**Calculating SEQ carrying capacity in a theoretical sustainable future**

**Michael Gutteridge**

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## 2.1 Aim

Accepted methods for calculating EF assume that Earth is the outer resource boundary and if economically achievable, all resources within this confine are available to contribute to a population's EF. Regional carrying capacity (CC) is effectively shrinking down the Earth available for populations through putting a boundary about a population and then asking how many people can be supported by the newly defined area, assuming various lifestyles which have some semblance of sustainability.

This paper attempts to calculate the CC of SEQ, for some date in the future, where it is expected that the population will be living off the Earth's resource in a more sustainable manner than at present, at least by some inter-generational measure.

## 2.2 Assumptions

It is assumed that in this future world, climate change will be having an effect and thus allowance must be made for potentially deleterio us effects that could reduce land and ecosystem productivity. (Latest estimate suggest up to700 ppm $CO_2$ over the next century, almost 3 times the pre-industrial concentration.) This future is also one where oil has peaked, coal is highly valued as a multi-purpose feedstock[1], see quote below, and for various other reasons it will be necessary to rely on renewable fuels, e.g. bio-fuels for transport, to a large extent. According to the Coal Technology Association & The International Technical Conference on Coal Utilization & Fuel Systems:

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[1] See transactions of: US Department of Energy "30th Clearwater Conference 2005", Florida USA

> "The peaking of world oil production presents the U.S. and the world with a problem of unprecedented magnitude. The world has never faced a problem like this. As peaking is approached, liquid fuels prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be immense. Viable mitigation options exist on both the supply and demand sides, but, to have substantial impact, they must be initiated more than a decade in advance of peaking. Coal-to-liquids is one of the few viable options for producing substitute fuels, which will be required on a massive scale."[2]

Predicting future lifestyles is difficult for it involves assumptions about many variables. As an example if we were all vegetarian, lived in high density communities, planted every golf course and road verge with fruit and vegetables, and used the very latest recycling technologies, then one would think that we could squeeze a lot more people into SEQ. Obviously the opposite could also be true, that is if we all drove Mack trucks, lived on 5 hectare el'ranchos and sent our children to the local pony club, then SEQ would carry far fewer people.

However there is a path out of this tangle of variables, and it starts with a starting point, and that starting point is the cultural profile of today. Once that is established, then we can start to generate scenarios that as much as can be anticipated, will be stable indefinitely, hence, sustainable. This exercise is also helpful as a measure of how much we need to change from our current lifestyle, or adopt technologies, in order to increase a region's carrying capacity.

We also have to accept the reality that many resources that are integral parts of our current way of life are not found within SEQ. These include common and rare ores and minerals, a variety of agricultural or commercial products, or human and

[2] http://www.coaltechnologies.com/2005%20Call%20for%20Papers.html (sponsored by the US Dept. of Energy)

industrial services such as some factories and research facilities. Hence we must accept that we live in an interconnected world, just as the local Aborigines did before European colonisation, and, hopefully as will a sustainable society 200 years from now.

A full analysis of all aspects of modern consumption patterns, hence the lifestyle of the SEQ population, was beyond the scope of this study. Hence, this analysis focuses principally on food production, and thereafter makes some informed guesses regarding other commodities and natural capital elements that are considered essential to the SEQ lifestyle and have been previously quantified in EF calculations[3]. (See appropriate section in this report).

## 2.3 Diet

The average Australian consumes approximately 10,000 kilojoules of food energy each day. This value varies with sex, age, ethnicity and can also fluctuate with climate and physical exertion. The range in food stuffs for the Australian diet is small and reasonably consistent in its balance of carbohydrates, proteins, and fatty foods etc, table 2.1.

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[3] Gutteridge, M., 2005. "Calculating the SEQ Ecological Footprint from a composite of Statistical Local Area economic, demographic and land use data", unpublished paper, Queensland Department of Natural Resources & Mines.

| Food type | classification | KG per year | | | |
|---|---|---|---|---|---|
| Food type | classification | KG per year | | tomatoes | 24.9 |
| Meat | beef | 34.9 | | leafy & green | 19.5 |
| | veal | 1.5 | | other vegetables | 25.1 |
| | lamb | 11.8 | Cereal | wheaten flour | 69.7 |
| | mutton | 5.7 | | breakfast (grain based) | 7.9 |
| | pork | 19 | | bread | 53.4 |
| | bacon & ham | 8.7 | | rice | 7.1 |
| | poultry | 30.8 | Nuts | peanuts | 2.3 |
| | fish imported | 4.5 | | tree nuts | 4.8 |
| | fish domestic | 3.6 | Oil | vegetable and animal | 18.5 |
| | crustacea & molluscs | 2.9 | Sugar | sugar | 43.4 |
| Dairy | dairy products other | 12.6 | | honey | 0.5 |
| | cheese | 10.7 | Beverages | tea | 0.9 |
| | market milk | 102.4 | | coffee | 2.4 |
| | eggs individual 137@ 60g | 8.22 | | carbonated (L) | 113 |
| Fruit | Fruit & juice (mostly citrus) | 135 | | beer low alcohol (L) | 24.7 |
| Veg | potatoes | 68 | | beer other (L) | 68.5 |
| | other root & bulb | 24.4 | | wine (L) | 19.8 |

**Table 2.1** The apparent Australian diet in kilograms of food types per year, equivalent to 16033 kilojoules per day, derived from the Australian Bureau of Statistics, “Apparent Consumption of Foodstuffs”[4].

The sum of kilojoules per day based on the diet in table 2.1 is 16033 kilojoules; however, we are not quite the over-eaters that this implies, although perhaps at the higher end by world standards. The average Australian consumes within the recommended range of kilojoules, and the difference is mainly due to wastage, estimated to be over 30[5] per cent; hence we already have considerable scope for efficiency.

If we convert this diet into food types that, where possible, could be derived from SEQ and apply current levels of agricultural productivity, then we arrive at probable areas necessary to support one adult for a year: see table 2.2 below. The assumptions that were needed for this exercise are detailed in Appendix 1.

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4 http://www.abs.gov.au/Ausstats/abs@.nsf/0/123fcdbf086c4daaca2568a90013939a?OpenDocument

5 Australians over-eating, wasting food: study. 08/05/2005. ABC News Online
http://www.abc.net.au/news/newsitems/200505/s1362441.htm
See also UK study, John Vidal “More than 30% of our food is thrown away – and its costing billions per year” in
http://society.guardian.co.uk/environment/news/0,14129,1460299,00.html

| Food types | Hectares per capita per year |
|---|---|
| Meat | 1.802 |
| Eggs & dairy | 0.046 |
| Fruit & veg | 0.015 |
| Grains, oilseed & nuts | 0.08 |
| Sugar & beverages | 0.004 |
| **Total** | **1.947** |

**Table 2.2** SEQ EF for agriculture based on standard Australian dietary intake and average SEQ yields.

This figure for food is higher than comparable figures calculated for example Canberra 1.4hcy[6] and London 1.6hcy[7]. It is believed that the principal reason for the difference is that other calculations, based on standard EF methods, draw resources from the most productive parts of the landscape where also the effects of fertiliser and water are optimal under current industrial farming methods. Also in the SEQ calculation, cattle and sheep are grazed and not placed in feedlots for finishing which is also likely to inflate the EF figure.

However pigs and poultry were calculated as if raised intensively, but it should be acknowledged that they make up a smaller portion of the diet than the grazed meats. As will also be shown further in the text, limitations on suitable land to either graze or grow stockfeed crops suggest that the calculations used in this report i.e. the mix of grazing and intensive farming, were the optimal use of the land resource for meat production in the future world senario. This is not to say, though, that meat eating is an optimal use of potentially scarce land and energy resources.

Given that the population's diet requires an area of 1.947 hcy from table 2.2, and that the total SEQ area is only near 2.2 million hectares, the carrying capacity would therefore be 2,200,000/1.947 = 1,129,943 people. In this model there is an assumption

[6] Lenzen, M. 2004. "Measuring Our Progress: Canberra's Journey to Sustainability", Volume 3, Commonwealth of Australia, Canberra

[7] WSP Environmental Limited and Natural Strategies LLC, 2003. "Towards a Sustainable London: Reducing the Capitals Ecological Footprint: Phase 1 Report, Determining London's Ecological Footprint and Priority Impact Areas for Action, London. http://www.wspgroup.com

that non-agricultural land is still considered as a resource, hence is counted as part of the EF which provides commodities such as timber, recreational reserves, or as an ecological preserve that buttresses the health of local stocks of natural capital, i.e. healthy water ways, biodiversity, clean air.

## 2.4 Bio-physical constraints

However, due to biophysical limitations imposed by the environment on agriculture, it is not possible to utilise all of the 2.2 million ha of SEQ to grow food as inferred by the 1.947 hcy calculation in section 2.3 above. Also some agricultural land is suited to only a limited range of activities e.g. grazing, hence there are regions that are more productive or suitable than others. Figure 2.1 shows the approximate percentages of SEQ that are given over to various land uses. It is assumed that historical development patterns have shaped the mosaic of agriculture, and, as is common in Australia, regions that were best suited to a particular form of agriculture were developed upon settlement and have usually remain in continual service ever since. Perhaps the main exception to this would be that good quality agricultural land that has succumbed to urbanisation in former capital city hinterlands. It is also assumed that those areas that have remained relatively undisturbed from their natural state are likely to be the least suitable for high value - high productivity agriculture.

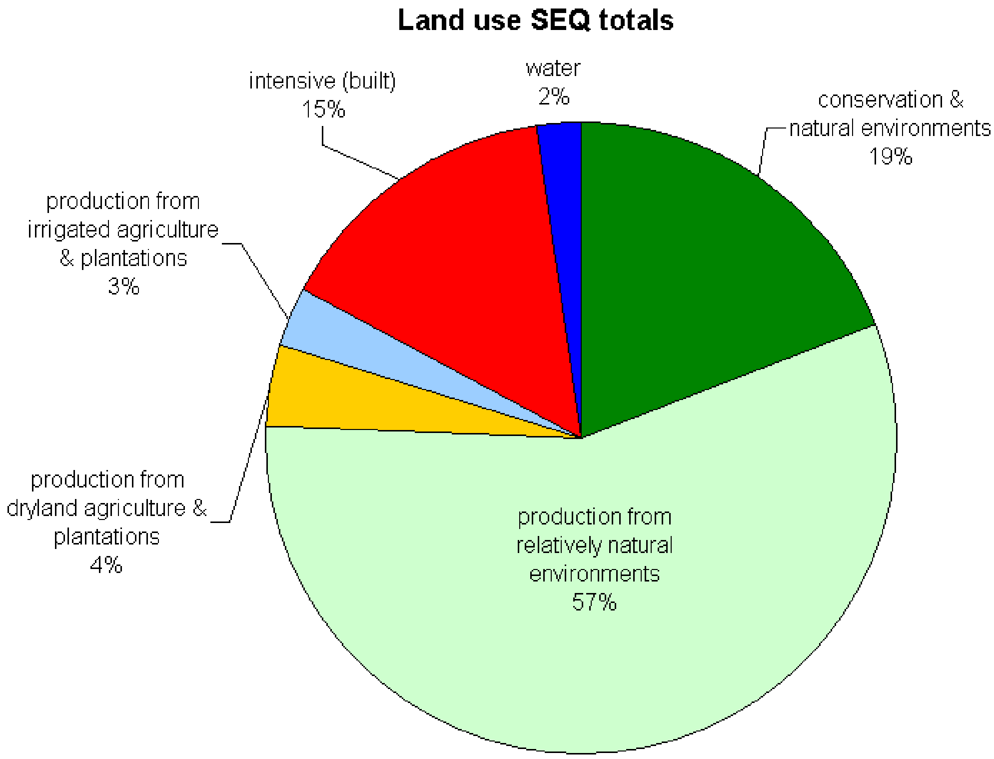


**Figure 2.1** SEQ classes of land use as derived from the 1999 NR&M land use map.

Based on the land use map, figure 2.1, there are approximately 1.6 million hectares of agricultural land in SEQ, of varying productive potential capable of fulfilling the populations dietary profile.

### 2.5 Land-types for food groups

The various food groups identified in Tables 2.1 – 2.2 can be assigned across the most appropriate agricultural regions, as identified in figure 2.1, such as grazing for beef and sheep to the class "relatively natural environments" (57%), dry-land cereals and oil seeds to "dry-land agriculture and plantations" (4%), fruit, veg and dairy from "irrigated agriculture and plantations (3%), etc. (Note, aquaculture was not calculated even though water area was registered at 2% of the SEQ area.) From the diet we can identify how much land area is required for the various food groups; see tables 2.3

and 2.4 below, and thereafter the population that can be fed on available areas suited to those land use types, in table 2.5.

| Percentage of diet | Farming region needed |
|---|---|
| 7.05% | meat from grazing |
| 8.83% | meat from broad acre |
| 1.19% | meat from water |
| 10.64% | dairy from irrigation |
| 4.48% | fruit from irrigation |
| 5.52% | veg from irrigation |
| 0.83% | eggs from broad acre |
| 29.82% | cereal from broad acre |
| 2.29% | nuts from irrigation |
| 10.75% | Oil from broad acre |
| 12.58% | sugar from irrigation |
| 6.02% | bev from irrigation |

**Table 2.3** Percentage of food groups in diet and their agricultural source[8].

| Totals | Land use | KJ |
|---|---|---|
| 7.05% | grazing | 1130.09 |
| 50.23% | broad acre | 8053.936 |
| 41.53% | irrigation | 6658.775 |
| 1.19% | water | 190.6 |
| 100.00% | | 16033.4 |

**Table 2.4** Kilojoules meet by each food group.

[8] It should be noted that even though fish, prawns etc were calculated as part of the diet, and makes a small contribution to the EF, the calculations were not carried through to fresh or marine water areas within SEQ.

| land area | Land use | MJ year | Population |
|---|---|---|---|
| na | conservation & natural environments | 0 | undisturbed |
| 1440360 | production from relatively natural environments | 121.12 | 422,975 |
| 111720 | production from dryland agriculture & plantations | 32000 | 1,064,105 |
| 72000 | production from irrigated agriculture & plantations | 33721.25 | 998,928 |
| na | intensive (built) | 0 | non agricultural |
| na | Water | 0 | not calculated |
| 1624080 | Total | | |

**Table 2.5** Land area available for each food group, and the population that can be supported based on the average diet.

The data in table 2.5 indicates that the SEQ agricultural landscape allows for only 422,975 people if grazing lands are deemed the limiting factor, 1,064,105 based on dry-land agriculture and 998,928 based on irrigated agriculture. Hence, unless there is a dietary change where more food is sourced from dry-land and irrigated agriculture, the population's upper limit is determined by limitations in meat production, hence the primary protein food group.

