 220 | 1987 |
| M.E.Gulf | 20 | 20 | 20 | 20 | 11 | 680 | 1974 |
| Other | 29 | 26 | 22 | 18 | 7 | 675 | 2005 |
| **World** | **67** | **61** | **54** | **47** | **21** | **1850** | **2005** |
| **Non-Regular Oil** | | | | | | | |
| Heavy Oil | 2.3 | 3 | 4 | 4 | 4 | 151 | 2021 |
| Deepwater | 3.6 | 12 | 11 | 6 | 4 | 69 | 2011 |
| Polar | 0.9 | 1 | 1 | 2 | 0 | 52 | 2030 |
| NGL | 6.9 | 9 | 9 | 10 | 8 | 276 | 2035 |
| **Total** | **13.7** | **25** | **25** | **22** | **16** | **550** | |
| **TOTAL** | **81** | **86** | **80** | **70** | **35** | **2400** | **2010** |

*Figure 2* shows the existing ASPO production profiles to 2004 and those projected to 2050 for its categories of regular and non-regular oil and natural gas liquids.

*A few giant oilfields dominate.* There are over 10,000 producing oilfields in the world. However, a small number of giants have always dominated supply with 116 giants producing 48 per cent of world production[2]. Of these, 16 produce 21 per cent and four 11 per cent **(Simmons 2001).**

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2 Giant oil fields are those producing over 100,000 barrels/day, or sometimes regarded as those with 500,000 barrels of extractable oil on discovery.

They are usually found first because they are large, easy to find, and produce the cheapest oil. They have long lives, 40-50 years and more. Many are ageing and already in decline.

*Figure 3* is from a paper by **Longwell (2002),** Executive Vice President of Exxon-Mobil. It shows the discovery and production profiles for oil and gas from 1900 to 2000 and his consumption projections to 2020—the latter conditional on a large increase in investment.

**Figure 2**
**ASPO Oil Production Profiles 2004**
**Billion barrels per year**

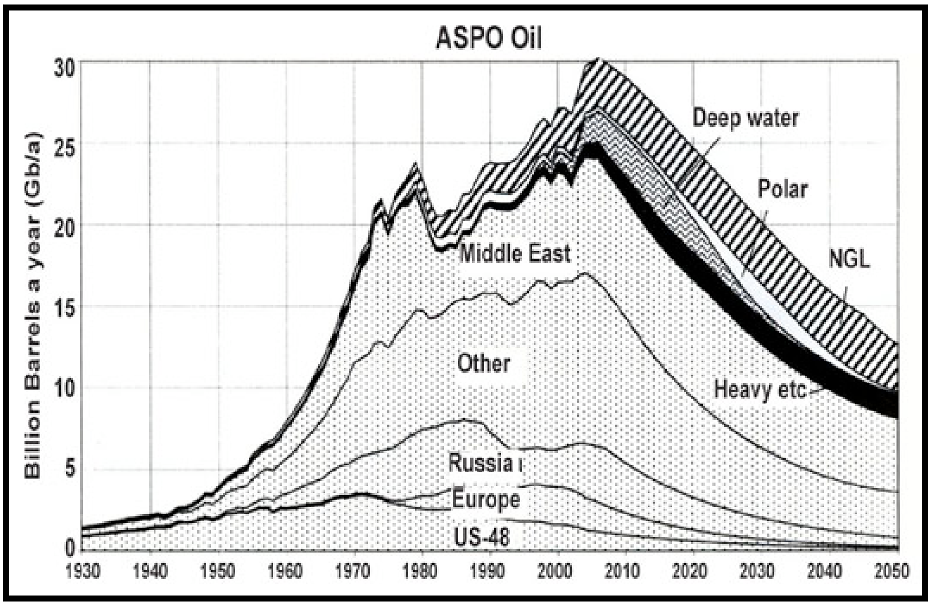
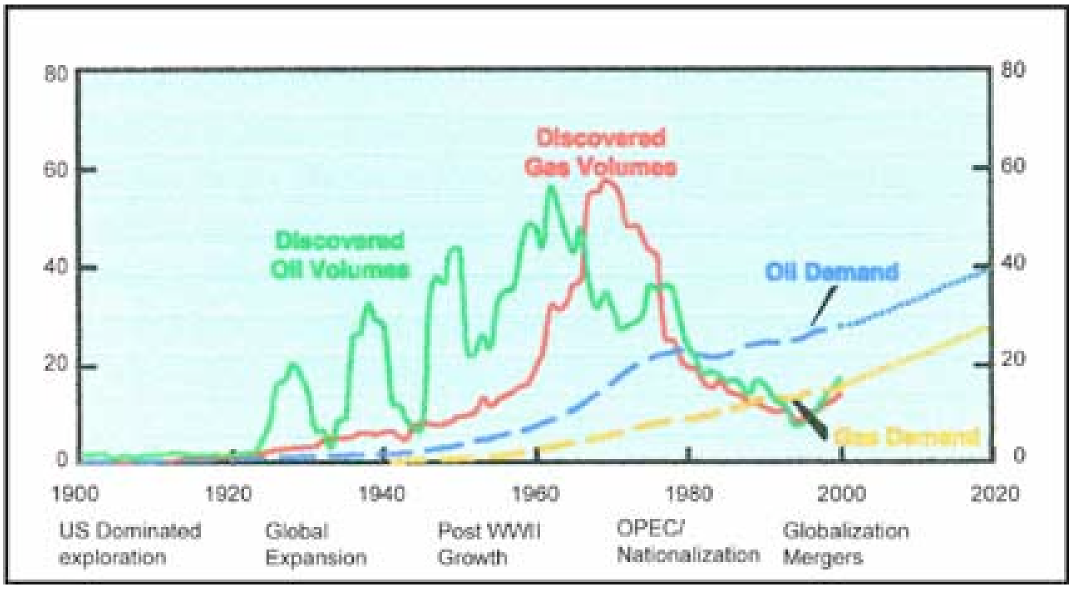



**Figure 3**
**World Oil and Gas Discovery/Production**
**Longwell: Exxon Mobil**
**Billion barrels oil-equivalent**




The discovery peaks for oil represent episodes of giant and super giant oilfield discovery starting with Venezuela in the 1920s, Texas, Iraq and Iran in the 1930s, the Middle East and Africa in the 1950s continuing into the 1960s with the former Soviet Union, Alaska and the

North Sea as well[3]. The secondary peak in the 1970s covered most areas and offshore exploration. *The discovery rate has been in decline for over 40 years*. An upturn has occurred in the 1990s with exploration offshore in the Caspian Sea and deep water offshore (>300m.).

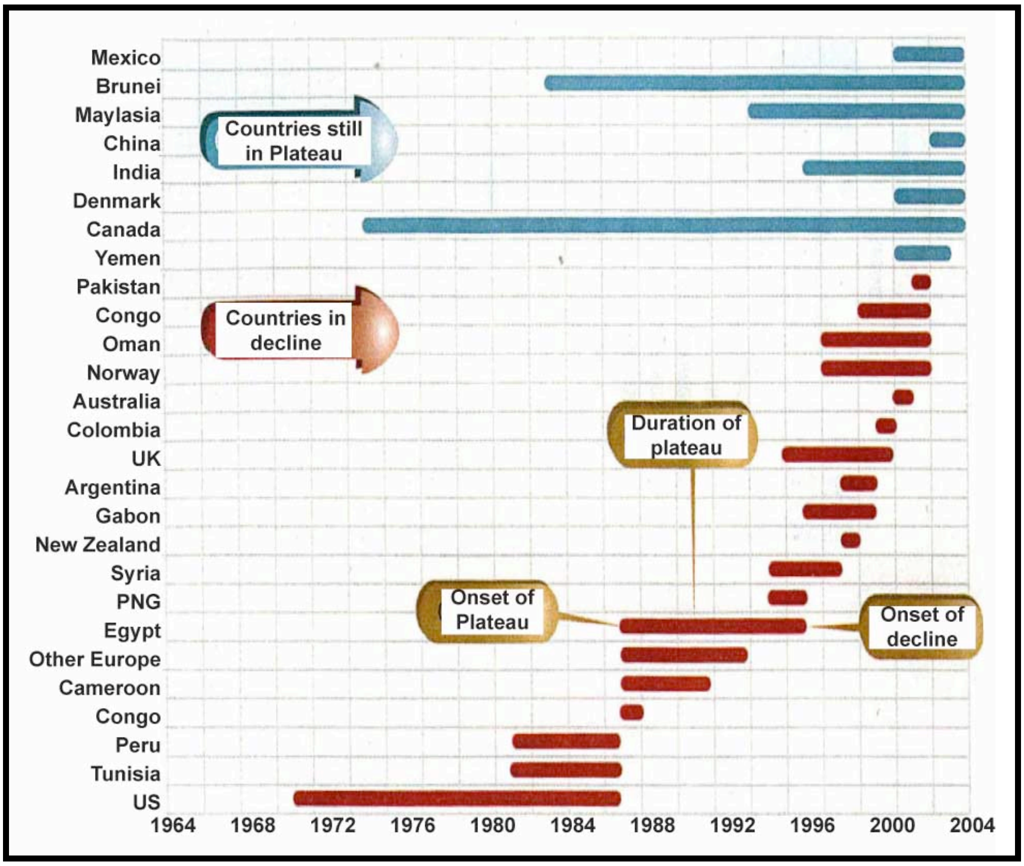
**Oil production has exceeded discovery since 1980 and is now about 3-4 times the discovery rate. Very few giant oilfields are being found. Longwell says discoveries are increasingly being made at greater depths on land, in deeper water at sea, and at more distances from consuming markets, especially for natural gas.**

*Natural gas discovery peaked* in the 1970s with major discoveries between 1960 and 1980 in Russia, the Middle East, North Sea and Indonesia. A minor upturn occurred in the 1990s from deepwater offshore exploration. Gas production has started to exceed discovery since 2000, some 20-25 years later than for oil, *Figure 3*.

## 4.2 Non OPEC production

**Rodgers (2004),** from PFC Energy, Washington DC, in a detailed analysis of production excluding OPEC and the former Soviet Union (FSU), says oil production in these countries has exceeded reserves addition by 12-15 billion barrels per year since the mid-1980s and production has reached a plateau since the mid 1990s. At least 20 of these countries (currently 19 million barrels a day) have passed their peak and are in decline, after producing 50-60 per cent of their reserve base. Their production declines by one million barrels a day. Another eight have reached a plateau at 13 million barrels a day and would all peak by 2010, Mexico and Yemen in 2006. *Figure 4* shows the detail. **New supply has to meet both production decline and consumption growth.**

**Figure 4**
**Non-OPEC Countries in Decline or Plateau**




[3] Super giants are those oilfields with over five billion barrels of extractable oil on discovery.

**Skebrowski (2004)** says mega projects on new giant fields are the main source of new supply and there is normally a six year lag between discovery and first production. He says several such projects have come on stream since 2003 with further projects well covered to 2007. But beyond 2007 looks bleak due to a decline in giant field discoveries from 2002. None were discovered in 2003 and only two in 2005. *That leaves the Middle East and the former Soviet Union as the main areas for growth.*

## 4.3 Former Soviet Union (FSU)

There was a steep FSU production decline from 12 to 7 million barrels a day between 1989 and 1998 consequent upon neglect of investment in petroleum infrastructure and the collapse of the Soviet Union, *Figure 2*. Some fields also peaked. Production has significantly improved since Putin became Russian President in 2000 and reached over 11 million barrels a day in 2005, 9.3 million barrels a day from Russia. Some of the recovery was due to commissioning giant offshore discoveries in the Caspian Sea and commissioning of a new pipeline in 2005 to the Turkish port of Ceyhan. The new Caspian oil is of poor quality—heavy 'sour' oil—and political instability is slowing progress. Not all refineries can process heavy sour oil. Higher oil prices together with the return of political and economic stability contributed to Russia's recovery. Much needed investment was possible.