As alluded to in the text previously, the agricultural districts that are already allocated to grazing are ill suited to other forms of agriculture. This is also true for dry-land and irrigated land uses where regions more the most part are not interchangeable. Theoretically the total population can be increased by skewing the diet away from meat in favour of cereals, fruit and vegetables, however in so doing we it would rely more on the these limited cropping lands and hence find the population increase wouyld not be substantial.

If we accept that the population is limited by the meat component of the diet, this equates to approximately 423,000 over an SEQ area of 2.2 million hectares, i.e. effectively an EF of 5.5 hcy. As with the previous calculation, this figure includes conservation areas, catchments and other non-agricultural regions, that perhaps, if society were pushed toward hunger or its values were to change significantly in the future, could be turned to agriculture, albeit less productive than already established regions.

This is indeed a relevant issue, for if it were to also argue that we are not already exploiting the agricultural lands to their full capacity, we must ask the question, how much more can we extract from the land? It should be noted that in SEQ, boutique crops such as turf and cut flowers, which it is presumed are dispensable, make up a negligible proportion of the land area, albeit often in prime locations.

### 2.6 Can production be increased?

Most crops are grown on the land with the best soil, and over the past one and a half centuries, the best parts have been exploited. What remains as grazing land is ill suited to either broad acre or irrigated cropping, and if it could have been farmed, it would have been done a long time ago[9].

#### 2.6.1 Organics

This report suggests that adopting organic farming is not likely to expand production for SEQ, and at best may only match current yields over the longer term, albeit by using more labour attributed to the loss of economies of scale inherent in industrial farming. This is not to say that organic would not be beneficial in the landscape, and there is considerable evidence to suggest that it would increase ecological capacity-resilience over the longer time period, it is just that the yield for the total area is not likely to increase. Within the research constraints of this report, it appears that the subject of organic agriculture has not been well documented in scientific literature, but some references are provided in the footnotes to help to substantiate the opinion forwarded by this report.[10]

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[9] Pers com Dr. Holger Mienke Qld Department of Primary Industries, APSRU office Toowoomba

[10] Trewavas, A, 2001. "Urban myths of organic farming: Organic agriculture began as an ideology, but can it meet today's needs?" in *Nature*, Vol 410, 22 March 2001, pp409-410 or Tilman, D, 1998. "The greening of the green revolution", in *Nature*, Vol 396, 19 Nov 1998, pp211-212 or Pimm, S.L., 1997. "In search of perennial solutions" in *Nature*, Vol 389, 11 Sept 1997, pp126-127. A considerable body of pro-organics literature was found on the Internet; however, very little credible evidence was given to imply that broad scale agricultural yields would be increased.

### 2.6.2 Water

Because the land is presumed to be utilised near capacity, and the landscape already suffers at some locations from hydrology-related problems (acidification, improper extraction or harvesting schedules etc), the application of more irrigation water is not likely to increase yields within SEQ[11]. That is not to say that some areas would not benefit; however, the evidence suggests that any extra water that could find its way into the district would be best suited to offsetting current rates of over-extraction and harvesting of ground water and dry-season channel flows[12].

### 2.6.3 Double cropping

For the most part climate and length of growth season limit opportunities for double cropping in SEQ. Once again, if it could be done it would have been part of optimal farming practice today. Hence this strategy is not expected to significantly increase yields.

### 2.6.4 Green houses

A problem with horticulture in SEQ is that, as far as vegetables and some fruits are concerned, it is *beautiful one day and perfect the next*, so the advantages gained from glasshouses as experienced in cooler climates are not transferable and in most cases the increased production costs do not justify the extra expense. Similarly, hydroponic glasshouse systems offer little advantage over current growing regimes in SEQ, if any. According to the Qld Department of Primary Industries:

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[11] Some studies have shown that if more water were available in the Darling Downs, a wider range of crops, or greater reliability in cropping would be possible.

[12] Queensland Government 2003. “State of the Environment Queensland 2003, State of Queensland Environment Protection Agency, Brisbane

> There is little potential to expand production of vegetables for domestic markets. And any major expansion of vegetable production in the region would have to be aimed at high value export markets to justify the costs[13].

The problem can also be looked at this way: tomatoes and other glasshouse-hydroponic vegetables deliver to the kitchen 11,200MJ/ha of energy to the human but wheaten flour is four times this at 45,000MJ/ha, and we can only solve the shortfall by going to a lower-entropy diet biased more toward cereals; hence, we would be better to replace current market gardens with cereal. Cereal crops, however, gain nothing from the construction of glasshouses and a mass change would introduce problems with dietary balance.

Indeed if we were to claim that yields in SEQ could be significantly increased, then we would have to admit that the current market system that allocates resources and investment is failing farmers and society in general. The counter argument, however, is that if society were to get desperate enough, then the market would force us to produce more food at the expense of other lifestyle choices, e.g. de-urbanise from good quality agricultural land, plough over parks and golf courses. Should that prove to eventuate, then one could argue that the markets have failed society by allowing the choices to become so stark as to necessitate radical approaches and indeed not even predicting this well in advance.

## 2.7 Sustainability

Having identified that there are not likely to be significant yield increases in the near future, it should also be question if the current agricultural yields, or exploitation of other resources, can even be sustained well into the future.. A reading of State of the Environment reports for Qld, volume on volume, suggests that the environment is indeed being continuously over-exploited. However, it is acknowledged that specific

[13] Qld Department of Primary Industries, Horticulture in the Lockyer Valley, http://www.dpi.gov.au

targets for change or detrimental land use type and methods are hard to identify, politically sensitive to name, or may be considered essential services to the society or the economy, hence they are considered necessary even though not environmentally sensetive. Some of these problems include loss of soil fertility, water quality, erosion, reductions in remnant vegetation or ecological integrity. Dunlop (2004) suggests that over most of Australia the population are living on borrowed time:

> "Due to ever increasing rates of addition of new agricultural land over the last 140 years, about half of Australia's cropland and sown pasture has always been less than 35 years old and relatively unaffected by loss of landscape function. This has masked the effects of sustained losses of landscape functions in older lands. When new land stops being added at this rate, the proportion of degraded land will increase dramatically unless future rates of loss of landscape function are reduced dramatically."[14]

For many years similar calaims have been made by environmental scientists such as Doug Cocks "Use with care", Tim Flannery "The Future Eaters" etc. Dunlop suggests in "Future Sustainability of the Australian Grains Industry"[15] retiring of the less productive lands or adopting other major strategies for maintaining production into the future will be a necessary part of Australian agriculture and land management in general. Many of the problems that he identifies across large swathes of Australia can also be found to varying degrees in SEQ.

This report assumes that we are already pushing both the agricultural and the natural capital resources of SEQ too hard and as a consequence current yields are not sustainable without major applications of fertiliser, hydrological works or other engineering solutions which may not be practical in the future. In the future our ability to rely on supporting technology may be inhibited by reduced access to energy for fertiliser production or transport oandengineering works that are prohibitively expensive when compared to potentially declining yields. Problems may also be

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[14] Dunlop, M, & G Turner, S Howden 2004. "Future Sustainability of the Australian Grains Industry", CSIRO Sustainable Ecosystems, Commonwealth of Australia, p2.

[15] ibid

exacerbated by the uncertainties of climate change where the manifestations may be beyond the capability of engineering solutions or economics.

This report will therefore suggest a figure by which we are taxing the SEQ environment, including the waterways and aquifers, the soils, the pockets of native vegetation and fauna, and, also will include a buffer for the potentially deleterious effects of climate change as well as natural variability and recovery from catastrophic events such as drought, fire, cyclone, flood, pestilence can be achieved through maintaining sufficient and resilient stocks of natural capital.

It is suggested that we need to reduce our rate of extraction from the agricultural lands by 25 per cent. Although there would probably be little argument in scientific circles that 25 per cent of Australia's least productive lands could be retired, and indeed Dunlop suggests that the rural economy would be better off due to improved efficiency if significant portions of marginal lands were put over to conservation or lower impact grazing. This report however goes further and suggests a broad spectrum approach whereby it is not just the least productive lands that are rested, but strategies should also be devised whereby the impact on all agricultural land is reduced, be that by retiring,extending fallow cycles or employing similar techniques. This approach would arrest the decline that has already been documented, and leave some natural capital in reserve to deal with some of the challenges that are looming on the horizon.

The reduced sustainable level of utilisation which repairs existing damage, provides for unexpected lean times or other catastrophes, and ensure continued production into the future reduces our carrying capacity to 317,250 people or an effective EF of 6.93 hcy.

**2.8 Energy**

If we accept the population that has been derived so far in the analysis 317,250 people that has been limited by agricultural potential and sustainable use of agricultural lands, we must also consider that the agricultural system upon which they rely is based to a large degree on high quality energy, either through mechanisation, or in the production and delivery of fertilisers. Without these technological inputs, yields would be dramatically lower and as a consequence so would be the population able to be fed off that area.

It is presumed that SEQ farms will require around 36.156 million litres of diesel per annum[16]. If we were to convert this to bio-diesel derived from canola, we would need approximately 37,600 hectares[17]. That is, approximately 50% of the best-irrigated lands, or more likely, 33% of the broad acre cropping regions in SEQ. It is not considered that grazing lands would provide high enough yields per hectare to achieve a net energy gain.

This figure is only for fuel used on the farm and does not include transport and distribution or processing energy, or even the energy embedded in fertilising or irrigation. Many commentators argue that there is little to no net energy surplus after growing bio-fuels when all of these are taken into account[18], (life cycle analysis) but we will be generous or cornucopian here and assume that we will need 45,000 ha to be converted successfully into farm-ready fuel.

Let us also assume that the SEQ population want some transport fuel, but because it is in the future, we will assume some structural changes and major steps in efficiency. We will assume that the average household only has one car, and that the vehicle is shared between 4 people in each house, though this is a major change from today. We will also make each vehicle a hybrid car that uses only 4L/100km, and furthermore, we will assume a reduction in distance travelled by each car from 15,000km to 7,500km; hence the population will need another 45,000 ha (approx), of dry-land agriculture to grow fuel crops. In this future world we have split the transport fuel demand evenly between agriculture and private urban vehicle use. This is of course

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16 Wang W., & R., Dalal 2004., *Long-term carbon mitigation potential of no-till, nitrogen application and stubble retention in a subtropical cereal cropping system*, unpublished paper, CRC for Greenhouse Accounting and NR&M

17 CSIRO 2003. *Appropriateness of a 350 million litre biofuel target*, commonwealth of Australia.

18 Pimentel and Tad W. Patzek, 2005. “Producing ethanol and biodiesel from corn and other crops is not worth the energy”*Natural Resources Research*,Vol. 14:1, pp65-76

very different from our current world where private urban transport is the largest consumer of liquid transport fuels[19].

On top of this is other fuel needs such as commercial services, public transport and possibly air transport, so it is not unrealistic that the area dedicated to fuel crops could easily inflate to 100,000 ha, even under these very conservative assumptions. However, we have only 111,720 ha of dry-land areas available and 72,000 ha irrigated, of which approximately 50 per cent of each is allocated toward fulfilling dietary requirements. Given that we have been extremely conservative in our future fuel consumption scenario, it is not likely that we could further reduce the amount required for the smooth operation of the society; hence, we would need to further reduce the population, and, although this is only an approximation it would not be unreasonable to round the population down to 300,000, which is an effective EF of 7.33 hcy. Of course if we were to project current rates of air travel into the future then it is likely that almost all of the area used to grow food crops would be consumed by energy crops. This last point raises serious questions about the viability of a tourism industry base on air travel in a sustainable future.

## 2.9 Other needs

We have focused on food and transport energy, as these categories make up approximately 25 per cent of the normal footprint calculation, but it must be noted that normal calculations to-date have not considered and factored in renewable fuels. So let us now take our 7.33 ha/capita (300,000 population) and add to it the remaining part of the footprint, that is 5ha/cap from Lenzen and others[20], but less the already accounted for 25% is 3.75 hcy. Now if we add to this 3.75 hcy a premium for renewable fuel which we have identified as having an inflationary effect of around 25%, and we ignore other unsustainable practice i.e. don't worry about the 75% utilisation that we factored into agricultural systems (which would be equally applicable to other activities such as forestry, water use, fishing etc), then we get an

[19] Gutteridge, M & others, 2004. *Queensland's Oil problem: Future considerations for NR&M*, unpublished paper for Qld Department of Natural Resources & Mines.
[20] Gutteridge, M., 2005. "Calculating the SEQ Ecological Footprint from a composite of Statistical Local Area economic, demographic and land use data", unpublished paper, Queensland Department of Natural Resources & Mines.

ecological footprint of 12hcy on our 2.2 million hectares of SEQ. This tabulates to a population of around 180,000 people. This finding is not so dissimilar to a recent EF report commissioned by the Mossman Local Government in that precinct of Sydney that argues for14.7hcy and a supportable population of 58 rather than the 28,000 domiciled there.[21]

## 2.10 Conclusion

It is expected that nearly 4 million people will be living in SEQ by the year 2030, yet we have established that the sustainable carrying capacity of the region, given a similar lifestyle, is approximately 180,000. It is likely that there will be a lot more people in the area than the CC; hence, by necessity goods and waste will need to be transported in and out of the region to maintain current lifestyle. Indeed to a large degree this already occurs.

Given however the requirements for sustainability, it is likely that this hinterland area would need to be considerably larger than SEQ, and, paradoxically, the larger it becomes, the larger it needs to be to support the energy requirements of the extended transport network. Inevitably there would be an upper limit to a population's hinterland, hence an upper limit to concentrations of populations in any one metropolis. This of course has implications for pushing too far with urban consolidation.

The envisioned sustainable socio-economic system of this hypothetical future is far removed from what currently exists today, even if the diet were to remain relatively static. And, if the assumptions for SEQ hold true for the rest of Australia, then it would imply that a comparable reduction in the population supportable by the resources of the region would also be necessary, as also a considerably different socio-economic system to accompany this. In this future world the sustainable population of Australia would need to be not greater than about 1 million people at

[21] http://www.smh.com.au/news/national/ Fairfax "Bigfoot alive and thriving on the North Shore" August 1 2005.

current lifestyle demands, and a few million more with significant lifestyle changes. As it is assumed, however, that there will be many millions of more people living within the country, we can expect that dramatic changes in lifestyle will be needed in both the near future and over the longer time frame to achieve any semblance of sustainability.

It is also likely that the changes necessary to support SEQ or the Australian population into the future will not occur in a positive and harmonious way if left to market mechanisms. Indeed the current system, a narcissistic consumption driven economy [narcon] is a product of the historical and contemporary market, increasingly devoid of socio-moralistic intervention. It is likely therefore that in the future government will need to address this imbalance and lay plans for a very different future to achieve a smooth transition from the present to something more sustainable.