*However, Russia has reached the limits of export capacity* and export growth will slow down. The main fields are in the Ob River basin in Siberia. New large pipelines would be expensive and need operation at near capacity for 20 years to justify projects. Furthermore, **Jean Laherrére (2003)** says Russian reserves are overstated by 30 per cent compared to the rest of the world as their definition of reserves takes an optimistic low probability view that ignores constraints to development. *The Russian production peak could be imminent.* The Russian government prohibits publication of the relevant performance data that would allow an independent audit.

## 4.4 Middle East production

*Table 3 shows current and sustainable production and reserves* of the Middle East OPEC countries. The run-down state of Iraq's oil infrastructure and the insurgency has kept oil production well below its current 'sustainable' capacity. The Middle East produces two-thirds of OPEC oil and the rest of OPEC[4] has negligible spare capacity as well. By the end of 2005 virtually the only spare production capacity in the world was in Saudi Arabia—and that was heavy sour oil (high sulphur content) when refinery capacity for such oils was fully committed.

**Table 3**
**OPEC Middle East**
**Million barrels a day**

| Country | Production Sept. 2004 | Sustainable production | Reserves Gigabarrels |
|---|---|---|---|
| Saudi Arabia | 9.56 | 10.5 | 263 |
| Iran | 3.97 | 4.1 | 133 |
| Kuwait | 2.46 | 2.5 | 99 |
| United Arab Emirates | 2.52 | 2.55 | 98 |
| Qatar | 0.81 | 0.83 | 15 |
| *Iraq* | *1.97* | *2.5?* | *115* |
| **Total** | **21.3** | **23** | **723** |

*However, ASPO and others question the validity of OPEC's figures for reserves.* All these countries substantially increased reserves in the late 1980s without published justification—a doubling by Iran and Iraq, 50 per cent by Saudi Arabia. Oil prices had collapsed following the

4 Libya, Algeria, Nigeria, Venezuela and Indonesia. Indonesia became an oil importer in 2005.

1970s oil crises and OPEC was trying to enforce production quotas on its members to support prices. The size of reserves was a factor in calculating these quotas and boosting oil reserves increased your quota. There may have been a case for some increase but not of that magnitude. Major oil companies do not publicly question these figures as it may compromise their chances for a return to these countries.

*Saudi Arabia dominates at 10.5 million barrels a day*. One super giant field, Ghawar, produces nearly 60 per cent of Saudi oil. Saudi ARAMCO spokesperson's say they can expand oil production to 15 million barrels a day and maintain this to 2050 (**Darley 2005).** This claim was a response to an in-depth study on Saudi oil by Matthew Simmons in his book *Twilight in the Desert*. He studied over 200 technical papers published by the Society of Petroleum Engineers since the early 1960s **(Simmons 2005)[5].** His suspicions were aroused by public Saudi statements that did not match what he observed on a visit to their oil installations in 2003.

*Simmons essential conclusions on Ghawar are summarised below.*

- Ghawar is the world's biggest oil field with complex geology that continually reveals surprises and problems that require *continuous* sophisticated exploration and development with the most advanced computer modeling and technology.
- Production is concentrated in the northern high-yielding part—the rest has poor geology with limited capacity to produce oil, in sharp contrast to the northern part.
- The complex heterogeneous geology constantly reveals pockets of 'stranded' oil needing many new wells to tap it and maintain production levels.
- Massive water injection systems are used to push the oil to producing wells—on average 1.4 times the oil produced, and is one of the most complex such systems in the world.
- Consequently, and due to the *uneven* geology, there are significant water cuts with the oil that must be removed. In addition underlying water is *up-coning unevenly* to wells.
- To overcome these problems 200 horizontal wells have been drilled, and more are planned. Simmons asks; *"what happens when the rising water reaches these wells"*?

**Simmons says these are the signs of a *mature oil field* approaching its climax, when comparisons are made with the history of other giant fields that have begun production decline.**

His book also covers the other Saudi oil fields where similar problems exist. He says technical papers reveal the Saudi's have recently explored the rest of their country with limited success.

**He concludes on the basis of these quality technical papers that Ghawar, and hence Saudi Arabia, is at a mature stage of oil depletion and that production decline may be near at hand. The true situation could only be confirmed if the Saudi's were to publish the historical performance data for ALL their oil fields for independent audit. The Saudi's counter claims lack credibility.**

Powerpoint presentations by Simmons on these and related issues are available on his company's website **(Simmons).**

**Iraqi producing oil fields** are in a run-down clapped out state after 25 years neglect since the beginning of the Iran-Iraq war in 1980 and following the era of sanctions after Gulf War I. Production has been flying 'blind'—failed and obsolete instrumentation—with a real risk that oil extraction may be permanently damaging the oil reservoirs. Water injection has become necessary. Massive investment is needed in these mature fields to upgrade facilities to a similar operational standard as in Saudi Arabia. Iraq may be the only Middle East country with significant discovered undeveloped oil fields capable of significant new production **(Djamarani**

[5] Simmons is the founder and head of Simmons & Company International, a Houston Texas based financial services company that specialises in the energy industry. He is a member of the National Petroleum Council and the Council of Foreign Relations, and is an active member of ASPO.

**2000)**. It is unlikely to happen on a sufficient scale while the insurgency continues and before other war-damaged infrastructure in Iraq is restored and a more stable social climate exists. **Gulf War II has severely compromised the future of Iraq's oil production prospects.**

Similar oil development problems arising from sanctions and the 1980s Iraq-Iranian war confront Iran, but not on the scale of Iraq.

**These are the principal reasons why ASPO does not expect Middle East oil production to increase much beyond its present level, before declining about 2020.**

## 4.5 US Geological Survey World Petroleum Assessment 2000 Description and Results. *An 'optimist' example*

The US Geological Survey (USGS) published this assessment in 2000. A criticism is given below of the USGS projections for oil discovery to 2025 based on a review by **Laherrére (2000).** It does not attempt a comprehensive coverage, focusing on undiscovered oil and reserve growth from 1995 to 2025—what might be added to the resource base. The USGS Report discusses both oil and natural gas; this review covers oil and natural gas liquids (NGL).

*Table 4* gives the USGS Report's mean *(i.e. statistically close to the most likely)* estimates for *new discovery* and reserve growth *for conventional oil* from 1995 to 2025. Adding the already discovered and produced-to-date gives a figure for the most likely ultimate production. Unconventional oil and reserve growth are discussed below. Laherrére discusses the assessments from their inconsistent application of statistical theory, the inadequate and inconsistent nature of definitions of conventional and unconventional oil, the poor statistical database generally and the unreliability of published figures for reserves. He says the USGS does not adequately discuss these issues to justify many of their conclusions. Furthermore, he says the definitions the USGS uses discount environmental, political and access constraints to potential oil extraction that always limit development and are a central feature of ASPO assessments. **The USGS 2000 estimates are optimistic low probability ones, not the most likely. They represent an upper bound.**

**Table 4**
**USGS Assessment—Conventional Oil 1995-2025**
**Additions to Reserves**
**Gigabarrels—Gb**

| Category | Yet to discover | Reserve growth | Total |
|---|---|---|---|
| Oil outside USA | 649 | 612 | 1,261 |
| NGL outside USA | 207 | 42 | 249 |
| **Sub-total outside USA** | **856** | **654** | **1,510** |
| Inside USA | 83 | 76 | 159 |
| **World total 1995-2025** | **939** | **730** | **1,669** |
| World reserves 1995 | | | 959 |
| Cumulative Prod. to 1995 | | | 717 |
| **Mean ultimate estimate** | | | **3,345** |

This compares with the ASPO ultimate estimate from Table 1 of 2,250 Gb, excluding heavy oil, the main component of unconventional oil. It implies a mean addition to reserves of over 50 Gb/year for 30 years. By contrast the peak discovery rate was about 60 Gb in 1962-3 *(Figure 3). It implies a sustained fivefold increase in the discovery rate that would require a return to significant discovery of giant oilfields, rather than the near cessation that has occurred.*
*If reserve growth is excluded* the USGS ultimate is about 2,600 Gb, much closer to the ASPO figure of 2,250 Gb—even closer if the optimistic nature of the USGS estimate is considered. We will now discuss reserve growth.

**Reserve growth** is a distinctly US phenomenon arising from the rules of the Securities and Exchange Commission (SEC). An orgy of speculation, dubious reporting and fraud followed the big discoveries in Texas in the 1930s. The SEC introduced company-reporting rules that limited reserves to the “proved” category—the oil that could be drained to a *producing* oil well. In the days of large oil fields this meant companies listed on US Stock Exchanges were compelled to under-report their reserves. Of course, as these fields were developed *and drilled up*, “reserve growth” naturally occurred. Over time much of this became falsely attributed to new technology. By contrast, in the rest of the world with good reporting legislation, companies reported “proved” plus “probable”—much closer to the statistically most likely. Reserve growth was much less than in the USA.

**Laherrére (2000)** says over the previous 20 years only six per cent of reserve growth in the USA was due to new discoveries. But the scope for reserve growth diminishes as oil fields age. With the size of new discoveries declining, and these increasingly offshore, companies can no longer afford to indulge in such under-reporting. *The USGS’ extension of the US reserve growth pattern into the future and extending these to non-US countries cannot be justified.*

## 4.6 Tar sands and shale oil

*Tar sands are solid bitumen-like hydrocarbons* embedded in porous sandy formations. There are large deposits in Canada and Venezuela. So-called shale oil occurs in hydrocarbon-rich formations containing kerogen, a precursor to oil that has not yet been subject to the pressure and heat needed to transform it into crude oil. It occurs extensively in the upper Colorado River basin in the USA, Brazil, Scotland, China and Australia. The potential resource base for forms of crude oil is very large. Appendix 2 (3p.) has a detailed description of both, and describes their limited potential as future sources of oil—probably nil for shale oil.

*After decades of development* costing billions of dollars and huge government subsidies oil is finally being produced from Canadian tar sands in Alberta at a rate approaching one million barrels a day. *An energy input equivalent to two barrels of oil (natural gas) is needed for every three barrels of product (EPR 1.5).* However, a crisis is impending as North American natural gas production is poised to decline—*see further comment below.* The environmental damage is huge as are the greenhouse gas emissions.

In summary, two or more tonnes of tar sands or shale must be mined and processed with water using heat to produce one barrel of heavy oil. To produce four million barrels of oil a day requires *mining and processing three billion tonnes a year* to yield products requiring further processing to produce the equivalent of crude oil. Oil from tar sands consumes large quantities of water that require large-scale treatment before discharge to the Mackenzie River.

Several attempts at getting oil from shale have been made since the 1920s. All have failed at a cost of billions of dollars, the latest in Australia.

These are the reasons ASPO sees a limited future for oil from these sources. *Oil from shale has been described as the fuel for the future—and always will be.*

## 4.7 Conclusions

**The ASPO viewpoint on the future of oil production has been developed, publicised and criticised since 2001. So far it has withstood the challenges while also responding to new information and its critics as events unfold. We will next address the status of world natural gas, then Australian oil and gas supply.**

# 5. WORLD NATURAL GAS

*The database for natural gas is less reliable than for oil.* Until recently natural gas did not receive the attention that has been given to oil. In the early years it was regarded as a waste product from oil production and flared at oil wells. Natural gas is also re-injected into oil fields to sustain oil production, often for later extraction as a marketable fuel. It is also used as a fuel in oil field operations. Consequently the data on past production is poor leading to more uncertainty in the statistics for discovered natural gas than for oil.

*The cost of transporting natural gas any distance is 6-10 times greater than for oil—because it is a gas. Consequently there will tend to be regional gas production peaks rather than a global peak.* Gas can flow more freely in geological formations and more of the gas-in-place can be extracted than is the case for oil—up to 80 per cent. These factors make infrastructure for natural gas expensive compared to oil, especially offshore. Consequently, the peak production profiles typical of oil tend to be more like extended plateaus for gas. As much as 80-85 per cent of the extractable gas can be extracted before production decline begins. When decline begins it can be steep.

*Table 5 shows natural gas statistics for 2004* **(BP 2005).** The difference between exports and imports is probably due to natural gas consumed in transporting gas. There is significant export and import of gas within the regions as well.

**Table 5**
## World Natural Gas 2004
**Billion cubic metres**

| Region | Reserves | Production | Consumption | Imports | Exports |
|---|---|---|---|---|---|
| | Billion cubic metres | | | | |
| Nth America | 7,300 | 763 | 784 | 19 | 0 |
| S&C America | 7,100 | 129 | 118 | 0 | 14 |
| Europe | 5,400 | 300 | 491 | 188 | 0 |
| FSU | 58,700 | 751 | 580 | 5 | 154 |
| Middle East | 72,800 | 280 | 238 | 5 | 44 |
| Africa | 14,100 | 145 | 69 | 0 | 74 |
| Asia Pacific | 14,200 | 323 | 368 | 35 | 1 |
| **Total** | **180,000** | **2,692** | **2,689** | **251** | **287** |
| Australia | 2,500 | 35 | 25 | 0 | 12 |

*North America produces 28 per cent of world gas but only has four per cent of reserves. Over 80 per cent of the discovered gas has been consumed and production is declining and natural gas prices undergoing a dramatic increase. The subject is fully covered in Appendix 3 (8p.).*

*Europe consumes 18 per cent of world production but only has three per cent of gas reserves. Consumption of discovered gas is approaching 80 per cent and UK production is declining rapidly. Gas from Algeria and Russia is piped to Europe and LNG imports are increasing* ***(BP 2005****). The Russian gas comes mainly from the Ob River basin. Cold weather this winter has stretched the Russian pipeline capacity to its limits. European gas production should be in decline by 2010—it comes mainly from North Sea gas fields.*

About 60 per cent of Middle East gas reserves are reputedly in one super giant gas field straddling the Persian Gulf between Qatar and Iran—about 20 per cent of world reserves. *Its location has profound geopolitical and security implications for the future of natural gas and the resource is the least developed in the world.* Will this field exhibit similar characteristics to Saudi Arabia's Ghawar oil field when serious development begins? Can we trust published figures for Middle East gas reserves?

The gas shortage in North America and Europe is generating a boom in liquid natural gas (LNG) development to compensate. China and India are also planning to increase their LNG imports. *More details on world LNG supply are in Appendix 3.*

European and North American gas will go into decline about the same time as world oil production peaks. There is less uncertainty about this conclusion than for world oil. Europe and North America consume 46 per cent of world gas production, but only have seven per cent of gas reserves. **We can expect natural gas prices to rise in the immediate future.**

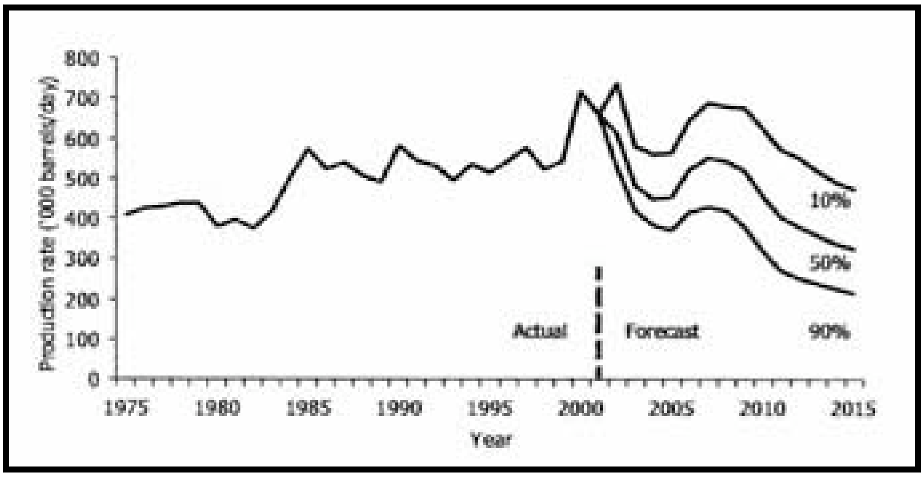
## 6. AUSTRALIAN OIL AND GAS

*Australia is a small player in oil and gas production.* Production of both began about 1970 after discoveries offshore in Bass Strait, Central Australia and Western Australia. More natural gas has been found than oil and most of it offshore. Geoscience Australia publishes regular reports on Australian oil and gas resources

### 6.1 Oil and natural gas liquids

*Only three minor giant oil fields have been found*, all offshore in Bass Strait around 1970, and their production has been declining since 1987. Subsequent small field discoveries have been developed offshore on the North West Shelf and in the Timor Sea. Central Australian oilfields are at a mature stage and elsewhere oil discoveries are erratic and small with liquids production increasingly dependent on natural gas liquids from the North West Shelf project. *Figure 5* shows Australian liquids production and estimates of future production to 2025 **(Geoscience Australia 2005).** Production has been declining since 2000 with a secondary peak expected about 2006-7 following minor offshore discoveries mostly on the NW Shelf. *Net oil production was equal to consumption in 2000.* The size of oil discoveries is declining.

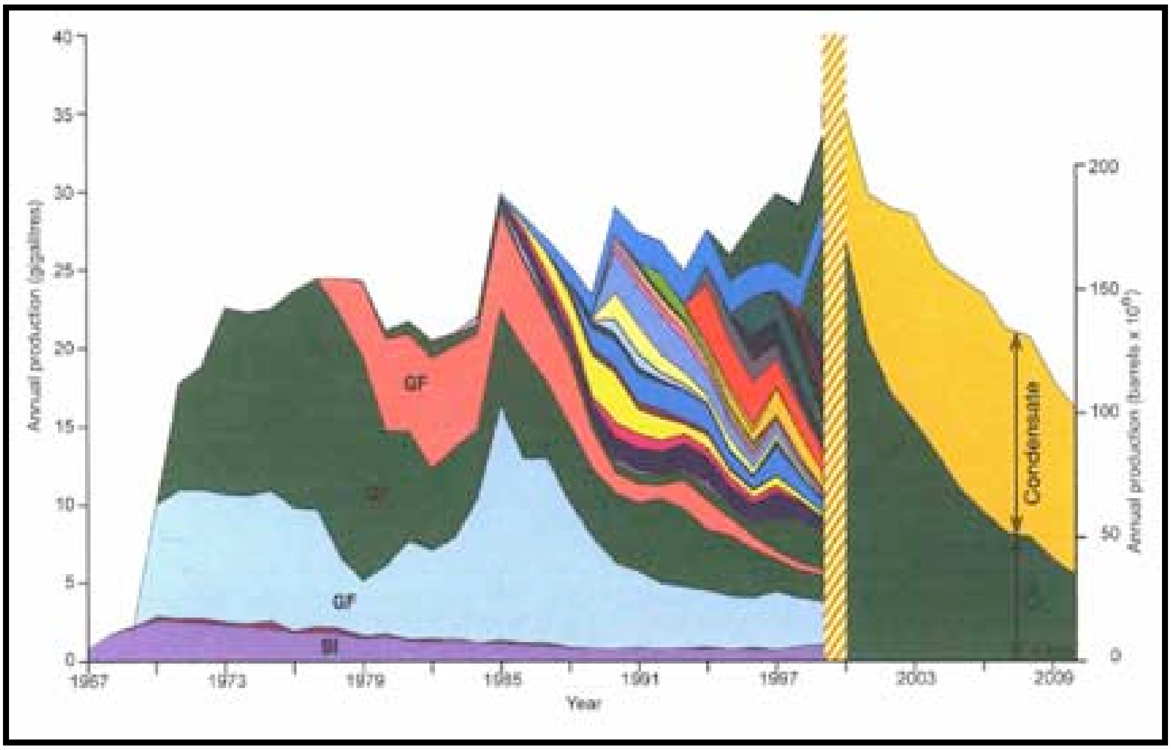
**Figure 5**
**Australian Crude Oil & Condensate Production**
**Actual 1975-2001, Forecast 2002-2015**
**Thousand barrels per day**




Governments have been unable to interest companies exploring in the Canning and Officer Basins as these remote land locations have so far been regarded as having low prospects due to their location and geological history[6]. *Figure 6* shows Australian production by oilfield, including the post 2000 contribution from gas condensate **(Powell 2001)**. It illustrates the relatively long life of the three Bass Strait giant fields and their subsequent replacement by many small fields that are *'here today and gone tomorrow'*. A similar pattern is emerging on the global scale.

6 The Canning basin is onshore from the coast between Port Hedland and Broome to the border of Western Australia. The Officer basin is north of the Nullarbor Plain.

**Figure 6**
**Australian Oil & Condensate Production by Field**
**Actual 1967 to 2000 Estimated Post 2000**




Geoscience Australia is investigating the potential for petroleum discovery in deep water offshore (>3-500m.). The high cost, exploration risk and remoteness of these locations are obstacles as there are only a limited number of the rigs needed. These are committed to more favourable sites in the northern hemisphere. If exploration does take place and commercial discoveries are made then production is unlikely until around 2020 **(Powell 2001)**. *The fact that Geoscience Australia sees these sites as the new frontier for exploration speaks volumes.*

The USGS Assessment 1995-2025 estimated a mean undiscovered for oil from 1995 to 2025 of 5,032 million barrels for the Bonaparte, Browse, Carnarvon and Gippsland Basins. So far this is not being achieved.

**Australia's self-sufficiency in oil is declining rapidly and is likely to continue. Reversal of this trend requires heroic discoveries in heroic locations with high risk attached—the oil will be very expensive to produce. Therefore a high priority needs to be given to reducing our dependence on petroleum-based fuels, especially for transport.**

## 6.2 Australian Natural Gas

*Table 6* shows the mean reserves at end 2003, production and discovery to 2003 and production in 2003 for the principal gas basins in Australia[7]. All the basins except the Cooper-Eromonga are offshore. Over 90 per cent of gas reserves are offshore between Carnarvon and Darwin **(Geoscience Australia 2005).** Sydney and Adelaide were connected to the Gippsland/Otway Basins in 2003 and 2004 to supplement their supply from the Cooper-Eromonga Basins. By 2005 over 80 per cent of discovered gas has been extracted from that basin which also supplies some gas to Darwin and Queensland. Decline has commenced. By 2005 some 55 per cent of the discovered Gippsland Basin gas will have been extracted and could reach 80 per cent by 2015. Gas exploration in the Otway Basin has so far not been very

[7] The Browse basin is off the Kimberley coast, Bonaparte basin in the Timor Sea, Otway basin west of the Gippsland basin and Cooper-Eromonga basin in Central Australia.

successful. Woodside Energy made a major natural gas discovery (Pluto) in the Carnarvon Basin in 2005 and is fast-tracking its development while confirming its size **(Clark 2005).**

The Bayu/Undan gas field in the Bonaparte Basin will come into production in 2006, including an LNG plant at Darwin. A 430 billion cubic metre gas field is under development in Papua New Guinea along with a pipeline to deliver gas down the Queensland coast to Gladstone **(Williamson 2005**).