Speech on Peak Oil in Queensland

Michael Gutteridge

March 2005

**1: Gold Rush**

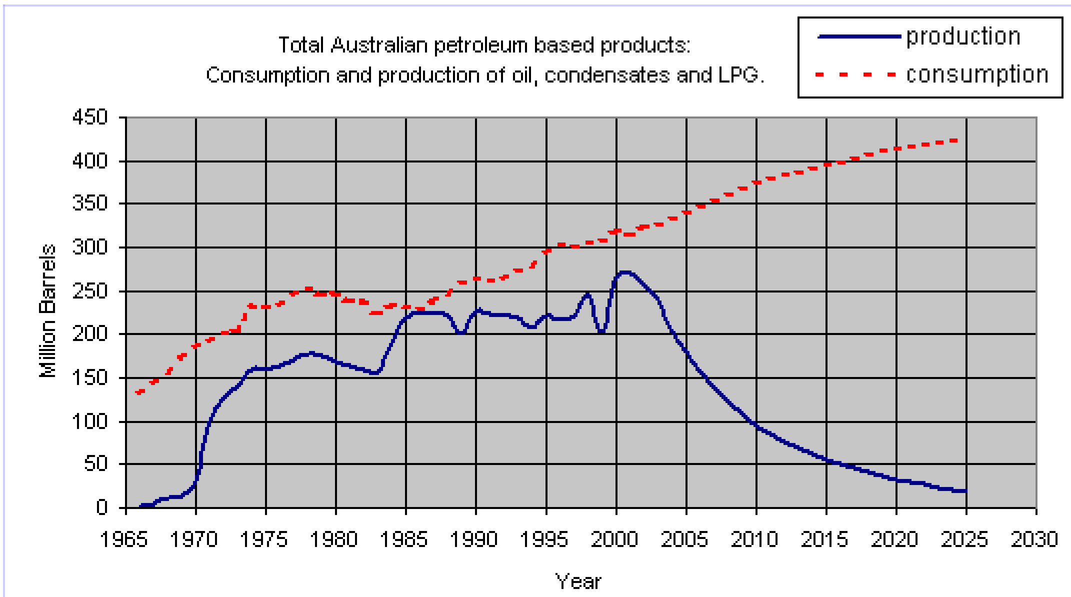
Australia's last major gold rush took place in Croydon Qld. A station manager found gold in 1885 and within a year a town had sprung from the mulga with over 6,500 people and 37 licensed hotels. Within six years a railway was built and the then bursting regional centre had industries, schools and the prosperity befitting the States fourth largest town. There are now 316 people left.

**2: Black Gold Rush**

Australia has a long history of prospecting for oil, yet despite our huge land area, and historically high demand, very little was found. Then BHP and Exxon (ESSO) ventured offshore in the 1960s and discovered the Gippsland fields in the Bass Strait. This small area has been the mainstay of our energy security through till today. Unfortunately nothing like it has been found since and is not expected to be found either in the NWS or frontier regions.

**3: Australia's oil balance**

Bass Strait is now in terminal and rapid decline and as a consequence so is Australia's total oil production. Perversely demand for oil and oil based products in Australia is growing strongly, expected to continue at the long term average annual rate of 2 per cent, at least through until 2010 and 1 per cent through to 2020.

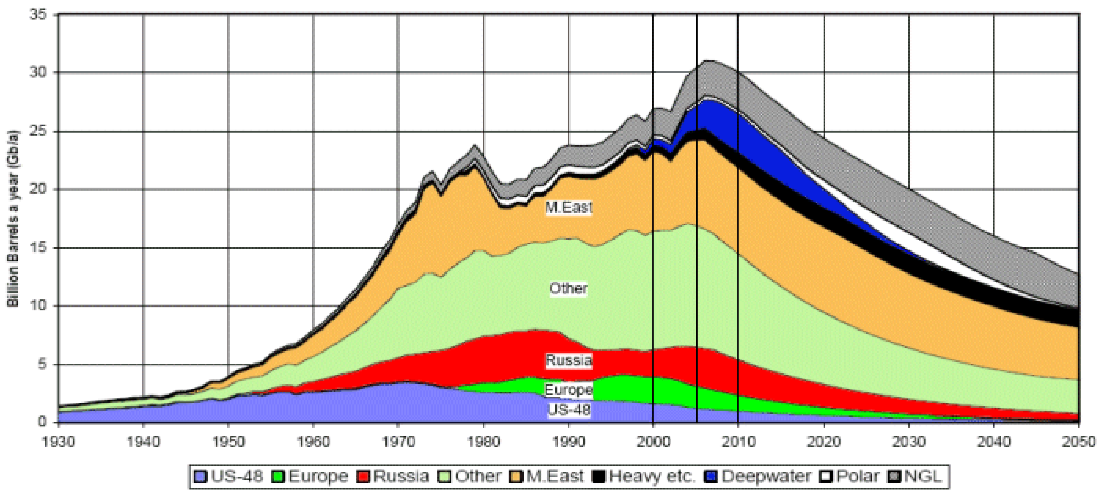



## 4: Imports

The gap will be filled with imports that are currently at 25 per cent but are expected to be 75 per cent in 2010 and 92 per cent in 2020. Hence our energy security is now reliant on what happens in the rest of the world.

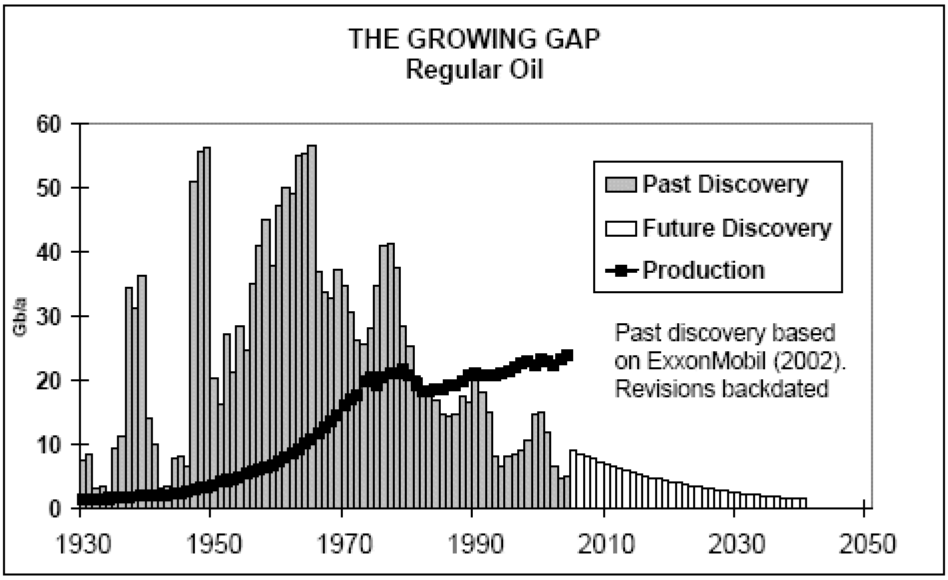
## 5: World oil balance

Unfortunately the time line of oil discovery, production and decline is not unique to Australia and as such has been or will be experienced in all oil fields around the world. Some fields were early starters, like the US and others later like the North Sea or the Bass Strait.



## 6: Found and lost

Technology and the pursuit of profits have extracted oil increasingly from more challenging environments and with greater efficiency. But despite the best efforts of the richest and most influential corporations in the world, and with generous concessions from governments, once the well is dry, it's dry. Sure there is still oil in the source rock, but it takes more energy to extract than it produces.




## 7: The numbers

I have conducted extensive research into oil depletion and modelled production and have found that the one that has greatest credibility is that which has been published by ASPO. I am not going to spend time defending this belief, suffice to say considerable argument was mounted in the previous paper, and through world wide scientific, economic, geological and engineering peer review it remains our best approximation. Essentially it projects discovery, production, technology and decline rates into the future so that we are able to extrapolate Global and regional production scenarios for given points in time. The results have been recently ratified, to a considerable degree, by the industry publication Oil & Gas Journal 21 Feb 2005.

| ESTIMATED PRODUCTION TO 2100 | | | End 2004 |
|---|---|---|---|
| **Amount** | | | **Gb** |
| **Regular Oil** | | | |
| **Past** | **Future** | | **Total** |
| | Known Fields | New | |
| 945 | 760 | 145 | 1850 |
| | 905 | | |
| **All Liquids** | | | |
| 1040 | 1360 | | 2400 |
| **2004 Base Scenario** | | | |
| M.East producing at capacity (anomalous reporting corrected) | | | |
| *Regular Oil* excludes oil from coal, shale, bitumen, heavy, deepwater, polar & gasfield NGL | | | |
| Revised 26/01/2005 | | | |

| **Annual Rate - Regular Oil** | | | | | **Gb** | **Peak** |
|---|---|---|---|---|---|---|
| Mb/d | **2005** | **2010** | **2020** | **2050** | **Total** | **Date** |
| US-48 | 3.4 | 2.7 | 1.7 | 0.4 | 200 | 1972 |
| Europe | 5.2 | 3.6 | 1.8 | 0.3 | 75 | 2000 |
| Russia | 9.1 | 8 | 5.4 | 1.5 | 220 | 1987 |
| ME Gulf | 20 | 20 | 20 | 12 | 680 | 1974 |
| Other | 28 | 25 | 17 | 8 | 675 | 2004 |
| **World** | **66** | **59** | **46** | **22** | **1850** | 2006 |
| **Annual Rate - Other** | | | | | | |
| Heavy etc. | 2.4 | 4 | 5 | 4 | 160 | 2021 |
| Deepwater | 4.8 | 7 | 6 | 0 | 70 | 2014 |
| Polar | 0.9 | 1 | 2 | 0 | 52 | 2030 |
| Gas Liquid | 8.0 | 9 | 10 | 8 | 275 | 2027 |
| Rounding | | 0 | 2 | | -7 | |
| **ALL** | **82** | **80** | **70** | **35** | **2400** | 2007 |

This is the best available knowledge of how much oil is left, regardless of what Oil Companies tell their stock holders or the IEA advises government policy makers.

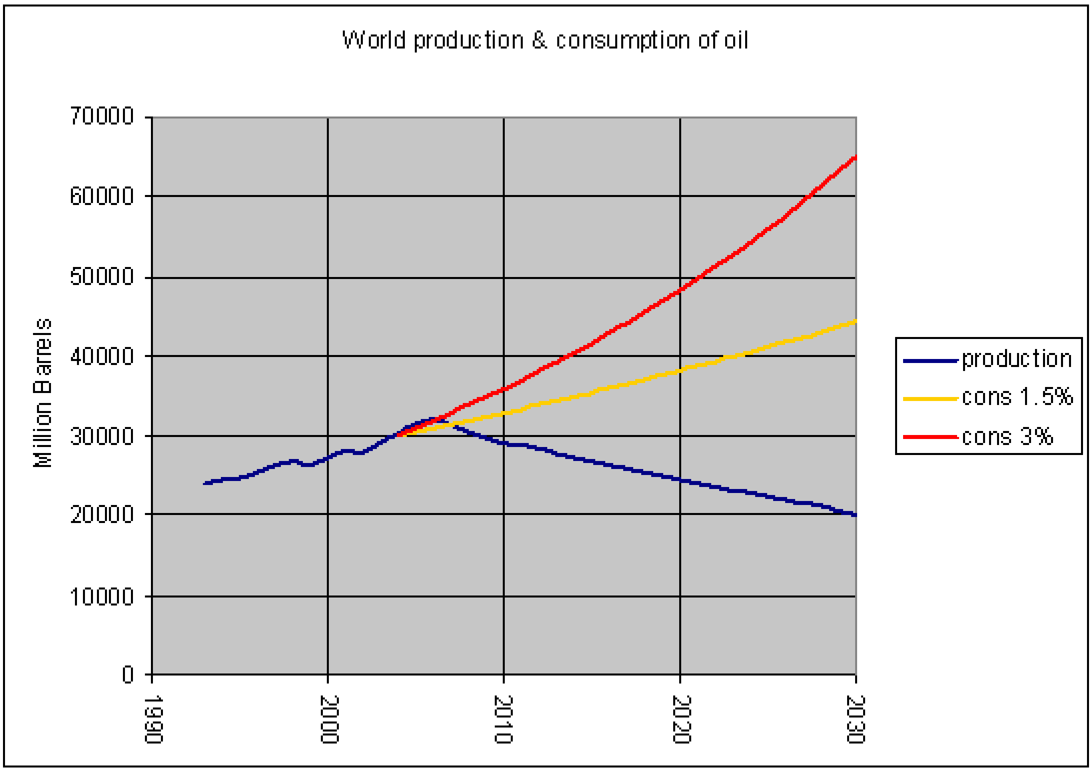
I found an interesting quote, it goes: If we accept that peak oil is a real phenomenon, then the next obvious question is; "When will the peak of extraction from the earth occur?" The answer to this depends on who you ask and ranges from 2007 to after 2067. Oil geologists tend to favour 2007; economists tend to favour 2067. That does expose the whimsical contradiction that economists appear to think themselves far better at finding oil than geologists.

## 8: Demand

However, the real problem is not how much is going to be produced in the future, or at what rate it declines, but instead how much will we demand. Demand is different from consume, because consume is what you end up getting, where as demand determines what you are willing to do to get it.

## 9: The gap

Demand is difficult to forecast because it is a product of population growth, increased industrialisation and wealth, and a myriad other factors that can make sense or can indeed be nonsensical. For instance economic research has shown that historically high oil prices have not dented demand in the short to medium term. Oil demand is inelastic and will be obtained at the expense of other goods either by the individual or the state. Of course at phenomenal prices this is not likely to hold true, or will it! Did I mention the cost of war? Two growth scenarios are presented here: 1.5 and 3 per cent. The lower is from the IEA the later is what is considered a conservative estimate based on trends over the past decade.




It is worth noting that the 1973-74 oil shock resulted from a 5 per cent reduction in oil supply. And, there was light at the end of the tunnel because the oil was still there.

There is still a lot of fat on the bone though with the average Australia household with the average Australian car spending $144 a month at the petrol pump. We can decide not to go on holiday and wear prices that are considerably higher, not so good for the tourist industry though!

**10: Supply and demand**

It is obvious that these demand scenarios cannot be met using conventional or non-conventional oils, including Canada's much touted tar-sand optimistically contributing 700 MMbbl/y. This has also been supported by the recent O&G Journal article that suggests that the IEA forecasts are unrealistic. There are two general strategies that countries can and are pursuing, the first is to secure supply and the second is to reduce demand. Examples of the former are the US using military and coercive means, or China, Japan and India using trade agreements and technology transfer. Australia, perhaps as a partner to the US may benefit from aggressive tactics, but for the most part we would fall into the second group, that is, to reduce demand which is more in line with European initiatives. The success of those in the first group however is of interest to those in the second, because one countries security promotes another's insecurity. Such is the history of humanity.

### 11: Demand reduction

This involves absolute reduction in oil energy consumption or it can be supplementing oil for other energy sources such as alternative fuels etc therefore stretching supplies. The problem of course is that we are faced with a Tragedy of the Commons situation where one country's efficiency will reduce the incentive for others to follow. Also some countries get a far greater return for each dollar spent on oil. China and India have such low economy-wide oil and energy-intensity (around 1/8th to 1/15th per capita oil-intensity of the US and EU countries) that they are easily able to absorb much higher oil and energy prices without strain to their balance of payments.

### 12: Global reduction

It is expected that most governments and industries will not move until a crisis occurs. A thorough reading of the Australian Federal Government's Energy White paper 2004 spells out clearly the Federal paradigm, that is: Cheap and reliable oil supplies will be available for the whole World for the next 40 years and then we will smoothly transition to a hydrogen economy. Conversely, McKillop writes:

> Planning for energy transition will be vital and urgent by 2008. Given the laissez faire or new economy doctrine in current political and business leaderships, it is unlikely that serious planning will occur, giving way to crisis by default.
>
> Andrew McKillop 2005

The Europeans are not so optimistic and are aggressively pursing all manner of alternative fuels and efficiency strategies. Fifty percent of the road transport is diesel and there are advanced plans for bio-diesel and ethanol production to replace 5.75 per cent of the oil market by 2010. This is in conjunction with a 25 per cent oil consumption reduction on new cars from 1996-2008. In consumption growth forecasts, the EU and Japan weigh lest in driving up World consumption. China is also planning to implement its own 25 per cent efficiency target although this will only make a small dent in its absolute contribution because of high growth in new cars. India has initiated plans to convert most commercial vehicles to run on natural gas. Brazil has its ethanol.

But America, home of the free-wheeling Hummer! Almost half of all new vehicles sold are of the SUV/van class. Hybrids in the US are expected to only be 3 per cent of the market by 2010.

It is predicted that by 2030 if all light duty vehicles were 25 per cent more efficient and all other modes 10 per cent more efficient, it would reduce global oil consumption by only 18 per cent. Most of that would occur close to the end of the time frame as vehicles were replaced. Too little to too late.

### 13: Australia’s ability to supplement

Australia is fortunate to have many natural resources, both fossil and renewable, that can be converted into energy that can function similarly to that which oil has done. However, from the outset it must be said that none of these sources of energy can match our historical supply of oil for shear consistency and volume, in price, convenience or for energy by weight. Hence it is with these criteria through which we should judge alternative fuels, for although something may seem feasible in the laboratory, it is often a very different case when it is applied to our predicament.

### 14: Natural Gas

Australia does not have endless supplies of cheap natural gas, regardless of the impression created by the gas industries. Traditional gas supplies on the mainland and from the Bass Strait are not expected to last much beyond 2008. North West Shelf gas is expected to prolong our self-sufficiency through till 2025 at current consumption rates. Here in is the catch though, current consumption rates! If we were to use gas as an oil substitute, it would peak by 2010 and then rapidly decline. Also, to use gas in such a way would require huge production and infrastructure upgrades which are not happening, and then there would be the conversion of vehicles, the loss of exports, and the driving up of the gas price.

Methanol can be extracted from natural gas and used as a fuel extender, but there is little hope for a large scale conversion to match gasoline demand.

Gas hydrates recovered from the sea floor hold some possibility in the future but it is not a solution for this generation.

**15: Coal**

Gasses and liquids can be extracted from coal in a range of processes to form the feed stocks for liquid fuels similar to those derived from crude oil.

By the end of WWII Germany was producing from coal 4.78 MMbbl/y and South Africa during apartheid 73 MMbbl/y. Recent US DOE studies suggested that a coal-liquids plant with 1,000MW generating capacity and producing 12.1 MMbbl/y would cost approximately US$2.2 billion. For our current 308 MMbbl/y demand Australia would need to build 26 plants at a cost of nearly AUS$70 billion, and that's before it begins to operate with all of the associated energy, water and environmental costs.

Using direct liquefaction one tonne of coal yields 3 barrels of oil after being heated to 400 degrees centigrade under high pressure with appropriate catalysts. That equates to mining and processing 100 Mt of coal per year, presumably using part of the end product for equipment fuel, and more coal for processing heat. In 2004 Australia produced 285 Mt of black coal, with 66.72 Mt consumed domestically. So we would need to mine a third more coal or drop exports by 50 per cent.

There is no doubt that this will be developed in Australia and around the world, in fact China will have a 7.3 MMbbl/y plant operating by 2007 and also Indonesia is at an advanced trial stage.

I have described one of many coal options, they all have differing pros and cons, but my point is this. Although many things can be done technically and at various scales, trying to prop up the oil economy structure in its entirety with inferior energy sources is delusion from an economic, social and environmental perspective. Coal will be very valuable in the future, considering that before too long it will be the World's only remaining fossil fuel.

It is amusing that the mantra for Third World development in the 1980s was "appropriate technology". The irony is lost on us.

**16: Shale oil**

Shale oil is nothing new; in fact it's been used for nearly 600 years in one form or another. There is believed to be 12,644 MMbbl bbl of proved recoverable oil in Queensland, with more in reserve. That is approximately 42 years worth of oil for the Australian market, or about 5 months worth in the world market. However it is not likely that Australia could keep this to itself, fee trade agreement and all. Many countries have tried this, in fact we thought about it in the early 1970s until the US shut it down, read Jim Cairns "Oil in troubled waters". Anyway, if we close our market, how can we expect others to stay open for us?

There are of cause problems, if there weren't it would have been pumped out long ago. Firstly, it requires about three times as much water in as oil out, and unfortunately there is not a lot of water where our deposits are. Then it also requires a lot of energy so there is not much net energy gain. To date it has not been economical, after billions of dollars of investment in the US and millions of dollars in Australia. Shell have however recently patented a new technology for in-situ extraction that reduces the amount of water required but I am not aware if this would be applicable to the Australian deposits. Some commentators speculate the financial problem the industry is currently facing is more about corporate manoeuvring than bleak future prospects.

Shale oil will probably be developed because we will need it, but it won't be developed to drive the 4wd to soccer practice.

To quote another source: "The fuel of the future and always will be."

**17: Bio-fuels**

This one is easy. Like most alcohol and cooking oil, great stuff in moderation. All of Australia's current cropping land would supply us with only 25 per cent of our transport fuel energy demand. After the first settlers mined Australia's soil nutrients there went the yields per hectare that are necessary to make this option viable. So when you add up the natural gas based and high transport cost fertilizers, farm and grain transport energy, the odd crop failure, you kind of get the picture. Sure it will be invaluable as a rural fuel, but forget it for the cities.

**18: Hydrogen**

A clean burning renewable abundant energy source and you can drink the waste water straight from the tail pipe. When something sounds too good to be true it usually is. This is covered extensively in the report, but in brief. Currently we get small amounts of relatively cheap hydrogen from natural gas. This cannot continue.

Hydrogen from water takes enormous amounts of electricity and water; we would have to go on a power station spending spree. Those stations would burn coal or gas. If we were clever we would produce it from solar energy, but this requires a visionary commitment that is lacking, despite our fortuitous position of having ample sunlight and vast tracks of inexpensive land. The water must also be of good quality, therefore desalinising sea water or building more dams.

You need to store it, transport it and then store it again, however it's not like natural gas, for it requires large amounts of energy to transport and exotic materials for containment.

Hydrogen can be burned directly in an internal combustion engine with minor modifications; however, the fuel tank is a tricky problem that is still at the laboratory stage. If it is used in fuel cells, regardless of what the platinum mining industry says, they is only enough raw material to build around 10 million small cars, or about a quarter of that in busses. As the demand for platinum rises, so will the cost of the vehicle, which presently is about 10 times more than it needs to be. If you want the fuel cell to last more than twelve months, you need to incorporate more exotic materials such as Ruthenium, meaning that vehicle numbers fall by about 75 per cent again cause it is rarer than platinum. Almost all of the rare metals come from one region of South Africa, and we thought OPEC was a problem.

Demand for platinum is already going through the roof because it is used in catalytic converters, and stricter pollution laws and an increase in diesel powered vehicles; especially in Europe, is behind this. Platinum prices are also being driven up by investors, and as it gets more expensive, demand will increase in jewellery.

Fuel cells are good P/R for the motor vehicle industry, good P/R for Bush's Freedom Car Project, and they will play a role in the future, but it is unlikely that you or I will ever own one.

**19: How much substitution?**

Now that we have established that there is no silver bullet energy alternative, how is this likely to play out globally? Well, in the short term, after an oil-shock between 2005-2010 there will be negligible substitution or extending of fuel, so everyone will hit the wall at full speed. This scenario is supported by O&G Journal, but was arrived at independently of their publication. After a period of time however, perhaps 10-20 years alternatives will perhaps make up about 25 per cent of consumption.

An oil crisis will not be an even event though, due to bilateral deals that are being put in place. There is little doubt that the pipeline wars have already started, the US NED has been working hard to determine FSU customers. The TransCanda pipe line will shut out the Chinese, but the ever meddling in Central and South America may just be to China's advantage should Venezuela's President Chavez survive the next coup attempt. Strategic interest is a euphemism for 'our oil hands off'. This is not conspiracy theory; it is the way all countries have operated when they could leverage oil trade, or any other trade, going back at least as far as the Phoenicians.

It should not take too much work to calculate how much oil will remain available to Australia, and there after what will be its probable price range. For this talk I chose a $200 floor price because that's what Osama Bin Laden reckons the bottom of the range should be and that's near enough equivalent in percentage terms to the price rise in the 1970s. But I should stress bottom of the range, especially if we look at a 10 per cent drop by 2010.

**20: Australia's substitution**

In the short term Australia will have little to no substitution, and this is likely to remain for well into the future. However when substitution does occur it is likely to come in at about 25 per cent of current consumption and this is after massive investment and turmoil.

Sure we will all run out and buy motor scooters, do car pooling and drive less; these are the knee jerk responses. But in Australia remember, it is 2000kms to Cairns, and almost as far from where you live to where you work to where you shop, to where the kids go to school etc. etc. You can't fit four kids on a scooter, even though they do in New Delhi.

So what will be the longer term structural changes? Well that depends on what we do now whilst money, energy and materials are cheap and the population aren't rioting.

**21: WWII**

So what happen during WWII? Well it took nearly a year, after the war had started before government was able to implement rationing. It seemed that sending troops was not a problem, but reducing fuel consumption was. Before the war the average Australian motorist travelled 3,000km, today we travel 15,000km. In 1941, government decided to limit private motor vehicle travel to 1,600km, approximately half. And all commercial vehicles by 10 per cent, and taxi rationing down from 450L per week to 100L per week. Gas producers, although widely publicised were ineffective. Petrol hoarding and illegal activity was widespread.

This occurred in Australia when public transport was far more widespread than it is today. This was a time before urban sprawl and the industrial park. There were still corner shops and the local school, many farms still had horses and were near cities and many self-sufficiency skills were still common practice in the community. By the end of the war, agricultural production was suffering and rationing had to be kept in place such that the population could be fed.

**22: So what is likely to happen?**

The global monetary system will be in big trouble, and credit will contract. Interest rates will rise dramatically as will inflation leading to under investment and unemployment. Stock markets will crash and the Great depression will be the ‘good old days’. Factories will close and the tourist towns, e.g. Gold Coast and Cains will wither on the vine. The service and retail industries will take a severe blow, and it is not inconceivable to imagine 40-50 per cent unemployment combined with household bankruptcies. Food production and distribution will be a major problem, so will domestic migration.

Land values will change and many goods on credit will be worthless, for example the six cylinder family car. Hoarding will take place until government prioritises distribution to essential services.

There is likely to be conflict as many other countries suffer food shortages. The situation that Japan faced before attacking the US Pacific fleet will be the dilemma of most countries. Countries that have urban and agricultural designs that are less transport intensive, such as old Europe, will fare better. This will not cushion them from a contracting would market however, with export trade likely to fall dramatically.

**23: What needs to be done?**

Necessity is the mother of invention, so no doubt there will be many responses that we are yet unaware of. What is crystal clear is that our dependence on oil based energy must be reduced immediately and dramatically; better now whilst the sky is clear, than in a few years time at the height of the storm.

Most of Australia’s fuel is used in private urban transport. Our cities were designed to promote motor vehicle usage and oil dependence. This does not necessarily make for a better city; it just makes for a more vulnerable population. Highly liveable modern communities do not need private motor vehicle ownership if they are located and designed properly, a car can be rented when needed. And lettuces do not need to travel 2,500kms from farm to market, and frozen spinach does not need to come from

Greenland, these are the lunacies of the age of cheap transport. Urban design followed pretty much static principles for 10,000 years; we only have to look at our past to see the future.

**24: The paradigm**

Even though it doesn't seem obvious at the moment, growth based credit economics is over for the time being. There is no doubt that something new will develop in time, but for now we need to contract and consolidate. Indeed we will have no choice shortly. There is not even the slightest hint of this type of thinking and stratagem in current government policy. And it won't come from industry or the Dept. of State Development.

We have to stop thinking that energy is an industry in itself that must be promoted and expanded. Energy has always been a means to an end, but we have made it an ends in itself. Actually that's not quite true, energy was found and governments and societies were augmented to consume it and indoctrinated or coerced to protect it. We should stop thinking of how to replace oil based fuel and start to think of how to do away with it. Of course we will always need some fuel, but to make access to it a condition of civil and economic life is foolish and is at the root of many other problems, e.g. climate, environmental, social inequity etc. With correct planning quality of life can increase whilst energy demand decreases, wasn't this supposed to be the promise of technology and the reason we put our faith in free market economics.

The impending oil crisis information needs to get out so that the markets can indeed function properly through transparency.

**25: Immediately**

We need to further research the impacts of the peak oil phenomenon, but rapidly, so that a cohesive and substantive statement can be made that overrides the commercially biased misinformation being fed to government and the public.

We need to expose all departments of government to the problem such that a multi-disciple, multi-departmental statement can be made.

We need to start getting the public used to the idea such that they can initiate transition toward a lower energy society. The worst of all worlds is to say nothing and let the system go into shock. A government that lets this happen will be held responsible.

1. Alternative fuel options (Michael Gutteridge 2005)

1.1. Bio-fuels

Australia has two established crop groups well suited to the production of ethanol, cereal grains and sugar cane. In both cases sufficient is grown above domestic consumption to allow for exports, Table 1.

| 5y average | area 000 ha | t/ha | Production kilo tonnes | Export kilo tonnes | Precent Exported |
|---|---|---|---|---|---|
| wheat | 11882 | 1.78 | 21243 | 15169 | 71.41% |
| other grain | 5392 | 2 | 10665 | 5095 | 47.77% |
| total grains | 17274 | | 31908 | 20264 | 63.51% |
| oilseed | 1924 | 1.43 | 2750 | 1735 | 63.09% |
| sugarcane | 419 | 31.47 | 13313 | 9709 | 72.93% |

Table 1: Five year averages ending 2003-04 crop area and production of wheat, other coarse grains, total of wheat & coarse grains, oilseed principally canola and sugarcane.