The impending depletion of Gippsland and Cooper-Eromonga Basins has stimulated development of methane from coal seams in NSW and Queensland for local use. It is more expensive than gas field supply but cheaper than gas transported from the other side of the continent. Some residents in NSW are resisting coal seam development in their area on environmental grounds. It is too early to judge its future role, but it may be significant.

**Table 6**
**Australian Natural Gas 2003**
**Reserves, Discovered & Production**
**Billion cubic metres**

| Basin | Reserves 2003 Mean est. | Production to 2003 | Discovery to 2003 | Production 2003 |
|---|---|---|---|---|
| Carnarvon | 2,368 | 247 | 2,615 | 20.5 |
| Browse | 733 | - | 733 | - |
| Bonaparte | 538 | 3 | 541 | - |
| Gippsland | 162 | 170 | 332 | 5.8 |
| **Sub-total** | **3,801** | **420** | **4,221** | **26.3** |
| Otway | 14 | 3 | 17 | 0.8 |
| Cooper-Eromonga | 54 | 151 | 205 | 7.3 |
| Other | 52 | 47 | 99 | 1.6 |
| **TOTAL** | **3,921** | **621** | **4,542** | **33.5** |

*Table 7 shows the USGS World Petroleum Assessment 2000 estimate* for mean gas discovery from 1995 to 2025 through new discovery and reserve growth for the Bonaparte, Browse, Carnarvon and Gippsland Basins, together with reserves and the produced-to-date in 1995, plus the estimated ultimate for 2025 **(Geoscience Australia 2001)**. Discoveries in the Carnarvon and Browse Basins have more than doubled since 1995 and increased in the Bonaparte Basin, but are static in Gippsland. The USGS estimate for Carnarvon will certainly be exceeded and the same is possible for the Bonaparte and Browse Basins, given the scope for more exploration, but this is unlikely for the Gippsland Basin. *However, most new discoveries are likely to be in deep water offshore.*

*Geoscience Australia's method for estimating likely discovery prior to 2000* was based on a limited 10-15 year horizon. It was focused on what investment the industry was likely to make, not so much on what the potential might be and generally gave a low priority to deep water offshore. Therefore the USGS estimates for the first three basins for 2025 may be valid, certainly for the Carnarvon Basin.

The tsunami off Sumatra in December 2004 has focused attention on the risks to offshore petroleum infrastructure on the North West coast. Geoscience Australia and Woodside Energy are reviewing the risks. The severe damage to offshore rigs and pipelines in the Mexican Gulf from hurricane Katrina in 2005, especially for those in deep water, has called in question the current engineering standards for these structures. New standards are likely that will increase the cost of deepwater operations. Category five cyclones (winds >250 km/hour) can be expected on the northwest and Northern Territory coasts.

**Table 7**
**USGS Assessment 1995-2025**
**Australian Natural Gas Discovery**
Billion cubic metres

| Basin | Reserves 1995 | Production to 1995 | Discovered to 1995 | USGS mean discovery est. | |
|---|---|---|---|---|---|
| | | | | 1995-2025 | Ultimate 2025 |
| Carnarvon | 1,161 | 79 | 1,240 | 1,832 | 3,072 |
| Browse | 625 | 0 | 625 | 569 | 1,194 |
| Bonaparte | 216 | 0 | 216 | 674 | 890 |
| Gippsland | 207 | 115 | 322 | 160 | 482 |
| **Total** | **2,209** | **194** | **2,403** | **3,235** | **5,638** |

It is possible another three LNG trains will be commissioned in the Carnarvon Basin by 2010—No. 5 on the North Shelf Joint Venture, stage 1 of the Gorgon project and Woodside Energy's new Pluto project. Together with other expanding uses of natural gas annual production of natural gas (e.g. chemicals and electric power) in the Carnarvon Basin could reach 45 billion cubic metres per year by 2010. Further LNG expansion could increase this to 60 bcm by 2015. There is scope for petrochemical plants as well.

## 6.3 Summary

*Australia faces declining self-sufficiency in oil* at a time when world oil production is approaching its peak. Most oil is used for transport fuels. There is much uncertainty about the potential for sustained oil discovery—Australia seems to be a gas prone region.

**Barry Jones (2003),** Executive Director of the Australian Petroleum Producers and Exploration Association (APPEA), has commented in their journal *Flowline* saying Australian governments need to give prominent strategic direction on this issue which he regarded as *far more important* than electric power reform. He said transport was most at risk, and required demand management initiatives with a priority for public transport. He also supported increased use of natural gas as a transport fuel and tax reform for the upstream oil industry.

Since 2000 petroleum development, and to a lesser extent exploration, has expanded, especially in natural gas, but for oil in smaller fields in more difficult locations. It may be difficult to sustain this level of activity due to a world shortage of petroleum geologists and engineers and other skilled staff. At the peak in 1981 the large companies employed 1.4 million employees world wide, compared with 900,000 in 1974. When oil prices fell in the mid-1980s staff were shed and employment fell to 600,000 in 1995 **(Smith 2005).** There has been a corresponding fall in students enrolled in these courses. *Current skilled staff are ageing and approaching retirement.*

**Eric Sreitberg (2005),** Managing Director of Arc Energy Ltd, reports that a straw poll taken at the 2005 APPEA Annual Conference demonstrated a belief that we have passed the oil peak. He says a telling statistic is that *over the last decade the percentage of capital devoted to exploration has declined from 30 per cent to 10 per cent.* He also says that the industry is greying and student enrolments are low and the median age of industry employees will be 56 in 2008. *There are shortages of equipment, such as drilling rigs, especially for offshore.*

These are reflections of the increasing energy cost of extracting oil and transforming it into useable fuels for human use—a declining net energy yield with reduced capacity for economic activity as we have known it. We will now shift our focus to the consequences for transport.

## 7. PETROLEUM AND TRANSPORT FUELS

*Petroleum products dominate transport fuels* with a minor role for electric rail traffic. Commercial shipping, and especially aviation, is almost exclusively petroleum powered. 60 per cent of the world's oil fuels transport. Land transport uses 65 per cent of Australian petroleum product consumption and nine per cent is used for aviation. *The following qualities have led to the domination of petroleum products as transport fuels.*

- They are liquid and available at convenient locations.
- They have high energy profit ratios, especially for oil from giant oil fields (see the discussion below).
- They have compact and cheap fuel storage characteristics—high power-weight and power-volume ratios;
- They have good storage and portability characteristics;
- Fine control is possible in compact responsive engines;
- The environmental impact from production to end-use is low compared to coal.
- Flexible responses to vehicle motion are possible.

It is most unlikely that alternative transport fuels and remaining petroleum can fully meet all these favourable characteristics. This section discusses criteria for comparing the quality and effectiveness of transport fuels. *Appendix 4 (6 p.) compares a range of land transport fuels based on the above criteria in more detail. Table 8* gives a snapshot of Australian refined petroleum products and shows the increasing volume and cost of net imports **(ABARE 2005)**.

**Table 8**
**Australian Refined Products**
**Megalitres ML**

| Year | Production ML | Consumption ML | Imports | | Exports | |
|---|---|---|---|---|---|---|
| | | | ML | $million | ML | $million |
| 1974-75 | 34,066 | 36,637 | 4.063 | 247 | 1,954 | 146 |
| 1984-85 | 35,924 | 37,204 | 2,823 | 683 | 2,207 | 641 |
| 1994-95 | 44,421 | 46,746 | 3,479 | 676 | 3,289 | 719 |
| 2000-01 | 47,690 | 50,010 | 4,746 | 1,896 | 4.564 | 1,844 |
| 2004-05 | 44,555 | 53,909 | 11,200 | 5,127 | 1,847 | 844 |

Consumption of refined products in 2004-05 is listed below in megalitres **(ABARE 2005)**.

- Refinery input 40,334
- *Auto gasoline 19,876*
- *Auto diesel 15,185*
- *Aviation turbine 4,730*
- Liquid petroleum gas 4,700
- Fuel oil 1,595
- Other diesel 15 —industrial and marine
- Bitumen 812
- Lubricants 470
- *Aviation gasoline 91*
- Heating oil 34
- Other 5,200 —includes industrial feedstock and refinery fuel.
- **Total 57,707 ML**

### 7.1 Net energy and energy profit ratio

*Net energy analysis is one way of evaluating the productivity of energy systems*. Some of the commercial energy obtained from nature must be used to extract and convert it into useful forms. A crucial economic issue is what proportion should be so used. Net energy compares the quantity of energy delivered to society by an energy system to the energy consumed *directly and indirectly* in extraction, conversion and delivery processes. It can be measured by *energy profit ratio (EPR),* sometimes called *energy return on investment (EROI)*.

$$EPR = \frac{\text{energy output}}{\text{energy input}}$$

Not all energy sources with the same EPR have equivalent performance in specific end uses, e.g. as transport fuels. Other qualities impact on the usefulness and economic merit of fuels, such as those listed above for transport. In most net energy analyses, inputs and outputs of different types of energy are aggregated by their thermal equivalents and disregard other aspects of energy quality. To paraphrase George Orwell from his famous book, *Animal Farm,* '*all fuels are equal but some are more equal than others'*.

For petroleum the EPR varies over the life cycle of oilfields. The highest net energy yield usually comes in the middle of the production cycle, *Figure 1*. On the downside, as production declines, an increasing energy input is required. Remaining oil production will not be as useful as it was on the production upside. These aspects are discussed in depth in Appendix 4 (6 p.).

## 7.2 Comparing effectiveness of transport fuels

*Figure 7 compares a range of land transport fuels* according to typical EPR's on the vertical scale and increasing transport effectiveness from left to right on the horizontal scale. Appendix 4 discusses the rationale for these rankings. Some brief comments.

The exceptional quality of transport fuels based on oil from giant oilfields in their prime is apparent—a phase now retreating into history. Electricity is an excellent transport fuel, but unfortunately it cannot be cheaply stored in bulk. Five litres of petrol has an energy potential equivalent to a one tonne lead acid battery. Hydrogen fuel cells are technically feasible. But hydrogen must be manufactured from other fuels and its storage in vehicles is bulky and expensive. The lack of a hydrogen distribution system is a major barrier to mass marketing of hydrogen-powered vehicles.

Biofuels, such as ethanol and biodiesel, are technically and commercially feasible (but still with subsidies). However, it is misleading advertising to call these 'renewable energy'. There is a significant fossil fuel input to growing and harvesting the crops, and for ethanol to achieve an anhydrous product after fermentation. This energy input can exceed the energy content of the ethanol obtained. *There is some disagreement on the methodology for making energy input/output analyses that need resolving.*

LNG may be an option *as a transition stage* to replace diesel in trucks, locomotives and mine dump trucks. Some freight trucking companies in Western Australia are already using LNG.

*If all of Australia's wheat crop, net of domestic consumption,* were converted to anhydrous ethanol its energy content would be equal to 23 per cent of that from our annual auto gasoline consumption, declining to 7 per cent in drought years such as 2002/03. *Table 9* compares the potential ethanol output from wheat and sugar with Australian oil consumption, all in gigajoules. Regardless of the net energy yield *there is no possible way that biofuels can replace petrol and diesel as transport fuels on a significant scale*. Australia produces enough wheat to feed 80 million people—about equal to the annual increase in world population. It would be a fatal mistake to go down this biofuel pathway. Appendix 5 (2 p.) has more detail.

There may be a case for on-farm production of biodiesel *for immediate local use* as a transition step in the adaptation to declining oil supply. This option needs further investigation.