The gross bio-fuel liquid energy yield at the refinery derived from export tonnages[1] is presented below in Table 2 and is compared with various petroleum based fuels[2] consumed in Australia 2003-04. Energy used in the refining process is not counted.

| Consumption 2003-04 | Million Litres | MJ/L | PJ | PJ Total |
|---|---|---|---|---|
| automotive gasoline | 19926 | 34.2 | 681 | |
| automotive diesel | 14426 | 38.6 | 557 | automotive **1238** |
| aviation gas and turbine | 4329 | 33-35 | approx. 162 | |
| fuel oils | | 39-42 | approx. 59 | auto, aviation & fuel oils **1459** |
| LPG | 3569 | 26.5 | approx 95 | |
| sugar | 2018 | 21.2 | 43 | |
| wheat | 5097 | 21.2 | 108 | |
| other grain | 1712 | 21.2 | 36 | |
| oilseed | 673 | 35.6 | 24 | **211** |

[1] Sugar is calculated on how many tonnes of cane are required to produce export raw sugar.
[2] LPG is included as a comparison but not included in the PJ Total column because it is assumed that it will not need to be substituted by biofuels in the short to medium term.

Table 2: Gross energy PJ consumed in principle transport petroleum products and the potential biofuel PJ substitute based on five year crop averages ending 2003-04.

It is clear from Table 2 that only 211 PJ in liquid transport fuel can be derived from Australia's crop exports. This represents 17 percent of current gasoline and diesel consumption and 14 per cent when aviation and fuel oils are taken into account. It is assumed that Australia's most productive crop land is already being utilised close to its full biomass potential, hence, there is no expectation that biofuels as a petroleum substitute can be expanded much beyond these modest figures. Indeed degradation of farm lands can often be attributed to over exploitation; hence, sustainable biofuel production is likely to be lower than 211 PJ.

All crops require additional energy in the form of fertilizer that is not already accounted for in petroleum based fuels. It is assumed however that all other farm and transport operations requiring petroleum based products, besides pesticides, have been accounted for[3].

## 1.2. Hydrogen

Hydrogen can be produced in two ways, steam reformation or electrolysis. Steam reformation relies on methane derived from natural gas, a scarce fossil fuel resource that is more efficiently used in its original form than reformed into hydrogen[4]. This analysis will focus on electrolysis. It should be noted, however, that hydrogen produced from steam reformation consumes less energy than via electrolysis, but the latter uses less water, and input energy as opposed to natural gas can come from a variety of sources including solar and wind.

The production, distribution and the economic viability of platinum and platinum based fuel cells will be severely limited[5]. The implications for Australia are that there are likely to be less than 50,000 light duty fuel cell cars in the country by 2020, and there is a good chance that this figure could be considerably lower especially if available platinum is utilised in public transport e.g. busses or seconded by other countries. It is therefore probable that if hydrogen is used to power a large number of vehicles it will be using internal combustion engines and then probably commercial or public fleet vehicles only. Before this is possible though substantial problems must be overcome regarding storage and distribution of hydrogen, both bulk and onboard vehicles[6]. Hydrogen is not likely to be ubiquitous as petroleum based products have been and will probably never be used in rural or remote areas.

Direct comparison of hydrogen energy content to gasoline or other liquid fuels can be a misleading exercise. Hydrogen has a high energy content but an extremely low density, thus to achieve a comparable energy density figure, hydrogen must be liquefied or pressurised which in turn takes energy and requires heavy, bulky and

[3] This can be considered as variable energy, as opposed to fixed energy such as the energy required to manufacture farm equipment like tractors.
[4] See appendix A.
[5] See appendix B.
[6] See appendix C.

sophisticated storage systems[7]. However, hydrogen powered internal combustion engines can be up to 38 per cent efficient, this is about 25 per cent more efficient than a standard gasoline engine implying that each kilogram or litre of hydrogen delivered can do more work than gasoline[8].

Each 1kg of $H_2$ contains 120MJ of energy and the electricity to produce it is 59kWh/kg + 5kWh/kg for compression or + 16kWh/kg for cryogenic liquefaction. Technological advances may reduce this to 55 and 66 respectively. This analysis will assume 55kWh for hydrogen stored at the refinery; which, given transport limitations could in all likelihood be a small scale electrolysis unit and filling station combination, however, we will calculate based on large scale generation facilities that currently exist or are planned to come on line in the near future. Ten litres of water is required for every 1kg of $H_2$.

### 1.2.1. Coal power station

Queensland's newest station is Kogan Creek, a 0.75GW-hour supercritical-steam coal-fired system planned to come on line in 2007. It is assumed that this represents the most advanced and suitable technology available for coal fired power generation. Assuming an 80 per cent capacity factor[9] it is expected that over one year the station will produce 5,585GWh. With an electrolysis ratio of 55kWh per 120MJ (1kg$H_2$), the station is capable of producing 12.19 PJ. (((5,585 / 0.000055) x 120)/1000000000) The station cost AU$1.1 billion and is expected to consume 2.8 million tonnes of coal per year[10]. To create 100 PJ of hydrogen, therefore 8 per cent of current petroleum based transport energy consumption, would require 8.2 new power stations costing $AU9 billion and consuming 23 million tonnes of coal per year. The cost of coal assumes no sequestration and is likely to rise as the operational costs of mining rise in conjunction with transport fuel and as the demand for coal increases. Under Free-Trade regulations, the Australian domestic market may not be the principal consumer of our coal resources.

### 1.2.2. Wind power

Windy Hill wind power farm in Queensland has 20 x 0.6 MW turbines. Windy Hill farm is built on privately owned farmland used predominantly for dairy and beef farming. Operating the wind farm has minimal impact on the farming activity[11]. Building wind farms in populated areas of subjective high aesthetic value could be problematic. The average capacity factor over the past four years was 26.3 per cent, and annual power sent out was 27GWh. The construction cost was AU$20 million for

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[7] Chemical storage systems including silicon and boron show considerable promise to overcome these but are still at the theoretical stages of development. See Auner, Norbert, 2004. *Silicone as an intermediary between renewable energy and hydrogen*, Institute of Inorganic Chemistry, Johann Wolfgang Goethe-University, Frankfurt.

[8] http://www.eesi.org/programs/cleanbus/hydrogen.htm see also http://www.ford.com/en/innovation/engineFuelTechnology/hydrogenInternalCombustion.htm

[9] The seven year average capacity factor for Stanwell is 79 per cent. See http://www.stanwell.com/PDF/SCL_ANNUAL_REPORT_2004.pdf

[10] http://www.power-technolgy.com/project_printable.asp?ProjectID=3224

[11] Ibid

0.012GW[12] capacity, or AU$740,000 per delivered 1GWh/year. With an electrolysis ratio of 55kWh per 120MJ (1kg$H_2$), the wind farm is capable of producing 0.06 PJ; (((27 / 0.000055) x 120)/1000000000). To create 100 PJ of hydrogen, therefore 8 per cent of current petroleum based transport energy consumption, would require 1,666 equivalent wind farms costing $AU33.3 billion and covering many thousands of kilometres of suitable landscape.

### 1.2.3. Solar power

Photovoltaic panels average 11 per cent efficiency and the overall electrical efficiency of the balance of systems components is approximately 79%. The annual average photovoltaic energy production in Australia is approximately 153kWh/$m^2$/year[13]. Each 1GWh/year would require 6,536$m^2$ of solar panels, and if priced at $500$m^2$ would cost AU$3.27 million. With an electrolysis ratio of 55kWh per 120MJ (1kg$H_2$), a 1GWh/year solar array is capable of producing 0.0022 PJ; (((1 / 0.000055) x 120)/1000000000). To create 100 PJ of hydrogen, 8 per cent of current petroleum based transport energy consumption, would require 45,455 1GW/year solar arrays or panels covering an area approximately 300$km^2$. Total cost at $500$m^2$ is AU$150billion.

[12] http://www.bcse.org.au/default.asp?id=70&articleid=55
[13] http://www.ecotopia.com/apollo2/pvepbtoz.htm Andrew Blakers and Klaus Weber, Engineering Department, Australian National University.

Michael Gutteridge 14 March 2005

Part of Chapter on Hydrogen Economics.

## Platinum

Most $H_2$ economy analysts assume abundant supplies of platinum and exponential improvements in load reductions for FC. Not long after the peak oil debate became public scientists started to question the limitations placed on visions of an FC economy through platinum scarcity. In response the Platinum mining industry issued a statement to allay fears:

IPA

For Immediate release March 4 2003.

**International Platinum Association Corrects Erroneous Reports on the Availability of Platinum for Fuel Cells.**

*Platinum is the only viable catalyst for proton exchange membrane (PEM) fuel cells; World Reserves are more than adequate for expected uses.*

…

On the eve of the National Hydrogen Association's 14th Annual U.S. Hydrogen Conference in Washington, D.C. this week, the International Platinum Association (IPA), which comprises the world's leading platinum groups metals, producers and fabricators, confirms that enough platinum resource is available worldwide to meet any foreseeable future demand spurred by the commercialisation of fuel cells.

…

According to a peer-reviewed South African study published in November 1999, the estimated reserves of platinum worldwide are on the order of 1.5 billion troy ounces (to a mining depth of 2 km). The conclusions of this study, "The Platinum and Palladium resources of the Bushveld Complex," by Prof. R. Grant Cawthorn of South Africa's Witwatersrand University's Department of Geology, are broadly in line with statistics released by the U.S. Geological Survey [the same organisation that inflated crude oil reserves] published in January 2000.

…

> As fuel cells become more competitive alternative cars, with on average a 70-kilowatt fuel cell engine, 15 grams of platinum per fuel cell engine (which is the equivalent of 0.214 grams per kilowatt) is though to be feasible. The levels of platinum used in current fuel cell vehicle prototypes are higher, but are being constantly reduced. The US Department of Energy has a goal of 9 grams of platinum for 50-kilowatt fuel cell by 2015 (equivalent to 12.6 grams for a 70-kilowatt engine).
>
> The platinum industry has already proven it can respond quickly to manufacturer's and consumer's demands through meeting the demand from the use of platinum in catalytic converters for automobiles. Catalytic converters were only introduced in the mid-1970s but are now fitted to some 90% of new cars produced worldwide.
>
> …

The objectives of the above statement are possibly commercial and political in nature, and are directly aimed at refuting arguments that question supply and of the industries ability to respond to demand. However, the statement does not represent the realities of the supply, demand and expected future price of the platinum metal group (PMG).

One area of South Africa and a handful of companies (four companies control 90 per cent) dominate world platinum supply. In 2004 South Africa produced 154.9 tonnes (77 per cent), Russia 26.4 tonnes (13 per cent), North America 11.2 tonnes (6 per cent) and the rest of the world only 7.5 tonnes. For the past six years supply has not been able to keep up with demand, and with there being no effective stockpile, as with gold or silver, and with corresponding slow increase in supply capacity, this is expected to continue and is part of the reason for its price near $1000 per oz.

> More important is the fact that with platinum trading at 24-year highs between $800 and $900 an ounce for all of 2004, up over 54% from its average price in the 2000-2001 period, supply increases were only 230,000 ounces in 2004. This is the real telltale sign that the supply constraints on platinum could be more severe than most people expect in the next few years.[1]

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[1] http://www.gold-investor.com/article.php/20050125141412546

PMG have unique properties, including corrosion resistance, high melting point, electrical conductivity and high durability, such that they cannot be easily substituted in many specialised processes. Indeed the 200 tonnes produced in 2004 is ubiquitous in modern society. Over 20 per cent of all consumer goods either contain or are produced using platinum, including automotive catalytic converters (53 per cent of PMG supply), jewellery (34 per cent), the chemical industry from unleaded gasoline through to polyester, electrical and computers components, glass, and a wide range of specialised applications and now also as an investment currency. To this under supplied list we would need to add the mass production of fuel cells.

Given that the current supply is already accounted for in the market, and demand is expected to increase as more motor vehicles are fitted with catalytic converters to comply with tighter anti-pollution laws, what is the ability of the production industry to expand in both the short and the longer term? Furthermore, how many fuel cells can be produced from new supply, and how many of the world's 800 million cars will be able to utilise a PMG based FC?

The Bushveld complex in South Africa has been described as a great bowl like structure buried in the ground[2]. The lower face of the bowl, as result of an igneous intrusion, is coated with a layer of platinum group metals 1-2 metres thick. Mining originated at the edges of the bowl near the surface. The width of the reef is 1-3 metres wide and reaches depths of over 3 km near the centre of the formation. This results in increasingly deep and narrow mining that is slow, labour intensive and expensive. Gerbino writes that the easily accessed western limb of the complex is almost exhausted after 60 years of production. This region had the lowest production costs and the most amenable geology implying that maintaining cost and volume may be problematic. Consideration must also be given to concentrations is source rock with a yield average of 1 oz for every 10 tonnes of ore after going through a lengthy and energy intensive process.

[2] Gerbino, Kenneth J. 2005. The Great South African Platinum Story. In http://www.goldeditor.com/archives-39.htm for extensive review of Bushveld complex geology and mining see Cawthorn at http://www.wits.ac.za/geosciences/bushveld.htm or http://www.platinum.matthey.com/production/africa.html

The Cawthorn report that the IPA refer to when stating platinum reserves are at 1.5 billion ounces misrepresent the actual figures put forward by the author. Part of the article that was published in the South African Journal of Science[3] is presented below.

> The Bushveld Complex is well-known for its large proportion of the world's platinum and palladium resources. There are three very different ore bodies, the Merensky Reef, the Upper Group 2 (UG2) chromitite, which together can be traced on surface for 300 km in two separate arcs, and the Platreef, which extends for over 30 km. Their global importance has justified several resource calculations in the past. Such historical data are compared with the information in recent mining company annual reports. Resource calculations tend to be bigger by a considerable factor, because mining company reports include only proven and probable reserves, where sufficient information is available rigorously to justify such a classification. However, the remarkable continuity of layers within the Bushveld Complex certainly justifies qualitative extrapolation to adjacent areas, although current mines are probably exploiting the most favourable sections of reefs. The major platinum mining companies hold most of the mineral rights to these areas.
>
> Historical estimates of platinum and palladium in these reefs, which indicate about 770 and 480 million ounces, respectively (down to a depth of 1200 metres), do not distinguish between the different categories of proven and probable reserves and inferred resource. The present calculations indicate about 204 and 116 million ounces of proven and probable reserves of platinum and palladium, respectively, and 939 and 711 million ounces of inferred resources, down to a depth of 2 km. Already mining is taking place at 2 km in the Bushveld Complex, and so inferred resources, and ultimately minable ore, could almost certainly be considered far greater than even these calculations suggest. These figures represent about 75 and 50 % of the world's platinum and palladium resources, respectively. These figures for proven and probable reserves in the Bushveld Complex alone are sufficient for the next 40 years at current rate of production. However, estimated world resources are such as to

[3] Cawthorn, R.G., 2000. *The platinum and palladium resources of the Bushveld Complex*, South African Journal of Science, Vol. 96, No. 6, June 2000, p481

> permit extraction at an annually increasing rate of 6 % per annum for over 50 years. Expected sufficiency is less for palladium. Thereafter, down-dip extensions of existing Bushveld mines, lower grade areas of the Platreef and the Middle Group Chromitite layers may become payable Demand, and hence price, will be the determining factor in such mining activities rather than availability of ore.

It is evident that the IPA is quoting *inferred resources* and not *proven or probable reserves* which stand at 204 and 116 million ounces of proven and probable reserves of platinum and palladium, principally attributed to South Africa. However the issue, regardless of the ultimate amount of platinum group metals existing or able to be extracted, is how rapidly they can be brought to market, and on this point Cawthorn suggests expansion of 6 per cent annually for the next 50 years, from an assumed base point of year 2000, 164.6 tonnes (5,290,000 troy ounces). At this rate of expansion, by 2020 the industry would have produced approximately 200 million oz of platinum, which is effectively the total proven and probable reserve of the world.

Short term industry expansion is expected to be the result of increased operations from the Anglo Platinum company of South Africa, the largest producer, and with inconsequential increases also occurring in North America and Zimbabwe[4]. However, due to rand-dollar fluctuations and workforce-community disharmony expected expansions may not eventuate in the short to medium term. Anglo Platinum[5] presently state:

> The Projects Division, established two years ago, is responsible for the feasibility study, evaluation, and execution phases of major expansion and replacement projects required to meet the Group's production targets.
>
> During the second half of 2003, the Group reviewed all aspects of its strategy and expansion programme against the backdrop of unfavourable economic circumstances. The impact of the review on Anglo Platinum's project suite was to slow down the implementation of a number of mining projects by between

[4] Johnson Matthey, Platinum 2004 Internal Review.
[5] http://www.angloplatinum.com

one and three years. Ore treatment, smelting, and refining projects will continue to be expanded commensurately with the build-up in the mining profile.

The Anglo Platinum group had decided in 2003 to slow down the rate of its expansion programme, which, in 2000, envisaged to ramp up production to 3.4-million Pt ounces a year by 2006. In 2004 the company produced 2.45-million oz and it is now only expecting a 6 per cent growth rate, delivering 2.6-million oz in 2005 and around 2.75-million oz in 2006. Presently there is no indication that this growth rate will change industry wide for the foreseeable future.

The long term global average annual growth in platinum production was 3.25 per cent 1975-2004. Projected growth through to 2020 according to Cawthorn is to continue at 6 per cent, meaning that production growth for new FC applications, assuming stability in traditional and resilient/inelastic demand, would be 2.75 per cent. If we project growth from 2004 at 6 per cent through to 2020, see figure 1, and isolate 2.75 per cent of growth for the FC market we gain approximately 251,000 oz in 2010 and 450,000 oz in 2020, see table 1.

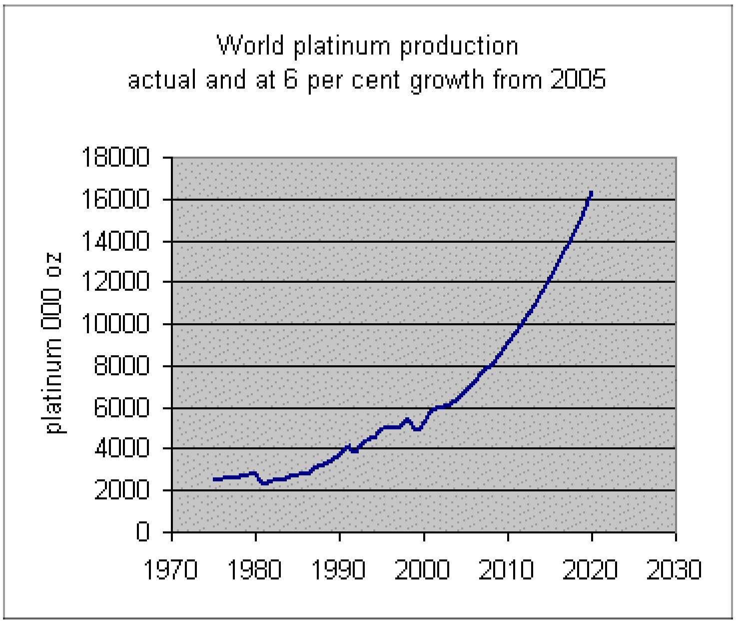


Figure 1. World historical and projected platinum production under an annual 6 per cent growth rate.

Obviously one could argue that there will be substitution and FC demand may steal supplies from another market segment. This may indeed be true, but considering the essential role that platinum plays in so many vital industries, except perhaps jewellery, it is hard to imagine the figures being too much higher than those derived above. With respect to jewellery and other non-essential functions, it must be acknowledged that as demand for platinum increases, it becomes a more sought after item for both jewellery and for investment.

Three rudimentary assumptions can be made about the future supply of platinum for FC applications, based on the 6 per cent growth rate. They are that it may only be available at the 2.75 growth rate or FC will steal from other markets and thus capture say 40 per cent of the market or FC will be high priority and consume around 80 per cent of the market. Given these scenarios platinum will be available in quantities detailed in Table 1 for 2010 and 2020.

| | 000s oz | | |
|---|---|---|---|
| | 2.75pcnt | 40pcnt | 80pcnt |
| 2010 | 251 | 3,648 | 2,797 |
| 2020 | 450 | 6,534 | 13,068 |

Table 1. Available world supply of platinum assuming 6 per cent growth rate, when capturing 2.75, 40 and 80 per cent of the market.

### How much platinum does a FC need?

Performance targets of FC for transport applications as stated in the conference *Scientific Advances in Fuel Cell Systems* 2004 Munich are summarised by Cameron[6]; as five interrelated characteristics: power density, operability, efficiency, durability and cost.

The UK Department of Transport reports that according to General Motors purchasing director David Andres, fuel cell stacks for cars currently use about 2 oz of

[6] Cameron, D. 2005. *Fuel Cells – Science and Technology 2004: Scientific advances in fuel cell systems reported in Munich*, in Platinum Metals Review, Vol. 49 No.1 January 2005.

PGM per unit. The fuel cell research team at Johnson Matthey believes that loadings can be reduced to about 1 oz by 2010 through better utilisation of platinum and thinner deposition layers. Other experts at Johnson Matthey and Advanced Power Sources estimate that when fuel cells are commercially produced each engine will require between 0.2 and 0.3 oz of platinum. However the lowest laboratory data on platinum loading for efficient performance of fuel cells is currently about 0.8 oz[7]. In comparison, autocatalysts use about 0.05 oz platinum and 0.15 oz palladium[8].

If we assume a 1 oz Pt loading for 2010 and an optimistic 0.5 oz Pt loading by 2020, the figures from Table 1 can be re-calculated.

| | 000s oz | World | | | | |
|---|---|---|---|---|---|---|
| | 2.75pcnt | vehicles | 40pcnt | vehicles | 80pcnt | vehicles |
| 2010 | 251 | 251,000 | 3648 | 3,648,000 | 2797 | 2,797,000 |
| 2020 | 450 | 900,000 | 6534 | 13,068,000 | 13068 | 26,136,000 |

Table 2. World wide number of FC vehicles that could be constructed given platinum availability.

There are around 800 million cars presently in the world, mostly in the OECD countries, and that number will probably reach 1 billion by 2010 given current growth rates, and for now ignoring oil depletion. Australia's proportion of the global vehicle fleet in 2010, assuming 10 million Australian passenger vehicles is 1 per cent. If we were to assume that FC vehicles were to be apportioned across the globe in the same ratio as vehicle fleets existing in 2010, then we could expect the Australian vehicle numbers as shown in Table 3, and the percentage of our fleet (at 10 million) in FC vehicles in Table 4.

| | 000s oz | Aust. | | | | |
|---|---|---|---|---|---|---|
| | 2.75pcnt | vehicles | 40pcnt | vehicles | 80pcnt | vehicles |
| 2010 | 251 | 2,510 | 3,648 | 36,480 | 2797 | 27,970 |
| 2020 | 450 | 9,000 | 6,534 | 130,680 | 13068 | 261,360 |

Table 3. Australia's share of FC vehicles based on platinum availability.

[7] http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_024056-03.hcsp
[8] http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_024056-01.hcsp

| | 000s oz | Aust | | | | |
|---|---|---|---|---|---|---|
| | 2.75pcnt | fleet | 40pcnt | fleet | 80pcnt | fleet |
| 2010 | 251 | 0.03% | 3648 | 0.36% | 2797 | 0.28% |
| 2020 | 450 | 0.09% | 6534 | 1.31% | 13068 | 2.61% |

Table 4. percentage of the Australian fleet that FC vehicles could make up based on platinum availability.

It must also be mentioned that the production of platinum exacts a heavy toll on the environment, even though fuel cells are claimed to be the environmental grail. Impacts include groundwater pollution and atmospheric emissions of sulphur dioxide, ammonia, chlorine and hydrogen chloride. However these impacts are reducing as the industry becomes more environmentally aware. The carbon emitted through the mining and processing of platinum is currently about 180 kg C per ounce. This equates to 360 kg for a current fuel cell car[9].

The only bright point in the platinum supply dilemma is that the metal is highly recyclable; hence most platinum can be re-used from fuel FC or salvaged from catalytic converters which will possibly increasing the FC numbers by perhaps 20 per cent each year. In 2004 recovery rates were around 9 per cent and it can be expected that this will increase dramatically in the future; however, it is not likely to have any effect on Australia’s position.

Durability is a problem with FC, and the lower the platinum load, the more susceptible the catalyst interface is to poisoning. FC can be made more durable by the addition of other PMG such as ruthenium; however, these are mined in such small quantities that their impact would be negligible for Australia.

It should also be considered that the numbers in tables 1-4 are for ultra light duty vehicles, however most FC application will be for public transport, such as busses servicing more people per oz of PMG, and they will consume 2-4 times the amount of platinum due to higher kW ratings. This being the case, the vehicle counts in the

[9] http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_024056-01.hcsp

tables could be reduced 50-75 per cent. Furthermore, should the market not evenly distribute platinum supplies, e.g. the majority being consumed by the U.S. or Japan, then Australia may get little to no platinum for FC.

Given the well established principle of price being established by supply and demand, we can safely say that the price of platinum will become astronomical, (hence the IPC media release aimed at ensuring demand), but more importantly, for most people/markets platinum will not be available at any price. It is almost inconceivable that many reports promoting conversion to an $H_2$ economy quote the long term average price of platinum (starting from 1880 when no-one knew what to do with it) of US$304[10] oz and invoke ridiculous and inappropriate economics to suggest that this will be the medium to long term price. These types of reports have been used since the late 1960s to bewilder and bewitch governments into bad policy choices to the detriment of the Nations that they represent and the financial security of future generations[11].

Given the full spectrum limitations of an $H_2$ economy as outlined in this chapter, references to a *smooth transition to an $H_2$ economy* with respect to Australia, at least for the foreseeable future, should be removed from all government projections for future transport options.

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[10] Carlson, E., 2003. *Platinum Availablity and Economics for PEMFC Commercialization: Report to US Department of Energy*, Tiax LLC, Cambridge Massachusetts.
[11] Perkins, J., 2004. *Confessions of an Economic Hit Man*, Berrett-Koehler Inc, San Francisco. See also George, S. 1992. *The Debt Boomerang: How third world debt harms us all*, Pluto Press, London.

# Queensland's oil problem:
# Future considerations for Governments

Michael Gutteridge & others

21-12-04

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## 1. Introduction

The purpose of this paper is to examine the validity of the widely reported growing gap between the global supply and the demand for crude oil (and natural gas as a substitute for oil); and to translate the global statistics to Queensland's circumstances. In Australia crude oil is primarily used to power transport, so substitutes for transport energy are identified. Finally, the implications of an oil insufficiency will be outlined and the role that Government may play in negating its worst effects. The paper examines arguments by industry analysts, professionals and academics, market analysts and the energy industries themselves.

For a decade or more, industry analysts and geologists have been arguing that the global demand for crude oil will some day soon exceed supply. This situation has been dubbed the 'oil peak' phenomenon. As the argument has matured, as industry and commentators have picked up the topic, and as modeling has become more sophisticated, various dates have been nominated for when the 'oil peak' will occur. The most optimistic of these dates is 2030[1] and the most pessimistic is 2005[2].

'Peak oil' is both a global problem and a problem for Queensland. Australia has a high reliance on oil and natural gas for transport, industry and agriculture. By 2010 Australia is likely to import most of its crude oil. However, some exports of its indigenous light crude and liquefied natural gas (LNG) will offset a growing and economically significant trade deficit in imported crude oil[3].

Demand for natural gas, like crude oil, is also expected to challenge supply and at projected consumption rates it too will decline. Under 'business as usual' forecasts, Australia's consumption of natural gas for traditional purposes such as smelting and

[1] IEA, 2002. "World Outlook 2002", International Energy Agency, Paris. P.25 (it will be explained that this date has large caveats, and can now be considered obsolete because forecast investment and production is unlikely to occur. This is highlighted in the appropriate section that makes reference to the IEA's latest report "World Outlook 2004" that suggests the date could be as early as 2010 and will most probably fall between 2015 and 2033.)
[2] Harris, Maury, 2004. (Chief Economist UBS Investment Research), quoted in John Schoen 2004 "How high will oil prices go?" NSNBC.com 1 Oct 2004.
[3] See: Akehurt, J. 2002. "World Oil Markets and the Challenges for Australia", Woodside Australia Energy & ABARE.

electricity generation is expected to double by 2020[4]. Optimistically the global peak may occur by 2030[5], and in Australia by 2025[6]. However, most of Australia's natural gas fields outside of the North West Shelf region are in decline and by 2010 are not expected to meet eastern seaboard demand. Also, the rate of decline will be determined by its use as a substitute for oil. It is suggested here that there will not be sufficient natural gas reserves in the North West Shelf or the Surat or Eromanga Basins[7] or domestic processing and distribution facilities to supplement crude oil sufficiently to meet Australia's projected demand for transport energy[8].