**There are no transport fuels in sight that can replace petroleum products as we now use them. Therefore the prime response to 'peak oil' must be demand management—to reduce the scale and extent of transport at all levels from the local to the global. This will take several decades to achieve.**

**Figure 7**
**Comparisons of Transport Fuel Effectiveness**

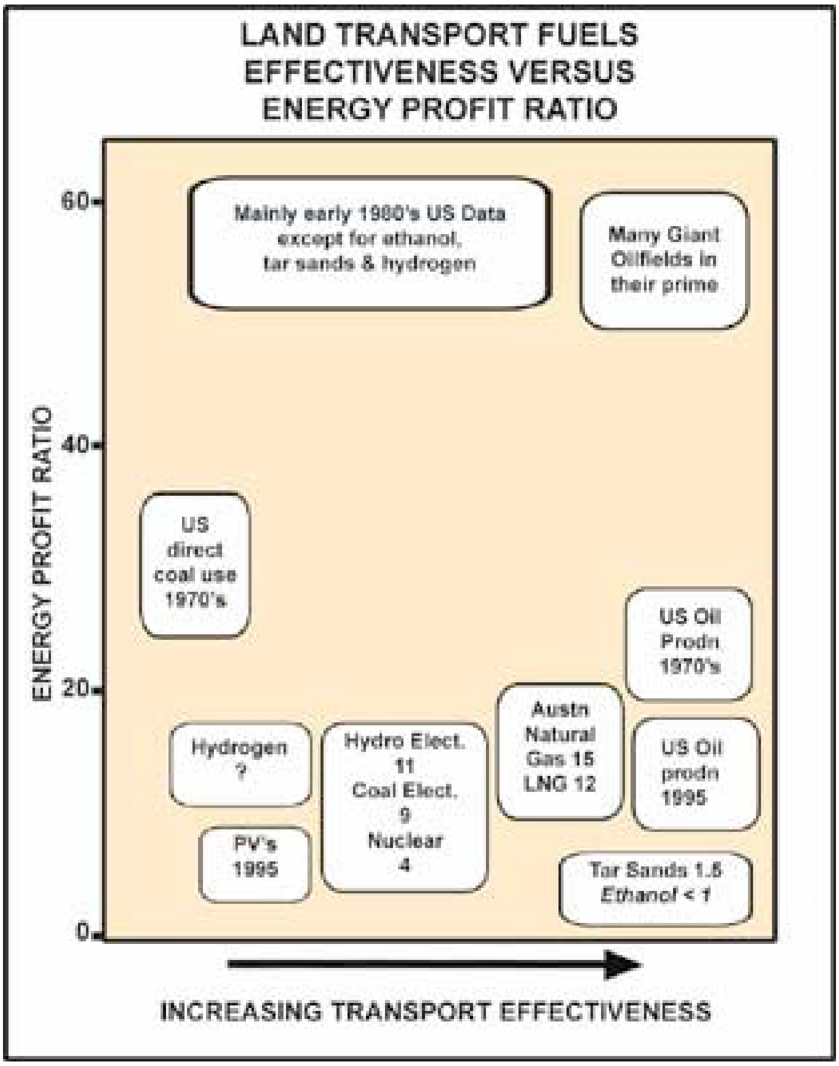



**Table 9**
**Potential Maximum Annual Ethanol Energy Output**
**Compared to Annual Petroleum Consumption**

| Annual Petroleum Products GJ x10$^{6}$/yr | | Wheat 161x10$^{6}$GJ/yr Good year | Wheat 47x10$^{6}$GJ Drought | Sugar 57x10$^{6}$ GJ/yr Good year |
|---|---|---|---|---|
| | | *Per cent of petroleum consumption* | | |
| **Gasoline** | 688 | 23% | 7% | 8% |
| **Diesel** | 586 | 27% | 8% | 10% |
| **Gasoline+diesel** | 1,274 | 12.5% | 3.5% | 4.5% |
| **Crude oil** | 1,630 | 10% | 3% | 3.5% |

## 8. INDUSTRIAL AGRICULTURE—THE FOOD CHAIN

*"Modern agriculture is the use of land to convert petroleum into food".*
*Prof. Alan Bartlett University of Colorado 1978.*

*Australia has a dry climate and the most nutrient deficient soils in the world*. Crop production and horticulture did not really develop until fertilisers and farm machinery were introduced 100 years ago and affordable rail networks became available to transport farm inputs and products to markets. The main expansion began after World War I when petroleum-powered transport and tractors became available, intensifying after World War II. Petroleum products enabled European style agriculture to be imposed on a vastly different Australian environment and has led to severe land degradation—e.g. soil erosion and impoverishment, salinity and polluted rivers, loss of biodiversity. The high labour productivity arising from petroleum-fuelled mechanisation is depopulating rural communities that are now struggling to survive, making possible the growth of cities. *Prof. Alan Bartlett's description of modern agriculture applies to Australia more than anywhere else in the world.*

### 8.1 Fertilisers

*The biggest single fossil energy input to Australian agriculture* is probably the embodied energy in nitrogen fertilisers whose use has expanded rapidly since 1990. *The global background to nitrogen fertilisers is in Appendix 6 (4p.).* Nitrogen fertilisers (the Green Revolution), coupled with cheap petroleum-fuelled transport, made possible the doubling of world population since 1960 and the subsequent growth in urban populations and the "factory farming" of animals. Natural gas is the principal input to nitrogen fertiliser manufacture via the synthesis of ammonia from hydrogen and nitrogen. China is now the world's biggest manufacturer of fertilisers followed by the USA, India, Russia and Canada. The biggest consumer is China followed by the USA, India, Brazil and France. *Table 10* shows world fertiliser production. China is importing soybean from Brazil and the USA for aquaculture to minimise the use of nitrogen fertilised grains at factory animal farms.

**Table 10**
**World Fertiliser Production**
**Million tonnes**

| **Fertiliser** | **Production** | | |
|---|---|---|---|
| | **1980/81** | **1990/91** | **2002/2003** |
| Nitrogen | 63 | 82 | 87 |
| Phosphate | 35 | 39 | 34 |
| Potash | 27 | 27 | 26 |
| **Total** | **125** | **148** | **147** |

*Table 11 lists recent Australian fertliser consumption and imports* (**ABARE 2005)**. Phosphate rock is imported from Morocco, China and Togo. Production has virtually ceased at Nauru and Christmas Island. These fertilisers contribute to soil acidification requiring massive inputs of lime in Western Australia, s*ee Appendix 7 (3p.)*.

*Table 12 lists lime, dolomite and gypsum used in Australia as soil conditioners* **(ABS 2001-02)**. In Western Australia nearly 2.5 million tonnes of fertilisers and lime is transported by road to farms, the majority to wheatbelt farms, or some 600 million tonne-km per year. It consumes about 20 ML of diesel fuel and causes significant damage to roads. Petrochemicals in the form of herbicides and pesticides are widely used to control weeds and insect pests.

**ABARE (2005a)** reports Australian agriculture sector primary energy consumption at 94.3 PJ for 2004/05. This would cover *direct use on farms* of which about 90 per cent would be petroleum products, equivalent to about 100,000 ML as diesel and petrol. This would not include the energy embodied in fertilisers, manufacturing machinery and petrochemicals, nor transport external to farms. *The statistical category of 'agriculture' understates the dependence of agriculture and food supply on petroleum products*

**Table 11**
**Australian Fertiliser Consumption & Imports**
**Thousand tonnes**

| Year | Consumption | | | Imports | | |
|---|---|---|---|---|---|---|
| | Phosphate $P_2O_5$ | Nitrogen N | Potash $K_2O$ | Phosphate $P_2O_5$ | Nitrogen N | Potash $K_2O$ |
| 1985-86 | 726 | 340 | 130 | 150 | 121 | 117 |
| 1990-91 | 580 | 439 | 145 | 306 | 270 | 147 |
| 1995-96 | 977 | 671 | 219 | 604 | 469 | 219 |
| 2000-01 | 1,097 | 1,002 | 203 | 637 | 705 | 203 |
| 2004-05 | 1,185 | 1,105 | 298 | 706 | 796 | 298 |

**Table 12**
**Agricultural Lime & Gypsum in Australia**
**Thousand tonnes**

| Lime & Gypsum | Australia | | W. Australia |
|---|---|---|---|
| | 2001 | 2002 | 2002 |
| Lime—acidity control | 1,745 | 2.353 | 785 |
| Dolomite | 155 | 197 | 78 |
| Gypsum—soil cond. | 1.376 | 1,715 | 228 |
| **Total** | **3,277** | **4,266** | **1,091** |

## 8.2 Energy used in the food chain

*The food chain* covers farm inputs, on-farm, transport, food processing, packaging, retail, customer travel and home energy use. The last study in Australia that I know of was for 1975 by **Muriel Watt (1982)** at Murdoch University—the food chain has become more energy intensive since then. **Brown (2005)** has published statistics for the USA that are summarised in *Table 13* below and would reflect a pattern applicable to Australia—we are possibly less energy intensive than the USA. The US uses a lot of fuel to dry corn, its biggest crop.

*Table 13 does not include customer car travel between homes and supermarkets*. Appendix 8 (2p.) investigates this aspect based on a hypothetical transport task for breakfast cereal processed in Sydney and sold in Perth. *Five per cent of the customers' car travel to and from supermarkets is allocated to cereal transport. By far the biggest transport task is between homes and supermarkets, Table 14.*

These estimates are only indicative—they are dependent on the assumptions made. Nevertheless they suggest that car trips by customers to supermarkets dominate the transport task in getting food from farms to households, even when the product is transported from one side of the continent to the other.

***There is an urgent need in Australia for new transport/energy assessments of the entire food supply chain from farm inputs to the kitchen table.***

The Earth Policy Institute article goes on to say that in industrial countries fruit and vegetables often travel 2,500-4,000 km from farm to store with trucks accounting for the majority. Processed foods now account for three fourths of total world food sales. Food supply has become very dependent on transport worldwide and vulnerable to disruption of fuel supply *The campaign for country-of-origin food labeling in Australia must be assessed from this viewpoint*.

**Table 13**
**Annual Energy Use in the US Food Chain**

| Food chain | Energy EJ[8] | Per cent | Transport & farm fuel GL |
|---|---|---|---|
| **Farms** | | **Farms** | |
| Fertiliser | 620 | 28 | |
| Irrigation | 150 | 7 | |
| Farm fuel | 750 | 34 | 2,850 |
| Grain drying | 680 | 31 | |
| **Sub-total** | **2,200** | **20** | |
| **Farm to table** | | | |
| Transport | 1,480 | 14 | 1,720 |
| Processing | 1,700 | 16 | |
| Packaging | 750 | 7 | |
| Retailing | 425 | 4 | |
| Restaurants | 750 | 7 | |
| Home | 3,400 | 32 | |
| **Total** | **10,551** | **100** | |

**Table 14**
**Cereal Transport—Farms to Perth Homes**

| TRIPS | Distance km | Load tonnes | Litres fuel | Km per tonne | Litre per tonne |
|---|---|---|---|---|---|
| Farm to railway by truck | 30 | 10 | 10 | 3 | 1 |
| Rail to Sydney, 90t hopper car | 200 | 90 | 90 | 2.2 | 1 |
| Road to & from Sydney factory | 20 | 20 | 8 | 1 | 0.4 |
| Rail, Sydney to Kewdale, Perth | 3,500 | 30 | 800 | 115 | 27 |
| Kewdale yard to Supermart | 35 | 15 | 12 | 2.3 | 0.8 |
| **Sub-total** | - | - | - | ***123*** | ***30*** |
| | | | | | |
| **Home-Supermarket-Home** | ***400*** | ***1*** | ***33*** | ***400*** | ***33*** |
| **TOTAL** | **-** | **-** | **-** | **523** | **63** |

*The replacement of neighbourhood shops by "super stores"* means consumers must drive further to buy their food and hardware and rely more heavily on refrigeration to store food between shopping trips. They cannot walk. Due to their preference for large contracts and homogeneous supply, most grocery chains are reluctant to buy from local or small farms. Instead food is shipped from distant large-scale farms and distributors—adding again to transport, packaging and refrigeration energy needs. The "just-in-time" logistics revolution in freight transport compounds these problems, in effect transferring most of the warehousing function to freight-in-transit. *Any disruption to freight, such as fuel supply, empties supermarket shelves in days.*

*Fossil fuel reliance may prove to be the Achilles heel of the modern food system. Oil supply fluctuations and disruptions could send food prices soaring overnight. Decoupling the food system from the oil industry is the key to improving food security.*

## 8.3 Conclusions

**The first priority for remaining oil and gas must be to reduce the dependence of food production on petroleum and simultaneously to end world population growth, then reducing it to levels not dependent on nitrogen fertilisers. This will take decades to**

8 One EJ = one exajoule = $10^{18}$ Joules.

**achieve and requires unprecedented global cooperation. Progressively reducing the level of processing, packaging and the distance food travels will help free up shrinking oil supply for this task. Likewise, a high priority should be given to rapidly reducing, even eliminating, the need to travel by car to shop for food.**

## 9. ROAD AND RAIL TRANSPORT

*It is certain that cheap and available oil will become more and more scarce as the demand for it grows. It is also certain that the cost of preparing too early is nowhere near the cost of not being ready on time.*

Alannah MacTiernan, W.A. Minister for Planning and Infrastructure, in her speech opening the W.A. Sustainable Transport Coalition's "Oil: Living With Less" Conference, August 2004.

### 9.1 Urban Australia

*Australian cities have become increasingly car dominated since Word War II* to a stage where congestion is acute along with a myriad of other associated social, economic and environmental problems. In regional Australia large urban centres have grown and small ones declined. These urban communities depend heavily on petroleum fuels for internal transport, and for imported food and raw materials as well as for the export of their products. The Institute for Sustainability and Technology Policy at Murdoch University in W.A. is a world authority on cities from these viewpoints. Below is a summary of their studies as presented at the *Beyond Oil* Conference organised by the Sustainable Transport Coalition of W.A. in February 2003 **(Kenworthy 2003).** It is based on a study of 100 large and small cities around the world for 1995 and gives insights on the responses needed for the post-petroleum era.

- *Passenger-km per capita* is by far the highest in the car-dependent cities of the US (18,195), ANZ (11,387) and Canada (8,645), diminishing significantly in Western Europe (6,202) and even less for other world cities. The same pattern exists for freeway length per capita.
- *Energy use per capita* for private and public personal transport follows the same pattern and scale with private energy use by car dominant.
- *Urban density in persons per hectare* showed the reverse pattern—lowest in the US, ANZ and Canadian cities and higher in the rest, for the most part. Auto-dependent cities are invariably low density. Central locations at higher density have much lower energy use than areas far from the city centre and at lower density. Perth represents an extreme case.
- *Transit boardings per capita* were lowest in the car dependent cities.
- *Bus-only cities* tend to languish in public transport patronage. Buses stuck in traffic cannot compete with cars.
- *Energy consumption per passenger-km* for rail transit was less than half that for buses in nearly all cities. Rail transit is almost all electric powered, not by petroleum products.
- *The proportion of trips by walking and cycling* in transit-oriented cities were several times higher than in car dependent cities.
- Centrality, density, mixed use of land, transit access and permeability of the urban environment are all factors that improve from the fringe to the centre.

*Kenworthy concluded* that there are some confronting, but ultimately optimistic conclusions:

- The whole problem of automobile dependence and high transport energy use must be tackled systematically through better technologies, better pricing and better urban and transport planning.
- The problems of energy use in transport cannot be solved by technology alone.
- The kind of urban planning principles we use, and the transport infrastructure priorities we have, will significantly determine how we cope with the post-petroleum era.
- Reducing our built-in energy dependence will, however, have enormous positive spin-offs in the overall sustainability and livability of the city.
- *Step 1*; Better public transport.
- *Step 2*; more use of non-motorised modes and better conditions for pedestrians and cyclists.

- *Step3*; compact, mixed use urban planning integrated with public transport.

*In addition **Laird et. al (2001)** show that car dependent cities spend almost double their wealth per capita on personal transport than those with a strong public transport focus and have a much higher incidence of deaths and injuries from transport accidents. Likewise fares in transit based cities recover a much higher proportion of the cost of public transport.*

*In Perth there has been a growing imbalance* between the city residences and employment locations leading to increased commuting from outer to inner suburbs for work, *Table 15* **(WAPC 2004)**. The outer suburbs are poorly served by public transport and people with low incomes and insecure employment prevail. Escalating urban land prices are increasing the adverse impacts of these trends. *These people, the unemployed and their communities are those most vulnerable to rising fuel costs. Similar patterns would exist in other cities*.

*Roads are financed* by government taxes (akin to a subsidy) supported by a powerful transport lobby whereas public transport infrastructure is mostly financed by loans in a climate where government borrowings have been frowned upon. This imbalance has been a major factor leading to car-dependent cities in Australia. **The trend to privately owned billion dollar toll roads since the mid 1990s and neglect of rail public transport is the most disastrous infrastructure investment strategy ever pursued in this country.**

*New suburban infrastructure is partly subsidised as well*, reinforcing the trend to low-density urban sprawl. Developers fund the local roads and water service infrastructure on Greenfield sites, but not the macro linking components. The marginal cost of urban sprawl is escalating.

**Table 15**
**Population & Employment Shares in Perth 1971-2001**

| Region | 1971 | 1981 | 1991 | 2001 |
|---|---|---|---|---|
| *Per Cent of Metropolitan Population* | | | | |
| Inner city | 31.8 | 21.7 | 15.5 | 13.8 |
| Middle | 45.7 | 39.8 | 36.0 | 32.4 |
| Outer | 22.5 | 38.5 | 48.6 | 53.9 |
| *Per Cent Metropolitan Employment Share* | | | | |
| City of Perth | 31.2 | 24.4 | 20.7 | 18.1 |
| Inner city | 29.6 | 25.2 | 22.8 | 20.6 |
| Middle | 26.1 | 32.0 | 33.1 | 31.8 |
| Outer | 14.1 | 18.4 | 23.4 | 29.4 |

## 9.2 The road deficit

*The ‘externality’ costs for road transport are very high, revenue does not cover costs*—there is a large road deficit. The principal items are listed in *Table 16* from **Laird et. al (2001).** The deficit would now be much larger due to ending of fuel excise indexing and other concessions, and much larger congestion costs. *The total costs of road transport were broadly estimated at some $80 billion in 1992-93 and could now be $130-150 billion.*

## 9.3 Freight Transport

*What road system costs are attributable to the operation of heavy trucks* is contentious and sensitive to assumptions and data limitations. There is significant under-recovery of road system costs from heavy articulated trucks and road trains that haul long annual distances—up to 80 per cent on long hauls[9]. Australia now has the highest road freight per capita in the world. *Table 17* summarises the situation for 1997-98 and shows a shortfall of over $2 billion including environmental and road crash costs **(Laird et. al 2001)**.

[9] The cost of damage to roads from vehicles varies as the fourth power of axle load.

Federal concessions on diesel excise in 2000 have increased the freight deficit by well over $620 million per year. Improvements in rail freight have eliminated rail deficits since the mid 1990s. Rail freight over medium-long distances is at least three times as fuel-efficient as road freight. There is a growing effort by Federal and State governments under the *Austrans* program to upgrade, integrate and standardise rail freight systems to increase the proportion of freight carried by rail. However, there is a huge investment backlog, especially in NSW and Victoria. Federal-state conflicts on strategy and financing are another problem. Proposals to progressively introduce mass-distance charges for road freight are being proposed as rail systems become improved to reduce the large subsidies to long-distance articulated trucks.

**Table 16**
**Australia's Road Deficit 1997-98**
**$ billion**

| | |
|---|---|
| Road system costs | 7.0 |
| Total cost of road crashes | 15.0 |
| Other health impacts | 3.0 |
| Net refunds for vehicle use | 2.8 |
| Queensland fuel subsidy | 0.5 |
| **Total costs** | **28.3** |
| Federal excises from road vehicles | 8.5 |
| Annual registration fees etc | 3.8 |
| Insurance premiums for road crashes | 8.0 |
| **Total revenue** | **20.3** |
| | |
| **Net road deficit—no congestion** | **8.0** |
| Road congestion in major cities | 11.0 |
| **Net road deficit with congestion** | **19.0** |

**Table 17**
**Australia's Road Freight Deficit 1997-98**
**Million dollars**

| | Articulated trucks | Rigid trucks | All trucks |
|---|---|---|---|
| Attributable road system costs | 1,955 | 545 | 2,500 |
| Road user charges | 720 | 495 | 1,215 |
| **Net road system costs** | **1,235** | **50** | **1,285** |
| Road crash involvement costs | 450 | N/A | 450 |
| Environmental costs | 282 | 157 | 439 |
| **Hidden subsidies** | **2,017** | **207** | **2,224** |

## 9.4 Perth: Network City Plan 2004

The *Network City: community planning strategy for Perth and Peel (2004)* attempts to address these problems of dysfunctional car-based urban development, and does so aware of the need to adapt to the era of declining petroleum fuels for transport[10] **(WAPC 2004)**. *An innovative democratic approach to developing such urban plans was used. See Section 1 for further detail*. Network City focuses on developing several urban centres and sub-centres as commercial and employment nodes and to maximise population growth by 'infill' in existing

[10] The focus on oil vulnerablity in Network City originated with the Minster for Planning and Infrastructure, Alannah MacTiernan. She publicly acknowledges that the future of oil supply is at the centre of her ministerial strategy and that she was inspired by my book *The Decline of the Age of Oil.*

urban areas, preferably around transit stations. Over time employment can be localised and car use and long-distance commuting reduced and strong local communities can emerge.

*At this stage 'peak oil' has a low public profile in Network City.* But the groundwork has been laid for people to mobilise and create a far reaching and rapid transformation of their lives to cope with the new energy environment. Democratic participation processes along the lines outlined in Section 1 will be necessary to achieve these tasks.

## 10. CHINA AND INDIA

*China and India, but particularly China*, are experiencing rapid economic and urban growth. Their population of 2.4 billion is double that of the developed industrial world with its high per capita resource consumption. *It is inconceivable that their resource consumption can grow to even half the levels of the developed world*. The most rapid rural-to-urban migration in history is occurring, partly as a consequence of the use of expensive nitrogen fertilisers in India that have undermined the viability of traditional agriculture. In China there is pollution on a massive scale and growing unrest as the wealth gap grows between the rural and urban population. 30 per cent of China's cropland is suffering from acidification from acid rain due to air pollution, and the impact of nitrogen fertilisers. China consumes 1.5 billion tonnes of coal a year and most of it is sulphurous.