While the general consensus is that crude oil will always be available, it is considered that by 2010 programs should be well advanced to make a transition from oil-based societies, because of dwindling accessible supplies, spiralling cost, geographical concentration and geopolitical instability. Given this time frame, responsibility for these programs, principally strategies for reducing demand, will by necessity fall to governments. This is happening in many European countries and Japan.[9]

The paper does not factor in the growing challenge posed by global warming, which can only make the optimistic scenarios of smoothly rising supply and demand less likely and can only accentuate the need for governments to manage demand. Other forms of pollution from motor vehicles that lead to health problems in cities also need to be controlled.

## 2. Conventional oil supplies

Large reserves of crude oil that can be recovered using less energy than it takes to extract and process it are finite, regionally specific and dwindling. The distribution, concentration and quality of crude oil were set by the geological forces of nature

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[4] ABARE 2003. *Australian Gas Markets; Moving Toward Maturity*, p.36.
[5] ASPO, item 387.
[6] Fleay, B.J. 2003. *Natural Gas: Natural Pudding or Depleting Resource*, Institute of Sustainability and Technology Policy, Murdoch University W.A.
[7] Dickson, A. and K. Noble, 2003. "Eastern Australia's Gas Supply and Demand Balance", APPEA Journal 2003, ABARE pp-135-145
[8] Fleay, B.J. 1998. "Climaxing Oil: How Will Transport Adapt?" Section 6.2, see also ABARE 2003 op.cit., p.34.
[9] British Government Foreign Secretary Jack Straw recently released an International Energy Strategy that acknowledged the dire situation Britain faces as the North Sea oil and gas fields rapidly decline. See ASPO December 2004 item 462.

millions of years ago and no amount of technology, investment and dependency can alter that fact.

### 2.1. Overview

In August 2004 the world consumed 83.6 million barrels of oil each day (Mb/d), which is close to maximum existing capacity of production infrastructure. The Monthly Oil Market Report, September 2004 states:

> "As a consequence of limited spare production and refining capacity and surging Chinese demand, the market is seen to be stretched tight and unyielding as a 'taut piano wire'"[10].

According to the *Wall Street Journal*, the world needs to add 6 Mb/d of new capacity every year (from 2004), of which 4 Mb/d is to replace production at depleting fields and another 1.5-2 Mb/d to meet growing demand[11]. World demand is forecast to exceed 90 Mb/d by 2010. This report concludes on the basis of scientific evidence from a variety of experts that meeting the global demand will be impossible for a range of reasons, including physical limitation, insufficient investment and political constraints.

Already, should one major oil exporter falter, especially with the onset of the 2004-05 northern hemisphere winter, a supply crisis would occur and this scenario, should it eventuate, could result in an immediate rise in the price of crude oil to US$100 per barrel[12]. However, each year, with US consumption growing at 1.7-2[13] per cent per annum (from a 2004 base of 20.4 Mb/d), and Chinese at 40[14] per cent per annum (from a base of 6.36 Mb/d), the precariousness of the balance between supply and demand is likely to worsen.

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[10] IEA 2004 Monthly Oil Review, September p.3
[11] Bahree, B. 2004. Oil firms need long lead times to boost supply, in Wall Street Journal, Oct. 4th 2004
[12] Deutsche Bank.
[13] US Dept. of Energy, 2004. "Short-Term Energy Outlook – September 2004", DOE, US
[14] Faber, Marc, 2004. "Just how high will oil prices go?", AME Info, http://www.ameinfo.com

Australia in 2001 consumed approximately 0.85 Mb/d for all purposes. Australia and New Zealand's forecast consumption of transport fuel is presented in Table1.

| Australia & New Zealand | Mtoe | PJ | Mtoe | PJ | Mtoe | PJ |
|---|---|---|---|---|---|---|
| | **1997** | **1997** | **2010** | **2010** | **2020** | **2020** |
| **Total passenger transport** | 19.5 | 816.1725 | 24.5 | 1025.4475 | 28.1 | 1176.126 |
| Cars | 14.6 | 611.083 | 18 | 753.39 | 20.4 | 853.842 |
| SUVs | 0.8 | 33.484 | 1 | 41.855 | 1.1 | 46.0405 |
| Bus | 0.3 | 12.5565 | 0.3 | 12.5565 | 0.4 | 16.742 |
| Passenger rail | 0.3 | 12.5565 | 0.3 | 12.5565 | 0.4 | 16.742 |
| Intra-regional aviation | 1.9 | 79.5245 | 2.7 | 113.0085 | 3 | 125.565 |
| Inter-regional aviation | 1.5 | 62.7825 | 2.2 | 92.081 | 2.8 | 117.194 |
| | | | | | | |
| **Total freight transport** | 9.4 | 393.437 | 12 | 502.26 | 14.7 | 615.2685 |
| Small trucks & vans | 2 | 83.71 | 2.4 | 100.452 | 2.7 | 113.0085 |
| Heavy trucks | 4.6 | 192.533 | 5.5 | 230.2025 | 6.1 | 255.3155 |
| Freight rail | 0.6 | 25.113 | 0.6 | 25.113 | 0.6 | 25.113 |
| Navigation | 0.5 | 20.9275 | 0.6 | 25.113 | 0.5 | 20.9275 |
| Freight air | 1.7 | 71.1535 | 2.9 | 121.3795 | 4.8 | 200.904 |
| Mtoe = millions of tonnes of oil equivalent<br><br>PJ = Petajoules of energy | | | | | | |
| Total | | 1209.6095 | | 1527.7075 | | 1791.394 |
| Source: IEA Transport Projections in OECD Regions p.150-51 | | | | | | |

**Table 1:** Projected demand for transport energy in Australia and New Zealand to 2020. New Zealand's population is 20 percent of Australia's but the profile of road transport is comparable. Assumes population grows by 1% per year to 2020, and development remains at its current rate, i.e. business as usual. From the OECD's International Energy Agency (IEA).

Figures specifically for Australia in 2001 are presented in Table 2.

**Australian road transport for year ending October 2001**

| | Bu | | Co | | Pr | | Total | | urban | road |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Km* | *Av 000* | *Km* | *Av 000* | *Km* | *Av 000* | *Km* | *Av 000* | *%* | *PJ* |
| Passenger vehicles | 36357 | 11.4 | 37261 | 7.7 | 70307 | 8.4 | 143925 | 15.1 | 72.38% | 390 Pr |
| Motor cycles | 25 | 4.8 | 452 | 4.3 | 745 | 3.4 | 1448 | 5.2 | 73.90% | |
| Light commercial | 19301 | 19.5 | 4962 | 7.7 | 6466 | 7.5 | 30728 | 18.8 | 59.77% | 585 Bu |
| Rigid trucks | 6463 | 22.3 | 101 | 4.5 | 63 | 3.2 | 6627 | 21.9 | 67.45% | |
| Articulated trucks | 5317 | 93.6 | 3 | 2.3 | 2 | 1.7 | 5321 | 92.1 | 25.95% | |
| Non-freight trucks | 265 | 15.3 | 1 | 2.3 | 0 | 1.5 | 20267 | 15.4 | 0.94% | |
| Busses | 1759 | 35.9 | 27 | 7.5 | 49 | 8 | 1835 | 34.3 | 65.29% | |
| **Total** | **69713** | **15** | **42807** | **7.6** | **77632** | **8.2** | **190152** | **16** | **68.81%** | **975** |
| | | | | | | | | | | |
| Bu = Business | | | | | | | | | | |
| Co = commuting | | | | | | | | | | |
| Pr = private | | | | | | | | | | |
| Km = total km x 1 million travelled per registered vehicle | | | | | | | | | | |
| Av 000 = average km x 1 thousand travelled per registered vehicle | | | | | | | | | | |
| urban = capital cities and regional centres | | | | | | | | | | |
| road = road transport sector | | | | | | | | | | |
| PJ Petajoules of energy | | | | | | | | | | |
| | | | | | | | | | | |
| Source: ABS Year Book Australia Transport - Energy | | | | | | | | | | |

**Table 2:** Australian road transport energy profile, primarily using imported crude oil, for the year ending October 2001.

In 2001 Australia consumed 312 million barrels of oil equivalent for all uses, with 33 percent refined for automotive gasoline (103 million barrels) and 25 percent for diesel (78 million barrels). Based on Table 2, the road transport energy value of 975 PJ represents approximately 206 million barrels of crude oil equivalent at the refinery. This is taking into account the percentage of a barrel of crude oil that can be converted to gasoline or diesel, approximately 46 percent and 22 percent respectively. Our urban transport needs were around 142 million barrels in the 2001.

If demand for road transport energy continues to grow at 2 percent until 2010, total road transport will require around 1160 PJ per year, which is around 245 million barrels of oil at the refinery, and the urban component will be approximately 168.5 million barrels.

Given that the largest consumer of transport energy is urban road transport, there is considerable scope for demand to be reduced through strategic planning. Should this occur more energy options could become available for mechanised agriculture and industry.

### 2.2. Independent Analysts

Presented below are three international and one Australian source of independent analysis on peak oil. These authors and the groups that they represent are considered to be authorities within their particular fields. They are independent in so far as they do not represent the commercial interests of the energy industry or the political interests of governments. For the most part they are affiliated with academic institutes or professional organisations and their assessments are transparent, hence, open to peer review. They are in agreement that the age of oil is coming to an end, and that crude oil is more a scare commodity than an obsolete *sunset* commodity. Hence, all believe that oil will increase in value and this will occur rapidly when the daily volume of crude oil available on the world market begins to shrink. They also believe that substitutes for oil, and strategies for reducing demand, will not be sufficiently mature or implemented in time to offset a supply crisis.

The Association for the Study of Peak Oil and Gas (ASPO) provides the most comprehensive reporting, expert commentary and analysis of global supply and demand for crude oil and natural gas. In their own words, the organisation is "…a network of scientists, affiliated with European institutions and universities, having an interest in determining the date and impact of the peak and decline of the world's production of oil and gas, due to resource constraints…"[15] with representations from 14 European countries including the United Kingdom. ASPO's mission statement is:

> "-To evaluate the world's endowment and definition of oil and gas;
>
> -To study depletion, taking due account of economics, demand, technology and politics;

[15] ASPO No.45 September 2004 http://www.asponews.org .

-To raise awareness of the serious consequences for Mankind".

The founder, Dr Colin Campbell, is a respected geologist, oil industry professional and the author of several books on oil depletion. The association produces a monthly newsletter and publishes excerpts from industry journals, press releases and conference proceedings relating to the energy industry[16].

ASPO maintains a database and dynamic model to estimate the peak in global oil production, and thereafter the rate of decline. Given current geopolitical conditions, and all things proceeding as forecast, regular[17] (conventional) oil is expected to peak around 2005 and when non-regular (non-conventional) is included the peak moves forward by just one year to 2006[18]: see Table 3 and Figures 1-2 below. Natural gas, the closest substitute for crude oil, is expected to globally peak around 2030 provided it is not used as the primary substitute for oil[19]. It is difficult to predict how much sooner gas may be depleted should its use be broadened to offset a decline in oil. However, due to extraction, transport and conversion limitations, for most countries there will not be the capacity or investment for natural gas to replace oil 1:1 by volume, but instead it may make up no more than 10-20 percent of the vehicle fleet should they have indigenous reserves like Australia.

Figure 1 below represents the total amount of reserves discovered for each year since 1930 (past discoveries) represented as the shaded bars. A projection of future discoveries is then added from 2004 (non shaded bars) using standard industry modelling. Finally production is presented as giga-barrels (Gb/a) of crude oil per year which is effectively drawn from the discovered reserves each year.

The bars show that discoveries have been in decline since the 1960s and will continue declining. Conversely the line that represents production continues to rise as the world

[16] All monthly ASPO newsletters between January 2003 (issue No. 25) and September 2004 (issue No. 45) were reviewed. When statistics and quotes are cited in this report, only the unique article number is footnoted except when full referencing is required.
[17] Easily and cheaply extracted oil, e.g. from Saudi Arabia or Bass Strait, compared to non-conventional oil that is expensive and predominately synthesised from tar or shales or condensed from gas.
[18] ASPO item 392.
[19] ASPO item 387.

consumes more. It is inevitable that there will not be enough left in the reserves to meet the likely future demand at contemporary prices. There is no doubt that there will always be oil, but as Figure 1 illustrates, the supply squeeze will become tighter with each year.

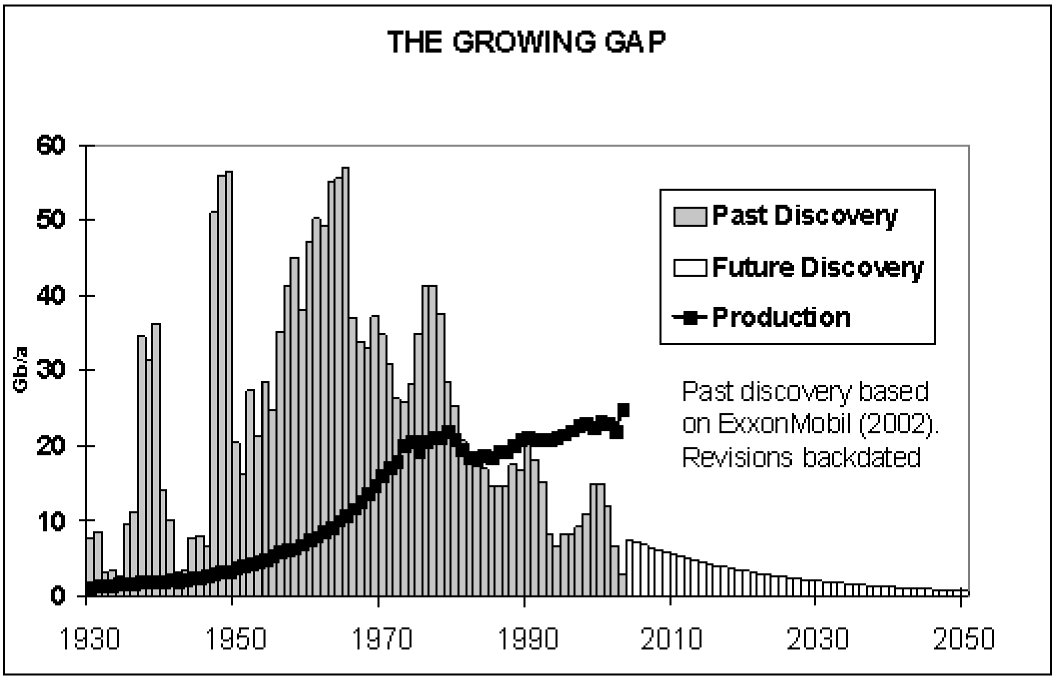


**Figure 1:** The growing gap between the discovery of oil reserves and the consumption of that oil.[20]

Figure 2 presents the production history for major regions, and also on the later portion of the graph, the contributions by non-conventional oils. It can be seen that the US has been in decline since the 1970s, Russia has a major dip during the decade of economic turmoil, and two down-turns have affected the Middle East corresponding to reduced global demand resulting from embargoes and price hikes. It can also be seen that non-conventional oils, including condensates from natural gas, are to be exploited as conventional supplies decline. However, it is also apparent that they represent only a small proportion of the total and these more expensive alternatives only delay declining production.