There has been an eight-fold increase in China's automobile production since 1995 to 2.6 million in 2005. *China is the main driver of world consumption growth of oil and is now the second largest consumer after the USA*. If China and India were to reach Japan's level of oil consumption per capita (60 per cent of US) they would be consuming 100 million barrels of oil per day, and the world twice as much (**Wordwatch Institute 2006).**

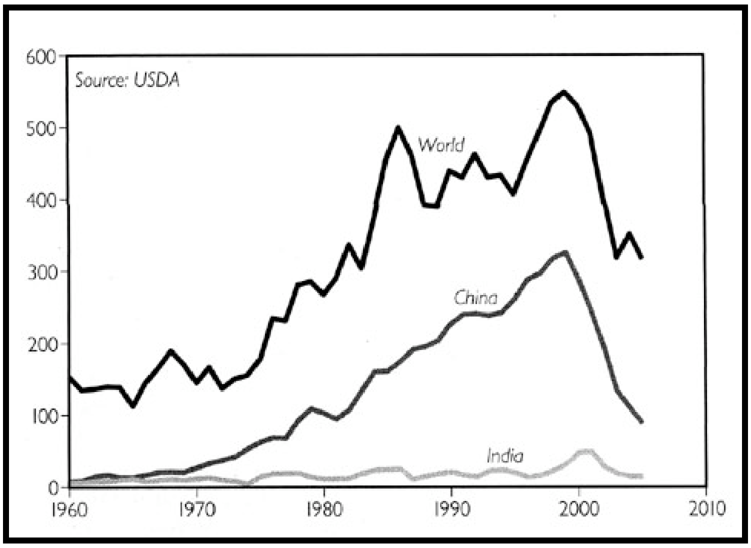
*China is reputed to be aiming at 200 million vehicles.* The USA has 214 million vehicles that use 160,000 $km^2$ of land for roads and parking—equals the area planted to wheat. At the Japanese level of road and parking provision (one-third the US rate per vehicle) 200 million vehicles in China would require 50,000 $km^2$ of land, *plus* the land consumed by urban sprawl.

*World grain production was flat from 1996 to 2003*, but increased by 9.5 per cent in 2004 due to favourable weather and higher grain prices, but still below consumption. Grain stocks have fallen since 1998 **(Flavin & Gardner 2006)**. *See Figure 8.* Grain consumption in China has outpaced production since 2000 where industrial and urban development is encroaching on cropland. Since 1979 China has lost an average of 5,000 $km^2$/year to urban development that now amounts to over seven per cent of the country's agricultural area—130,000 $km^2$, and most of this since 2000. The rate of loss would be even higher now as urban development is accelerating. *Additional agricultural land is being lost to infrastructure provision and industrial parks.*

Water shortages are also adversely impacting on grain production. Groundwater is pumped to irrigate wheat in northern China at rates exceeding recharge of aquifers from rainfall. As aquifers fail wheat production falls, compounded by the competition between cities and farmers for this water. This has been an important factor in China's grain production decline since 1998. In the 1990s in India 21 million tube wells were drilled and farmers pump out 200 $km^3$ of water each year at rates well in excess of recharge. One quarter of farms are irrigated with this water **(Brown 2004)**. India is facing grain supply and rural water crises of major proportions.

*Do water shortages and urban/industrial development in China and India mean that their economic development is unsustainable because it compromises grain production? The world cannot meet the shortfall.* The physiological limits of plants for further increases in grain yield per hectare are being reached. There is a limit to the proportion of the products of photosynthesis that can be diverted to grain at the expense of roots, stalks and leaves.

**Figure 8**
**Grain Stocks**
**World, China & India 1960-2004**
**Million tons**




*China's escalating consumption of minerals is driving Australia's economic growth—iron ore, coking coal, nickel, alumina and copper. Our economic future is becoming integrated with that of China's, and to a lesser extent India, as they expand manufacturing, urban and service provision.*

**The Western industrial model is not an option for China or India. This reality will probably surface in the near future when a bad season leads to low grain production.**

## 11. GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

### 11.1 Asia Pacific Partnership on Clean Development and Climate

*Debate has grown since the 1980s over climate change* due to carbon dioxide emissions from the burning of fossil fuels and other factors. The deliberations of the Intergovernmental Panel on Climate Change (IPCC) led to the draft Kyoto Treaty in 1999, formally endorsed in 2005. Australia and the USA are among a few nations that have not signed on to Kyoto. Recent weather patterns have led to growing acceptance of the reality of anthropomorphic climate change. That led to the inaugural meeting of the Asia Pacific Partnership on Clean Development and Climate (APPCDC) in Sydney in January 2006—Australia, China, India, Japan, South Korea and the USA. Only Japan has joined the Kyoto Treaty.

The Australian Bureau of Agriculture and Resource Economics (ABARE) produced a background report for the APPCDC meeting, *Technological Development and Economic Growth; Research Report 06.1* **(ABARE 2006).** The reference year is 2001 with projections to 2050 for population, economic growth, fuel consumption and greenhouse gas emissions. It examined three scenarios related to greenhouse gas emission reduction from fossil fuel use, (1) business-as-usual, (2) energy efficiency and fuel options, and (3) the latter plus greenhouse gas sequestration. **The report did not discuss the peak oil debate or its implications AT ALL, nor did it question any resource constraints to economic development that might**

**exist, as have been raised in this submission.** *Table 18* show the report's projections for oil consumption for the reference year and 2050 projections for scenario 3[11].

*The ABARE projection for APPCDC oil consumption continuously increases to 2050 and is double the ASPO estimate for 2050 and approaches world consumption in 2005.* APPCDC projected consumption of *all energy* in 2050 is more than world consumption in 2001 at 9,200 million barrels of oil equivalent (BP 2005). The ABARE projection implies cumulative world oil production by 2050 of around 3,000 Gb, which further implies a world ultimate of at least 6,000 Gb, 2.5 times the ASPO estimate. ASPO estimates world oil production in 2050 will be 35 million million barrels per day and will have virtually ceased in the US-48, Europe and Russia, *Figure 2. The US could not afford to import oil at more than double its current rate in 2050—and all its natural gas as well.*

**Table 18**

**ABARE Oil Consumption Projections 2050**

**ASIA PACIFIC PARTNERSHIP ON CLEAN DEVLEOPMENT AND CLIMATE**

| Country | 2001 | | 2050 | | | |
|---|---|---|---|---|---|---|
| | Oil—actual | | All energy | Oil | | |
| | M.toe[12] | M.bls/day | M.toe | Per cent | M.toe | M.bls/d |
| Australia | 38 | 0.75 | 230 | 34 | 78 | 1.6 |
| China | 232 | 5.0 | 3,750 | 26 | 975 | 19.6 |
| India | 107 | 2.3 | 1,550 | 37 | 575 | 11.5 |
| Japan | 507 | 5.4 | 450 | 48 | 215 | 4.3 |
| S. Korea | 103 | 2.2 | 350 | 50 | 175 | 3.5 |
| USA | 896 | 19.6 | 3,300 | 42 | 1,385 | 28 |
| **Total** | **1,614** | **35.3** | **9,650** | | **3,400** | **68.5** |
| **World** | **3,552** | **76.3** | **Implied world oil consumption** | | | **~140** |
| **ASPO** | | | | | | **~ 35** |

*ABARE projects a proportionate decline in coal use* in all six countries by 2050, and in aggregate a corresponding slight increase for oil and gas and a strong increase for nuclear power. Nevertheless, consumption of ALL the energy sources considered increases from 2001 levels. There is not much doubt that resource depletion for petroleum resources will shape future energy regimes. *Neither coal nor nuclear have the qualities needed to substitute for petroleum in transport and agriculture as we use them today.*

**The approaching decline of oil and gas production will be the main driver reducing greenhouse gas emissions arising from fossil fuel consumption. It is unrealistic to expect coal-based fuels to replace oil and gas in their transport roles. Policies to curtail fossil fuel consumption to reduce greenhouse gas emissions MUST be integrated with those for managing the decline of oil and gas production.**

**Government agencies like ABARE MUST start seriously addressing the peak oil issue and factoring it in to all their reports and recommendations.**

## 11.2 Intergovernmental Panel on Climate Change

Since 1992 the Intergovernmental Panel on Climate Change (IPCC) has published reports on climate change arising from greenhouse gas emissions based on fossil fuel combustion scenarios and other factors ***(IPCC 2000).*** These scenarios are not reported in the media nor does IPCC make assessments of their likely occurrence. Environmentalists and others accept

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[11] The data for 2050 in Table 13 was scaled off charts and should only be regarded as approximations. Actual oil data for 2001 is from BP (2005)

[12] M.toe equals million tonnes oil equivalent.

these emission projections without questioning their validity. **Few people are aware that the IPCC does not attach probabilities to them.**

*The 40 IPCC scenarios for coal, oil and natural gas consumption* are grouped into four major scenarios, each with variations within common themes. The storylines are based on economic and population growth patterns, environmental, greenhouse and land-use factors, technology innovations and polices together with different biases in fossil fuel consumption. *These lead to per capita fossil fuel consumption scenarios to 2100.*

*The essence of the scenarios are described and critiqued below* based on a study at Upsalla University in Sweden *(Sivertson 2002).* My aim is to raise sufficient questions needing answers to stimulate others to take the issues up in greater detail. The IPCC has begun revising its year 2000 scenarios, to be completed by late 2007.

*IPCC developed a set of four scenario families* incorporating the 40 scenarios. Each is described by a storyline ***(IPCC 2000a)***. Six teams developed long-range economic, technological and environmental models to generate quantifications of the storylines for different scenarios. The modeling teams are shown in *Table 19.* All scenarios from the same storyline constitute the scenario family. ***Marker scenarios*** were chosen as the most illustrative of a particular storyline but are neither more nor less likely than any other scenario.

***There were no business-as-usual or disaster scenarios, nor surprise ones such as large-scale environmental or economic collapses***. The scenarios were not intended to predict future energy prices, nor factors such as taxation levels.

**Table 19**
**IPCC Scenario Teams**

| Acronym | Model name | Origin |
|---|---|---|
| **AIM** | Asian Pacific Integrated Model | National Institute of Environmental Studies in Japan |
| **ASF** | Atmospheric Stabilization Framework Model | ICF Consulting in the USA |
| **IMAGE** | Integrated Model to Assess the Greenhouse Effect | National Institute of Public Health and Hygiene in the Netherlands |
| **MARIA** | Multiregional Approach for Resource and Industry Allocation | Science University of Tokyo in Japan |
| **MESSAGE** | Model of Energy Supply Strategy Alternatives and their General Environmental Impact | International Institute of Applied Systems Analysis in Austria |
| **MiniCAM** | The Mini Climate Assessment Model | Pacific Northwest National Laboratory in the USA |

*The four main storylines are named A1, A2, B1 and B2*. A1 has three sub-scenarios and several groups of scenarios, including ones that explore alternative fossil fuel-intensive developments, technology and economic growth differences. The four storylines describe future world's that are generally wealthier compared to the current situation. These are described below and shown in *Table 20,* with population projections for the *marker* scenarios.

- **The A1 storyline and scenario family** describes a world of low population growth and rapid economic and technology growth with convergence among regions dominated by American and European entrepreneurial and market perspectives, with high consumption.
  There are three sub-groups, as follows;
  ***AIC**:* clean-coal and environmentally friendly technologies, except for GHG emissions.

***AIG:*** an oil and gas rich future with a rapid transition from *conventional* hydrocarbon resources to rich *unconventional* resources, including *methane hydrates*[13].

***AIT:*** a non-fossil fuel future with rapid development of solar and nuclear technologies, with mini-turbines and fuel cells used in energy end-use applications.

- **The A2 storyline and scenario family** describes a world with self-reliance, lower trade and slow capital stock turnover, fewer social and cultural interactions and local identities maintained. High population growth. Regional economic development with slower economic growth and development of technology, is more fragmented and slower than in other storylines. Regions with energy and mineral resources become resource-intensive economies. Regions poor in resources minimise import dependence through technological innovation and use of alternative imports. Agricultural productivity has a high focus.
- **The B1 storyline and scenario family** describes a convergent world with the same low population growth as A1, but with rapid changes to a service and information economy with reduced material intensity and clean resource-efficient technologies. There is a global approach with high environmental and social consciousness and attention to equity, social institutions and environmental protection, income redistribution and high taxation levels. A transition to alternative energy systems. Cities are compact and designed for public transport. Low-impact agriculture and large wilderness areas. Low GHG emissions.
- **The B2 storyline and scenario family** emphasis is on local solutions to economic, social and environmental sustainability with high levels of education and welfare, moderate population growth, intermediate levels of economic development on local and regional levels with environmental protection and social equity. Urban development reduces car dependence and growth with an emphasis on food self-reliance. Reduced hydrocarbon-based energy systems.

The features belonging to the same family were ***harmonised*** in 26 scenarios to have common assumptions about global population and gross domestic product. The scenarios share some features but differ in others. The remaining 14 scenarios explain alternatives to the harmonised scenarios, e.g. in economic growth and population projections.

**Table 20**

## Features of the IPCC Scenarios

| **Family** | **A1** | | | | **A2** | **B1** | **B2** |
|---|---|---|---|---|---|---|---|
| **Scenario** | **A1C** | **A1G** | **A1** | **A1T** | | | |
| Population growth | Low | Low | Low | Low | High | Low | Medium |
| Billions 2050<br>2100 | **9**<br>**7** | | | | **11**<br>**15** | **9**<br>**7** | **9.5**<br>**10** |
| GDP growth | Very high | Very high | Very high | Very high | Medium | High | Medium |
| Energy use | Very high | Very high | Very high | High | High | Low | Medium |
| Land-use changes | Low-med. | Low-med. | Low | Low | Medium-high | High | Medium |
| Resources available | High | High | Med. | Med. | Low | Low | Medium |
| Technical development | Rapid | Rapid | Rapid | Rapid | Slow | Medium | Medium |
| Change favouring | Coal | O&G | Even | Non-fossil | Regional | Efficiency and dematerialisation | Dynamics as usual |

13 Methane hydrates are formed in cool deep ocean water (~ $0^{o}C$ and > 500 to 800m. depth) and comprise methane entrapped in a solid water molecular structure. About $900m^3$ of methane becomes trapped into a $1m^3$ solid. Unconventional gas includes methane hydrates and gas from coal beds.

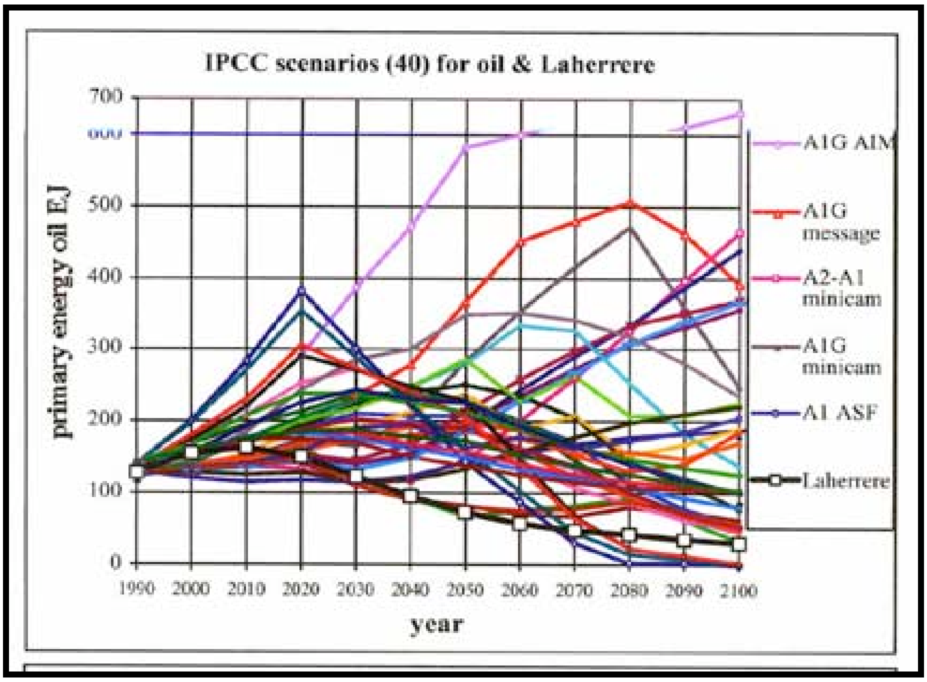
***Figures 9 and 10*** **plot the oil and gas production scenarios to 2100 for the 40 scenarios (Laherrére 2001). At the bottom in black are the ASPO projections for oil and gas for comparison.**

## 11.3 IPCC discussion

**World population** peaks at nine to fifteen billion people in some IPCC scenarios and some reach a peak before 2100 followed by population declines, *Table 20*. The discussion above on *agriculture, China and India* strongly suggest that the limits to world grain production are being reached, consumption growth has started to outstrip grain production growth, a key indicator of food sufficiency. World grain stocks per person halved between 1998 and 2003 *Figure 8.*

**These facts suggest that world population will reach a peak of less than 8 billion people in the near future, followed by decline, limited by grain supply as the key element in food supply. Population levels of 9, 10 and 15 billion are quite unrealistic. IPCC fuel consumption projections are derived on a per capita basis. The A2 and B2 scenarios can be dismissed on these grounds alone.**

**Figure 9**
**IPCC 40 Oil Scenarios & Laherrére**
**1990-2100**

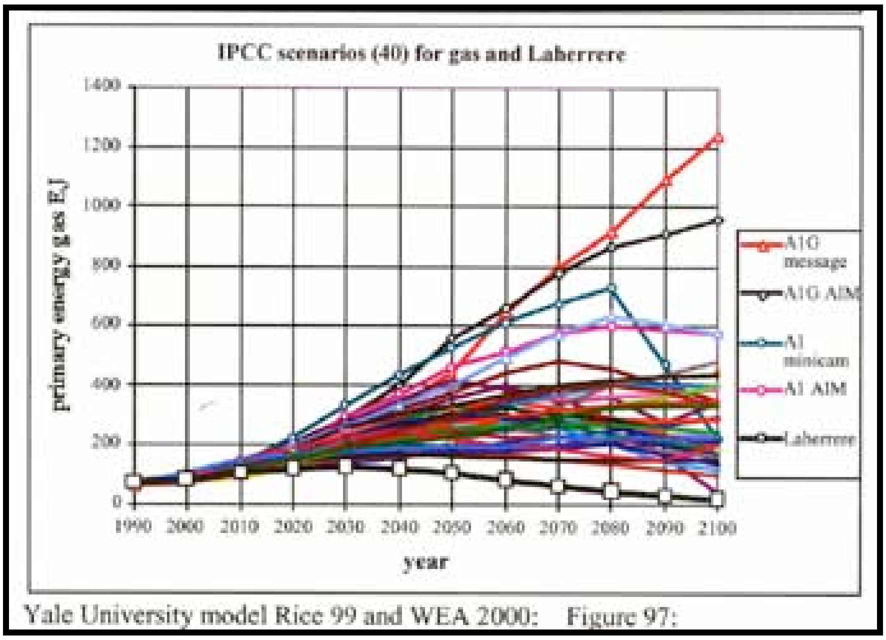



**Economic growth** is projected to continue to 2100 in all scenarios, up to twenty times recent levels for some. In the A1 scenarios all regions converge to the consumption levels of developed European nations. China and India aspire to the lifestyles of developed nations. As described above good agricultural land in China is being consumed at a rapid rate to this end and China is about to become a major grain importer on a scale that the world cannot meet. *China's present economic path is not sustainable in the short term.*

**The Western Economic Model will not work for China or India or any other densely populated developing country (Brown 2005). But many IPCC scenarios are based on this model.**

**The unconventional oil and gas** scenarios are derived from the IPCC population and economic growth models. Most A1, A2, B1 and some B2 scenarios assume large increases in *unconventional* oil production to 2100 that are unrealistic, as discussed above for tar sands and shale oil.

**Figure 10**
**IPCC 40 Gas Scenarios & Laherrére**
**1990-2100**




Methane hydrates occur extensively at shallow depths on the ocean floor where the temperature is close to $0^oC$ and the depths below 800m. The hydrate disintegrates at higher temperatures and lower pressures, releasing methane gas. Large-scale mining operations would be needed with *massive* environmental consequences *on the ocean floor* and where the methane is extracted and compressed for piping onshore. *The cost would be enormous and the risks very high.* The location and scale of such ocean floor projects would be beyond the scope of technology advances to make viable, the energy cost would be very high.

**The high IPCC scenarios for unconventional oil and natural gas assume large-scale affordable production of oil and natural gas following major technology advances. The probability of this happening is virtually zero.**

## 11.4 Conclusions

*The IPCC scenarios to 2100* for population, economic growth, unconventional oil and gas are seriously deficient. There are other deficiencies as well that are not described, but the ones above are sufficient to make my point.

*The decline of oil, followed by natural gas, will set the agenda* for reduced greenhouse gas emissions from the burning of fossil fuels. Where coal might fit into this likely supply scenario is not yet clear and assessments are urgently needed. Using carbon trading to reduce greenhouse gas emissions is now an obsolete concept—it implies greenhouse is the sole determinant of energy policy. Oil has been made from coal in Germany (World War II) and in South Africa (apartheid years) but at high cost and low EPR, and considerable pollution. Coal is most unlikely to replace oil for transport. There are many other factors than greenhouse gas emissions involved in the future use of fossil fuels.

**An integrated approach is needed that draws together population growth, food supply and transport dependence issues with controlling greenhouse gas emissions and responding to declining oil and gas supply.**

*However, global warming arising from anthropocentric greenhouse gas emissions is still a serious issue, but it is not the only one. For example, polar warming due to anthropocentric greenhouse gas emissions is melting permafrost in arctic regions with the potential to release massive quantities of trapped methane to the atmosphere, a potent greenhouse gas.*

**Why did the IPCC choose such outlandish scenarios** for population, economic growth and production of petroleum-based fuels? *I offer this explanation.* IPCC began drafting its scenarios 15 years ago and faced the problem of persuading the member nations to agree to them. The IPCC based these high oil and gas scenarios on the assumption that technologies could emerge for their economic extraction from the resource bases that existed. But **IPCC did not attach probabilities to their technology projections[14]. T**he first priority of IPCC was to commence assessments of the climate consequences. No governments would have taken kindly to assessments projecting an end to economic growth, for example. *Instead IPCC adopted a wide range of options to accommodate all viewpoints on exploitation of the hydrocarbon resource base. Avoiding debate on these contentious issues allowed serious international investigation to begin into the consequences of anthropocentric greenhouse gas emissions.*

**But 'peak oil' is now firmly on the world agenda in ways that did not exist 15 years ago. It is now possible to define probabilities on the 40 IPCC scenarios for oil and gas production.**

*Fifteen years of solid research* into the influence of greenhouse gas emissions and other factors on climate change have followed. There is a growing acceptance of the reality of anthropocentric induced climate change and the need to respond to it. The southwest of Western Australia is already experiencing severe water shortages from the impact of sudden climate change to drier autumns and winters since the mid 1970s. The Water Corporation is investing some $1.2 billion in new water sources from 1998 to 2008 to meet the supply shortfall, along with demand management initiatives to curb water consumption.

**The time has now arrived to abandon these obsolete IPCC scenarios and to replace them with more realistic ones that attach probabilities to the oil and gas projections to 2100. Strategies that respond to anthropocentric greenhouse gas emissions need integrating with those responding to the decline of oil and gas production.**

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[14] "Personal communication from Dr. Barrie Pittock, a Lead Author of the IPCC Third Assessment Report, and former Leader of the CSIRO Climate Impacts Group. He and others have advocated estimating probabilities for emission scenarios and global warming trajectories, but this is still being worked on. The next IPCC assessment, due out in 2007, will discuss probabilistic assessments, which are needed for risk management."

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