[20] ASPO Newsletter 45 September 2004

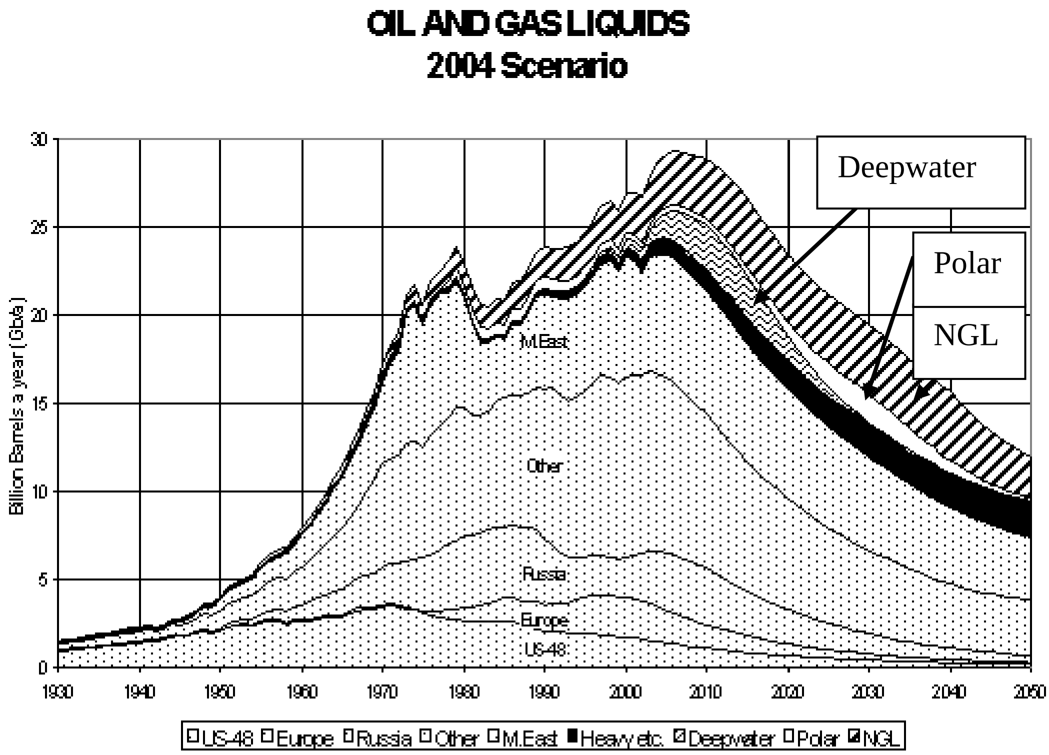


**Figure 2:** Production profiles for different regions and technologies.[21]

Table 3 summarises some of the data used to construct figure 2 and is ASPO's predictions up to August 2004. The model concludes that the world had, since production began, 1850 Gb of regular (conventional) crude oil that could economically be recovered, and 2500 Gb when all liquids (i.e. non-conventional) are included, and of this 920 Gb of conventional oil has already been extracted, and 990 Gb of all liquids. For most of the world, given annual rates of discovery and production, there is a plateau or decline from 2005 onward, and decline in Russia from 2010.

The annual production rates of other (non-conventional) oils including Canadian tar-sands and Venezuelan heavy oil slowly increase, but for all others decline by 2050. Global heavy oil production is expected to yield 4Mb/d in 2020; this represents only 20% of the USA's 2004 consumption of 20.4 Mbd. Gas liquid shows the most promise through to 2020, but at its peak of 11 Mb/d, this resource must be shared between traditional natural gas applications and conversion to transport fuel.

[21] ASPO Newsletter 45 September 2004.

Based on the projections in Table 3, by 2010 production of cheap conventional crude oil will be down by 40% on 2005 production and expensive non-conventional will bring production to around 90% of the forecast demand of 90 Mb/d. It is therefore likely that some countries will get their full quota of crude oil, whilst others will suffer reductions. It can be speculated that powerful, strategic and producer countries will get their full quotas, whilst others will suffer a disproportionate reduction.

| **ESTIMATED PRODUCTION TO 2100** | | | | | | | | | | End 2003 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Amount Gb** | | | | **Annual Rate - Regular Oil** | | | | | **Gb** | **Peak** |
| **Regular Oil** | | | | Mb/d | **2005** | **2010** | **2020** | **2050** | **Total** | **Date** |
| **Past** | **Future** | | **Total** | US-48 | 3.6 | 2.8 | 1.7 | 0.4 | 200 | 1971 |
| | Known Fields | New | | Europe | 5.0 | 3.6 | 1.8 | 0.3 | 75 | 2000 |
| 920 | 780 | 150 | 1850 | Russia | 9.1 | 10 | 5.5 | 0.9 | 210 | 1987 |
| | 930 | | | ME Gulf | 19 | 19 | 17 | 10 | 675 | 1974 |
| **All Liquids** | | | | Other | 27 | 23 | 17 | 9 | 690 | 1997 |
| 990 | 1510 | | 2500 | **World** | **64** | **58** | **43** | **20** | **1850** | 2005 |
| **2004 Base Scenario** | | | | **Annual Rate - Other** | | | | | | |
| M.East producing at capacity | | | | Heavy etc. | 2.6 | 3 | 4 | 5 | 195 | ~ |
| (anomalous reporting corrected) | | | | Deepwater | 4.7 | 7 | 5 | 0 | 55 | 2014 |
| *Regular Oil* excludes oil from | | | | Polar | 0.9 | 1 | 2 | 0 | 50 | 2030 |
| coal, shale, bitumen, heavy, | | | | Gas Liquid | 8.2 | 9 | 11 | 6 | 270 | 2027 |
| deepwater, polar & gasfield NGL | | | | Rounding | | 1 | | -2 | 80 | |
| Revised 06-08-04 | | | | **ALL** | **81** | **80** | **65** | **30** | **2500** | 2006 |

**Table 3:** Production forecasts for regions and technologies.[22]

In 2004 a comprehensive report by Dr Klaus Illum of the Danish Board of Technology and the Society of Danish Engineers called *Oil-based Technology and Economy: Prospects for the Future* was researched and critiqued by over ten professional and academic bodies, and a further five eminent persons, and can be considered the most up-to-date peer-validated compendium of the state of knowledge regarding global oil depletion. The report states:

> "The aim of the review is to outline the characteristics of the cheap-oil economy and provide an overview of different scenarios for the future development in demand and supply presented by various experienced

[22] ASPO Newsletter 45 September 2004

researchers and institutions who base their analysis on different methodologies"[23].

Illum does not give an exact date for peak oil but is critical of the International Energy Agency's optimistic date of 2030[24], suggesting that it depends on unrealistic investment, technological achievement and statistical methods that distort reserve figures. He suggests that the peak falls between 2010 (Campbell's previous figure, now revised to 2006) and 2025. However, given the forward revision of Campbell's date, the Illum figure could now be closer to 2010.

The Illum report stresses that the exact date of peaking is not important, and will not be known till after the fact: what is important is that it will occur very soon, that free market mechanisms are not likely to avert a crisis, and that governments should act now.

Leslie Magoon is a distinguished United States petroleum geologist who began his career with Shell then moved to the United States Geological Survey (USGS) some thirty years ago. He is co-editor of the profession's seminal text *The Petroleum System-From Source to Trap*[25], and few could be considered more experienced in North American reserves, exploration and technology. On technology he writes, "Technology is great, but it can't find what's not there."[26] Magoon puts the production peak around 2010[27] and advocates immediate action before decline creates serious price and supply problems.

Brian Fleay an engineer, former civil service manager with the Western Australian Government and member of the Murdoch University Oil Depletion Analysis Centre, has written several papers on the topic and published the book, *The Decline of the Age of Oil*. His papers[28] were reviewed for this report and were found to closely align with

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[23] Illum, Foreword.
[24] Illum, Section 3.1 & 5.4.
[25] 1994 USGS. pers.com John Draper.
[26] http://www.geopubs.wr.usgs.gov/open-fiile/of00-320/ .
[27] Leslie B. Magoon, 2000. *Are We Running Out of Oil?* USGS.
[28] *Climaxing Oil: How Will Transport Adapt?* 1998 and *Natural Gas: 'Magic Pudding' or Depleting Resource?* 2003.

the findings of the previous authors, but have a distinctly Australian focus. In the 1998 paper he writes:

> "The decade to 2010 will see this transition [oil] to decline. However, economic and political events will shape its character as much as the decline rates of the oil fields."[29]

Fleay's forecasts are not optimistic for Australia's agricultural and heavy industries in a world in which gasoline, diesel and natural gas are expensive. The 2003 paper contains detailed analysis of Australia's natural gas provinces, industry and markets. He calculates that at projected consumption rates, with no major increase due to crude oil substitution, supplies of natural gas are expected to rapidly decline after 2025 in the North West of the Australia, and around 2008 on the eastern seaboard[30].

Many governments around the world are taking these arguments seriously, and although only four authors have been presented in this report, they are representative of the much larger body of work being published. It is suggested that because of Australia's commitment to an oil-fuelled economy, the Queensland Government should also consider the implications of these arguments with urgency.

### 2.3. Industry and Markets

In conjunction with the independent analysis, detailed below is a range of arguments presented by those in the energy industry and global markets concerned with oil and energy. In October 2004, the energy industry's premier publication, *Oil and Gas Journal* (OGJ) published some of the concerns raised by industry professionals and executives. They included:

> High oil prices have not created the expected rise in exploration and recovery to stave off a short-term crisis.

[29] Fleay 1998 p.2
[30] Fleay 2003 p.11-12

Windfall profits are being retained by companies through buying their own stocks instead of expanding into risky non-conventional ventures. This is despite there being 470 large fields that could be redeveloped to take care of supply shortfalls that appear likely by 2015.

Improved recovery is depleting existing fields faster than expected.

Similar findings have been also published[31] by the World Markets Research Centre (WMRC), part of the Global Insight Group of companies. They suggest that there will be *tightness*, through to 2010, perhaps a relaxation through to 2015 and then major problems thereafter. However, large caveats are attached to these forecasts, including political stability in key oil-producing regions that at present is appearing less likely, and strategic investments that are also appearing less likely.

Deutsche Bank estimates that only 6 of 15 major oil companies have managed a reserves-replacement rate better than 100% during 2001-03. Royal Dutch/Shell, Total SA, Conoco-Phillips, and Exxon-Mobil Corp. all fell short of that target. According to Chevron-Texaco's General Manager for Global Explorations, his company is only finding 40% of current production[32]. The Bank concludes that relatively low investment by international oil companies in exploration and production[33], together with expected slow growth from national oil companies such as OPEC members, raises worries over medium term output,[34] unless there is a major downturn in the global economy and that downturn reduces a demand that has in the past been resiliently inelastic[35].

Cassidy writes:

[31] OJC, 6 Oct. 2004.
[32] Robert Ryan, General Manager of Global Explorations, Chevron-Texaco, quoted in ASPO 401.
[33] Major oil companies are now buying up smaller fields and consolidating their positions rather than put in the expense of fining increasingly smaller fields in remote locations, and thus not taking on the exploration risk. See ASPO Dec 2004 item 450, see also "The Rude Awakening", Wall Street Journal Nov 02 2004.
[34] OGJ Oct. 2004. Oil supply threatened by limited E&P opportunity, low investment.
[35] In the US after the 1973 oil shock it took 2 years for demand to drop 5%, and then 5 years to drop 10% after the prolonged shock of 1978. See Schoen, J., 2004. "Why high oil prices haven't cut demand?" MSNBC.com 14 Oct. 2004.

> Not so long ago, the deep waters of the Gulf of Mexico were considered a fertile exploration area. Lately, after much costly and frustrating drilling, it has proved something of a disappointment. Lee Raymond, the chairman and chief executive of Exxon-Mobil, was recently moved to comment that the company would have done better financially if it had given up after sinking a single well there.[36]

For the longer term WMRC states:

> Assuming a 1.8% annual increase in oil demand, production will need to reach an average of 100 Mb/d by 2015… This is a significant amount to add within just 11 years, roughly corresponding to the output of two new Saudi Arabias or one new Libya each year. With some 18 Mb/d of new production needed, it does not seem that the areas [now] open to International Oil Company oil exploration will be able to meet this need.[37]

WMRC's predictions for the future are not optimistic and they continue to write:

> [International oil companies'] exploration is down, drilling is down, discoveries are down, and new opportunities are not opening up with the speed the industry would like. In addition to this… lead-in times for new projects are becoming longer. – [They] are undoubtedly concerned about the current price spike's being little more than a bubble, but if this proves not to be the case, there could well be a lack of new oil in 10-15 years' time.[38]

In September 2004 the *Wall Street Journal* published the findings of the Washington-based PFC Energy oil-forecasting group. They warned that the world wouldn't be able to produce more than 100 Mb/d, and then only near that level for a few years. They went on to say:

[36] Cassidy, J. op. cit. 2004. p.2.
[37] OGJ Oct 2004. Oil supply threatened by limited E&P opportunity, low investment.
[38] ibid.

> After a country-by-country study, PFC concluded that if oil consumption continues to grow strongly, at a pace of 2.4% annually, even the Organization of Petroleum Exporting Countries' huge reserves would be insufficient to meet global demand as early as the middle part of the next decade… PFC concluded that the limits to global oil production will mean that demand for oil will have to be curbed, and alternative sources of energy found. Herman Franssen, a former chief economist for the IEA who is now president of an energy consulting company, said the conclusions essentially tell policy makers that 'they have a decade to put our [USA] house in order; for instance, it takes that long to retool the car industry' to use another fuel.[39]

This new era of frankness from the oil industry has followed criticism from independent groups, such as the Association for the Study of Peak Oil and Gas (ASPO), the International Energy Agency (IEA), and recently Standard and Poor's Rating Services (S&P). The later group has called for greater accounting transparency after Royal Dutch/Shell downgraded their proved reserves by 24%. Others followed suit including El Paso Corp., Houston, Forest Oil Corp., Denver, Vintage Petroleum Inc., Tulsa, Nexen Inc., Calgary and Husky Energy Calgary. Estimated reserves have also been revised by BP and Total, with acknowledgement that a production peak is imminent and total global reserves are in line with those figures published by ASPO[40].

Over the past two decades the IEA has published optimistic forecasts of crude oil reserves, in line with the energy industry and OPEC members. The IEA is subject to considerable industry and political influence and many commentators consider its forecast of 2030 for peak oil to be too optimistic. In any case large caveats were attached to the IEA forecasts, including massive investment, exploration success, technological success and political stability. A review of the IEA's World Energy Outlook 2004 by ASPO (published too recently to fully integrate into this report) accept that earlier forecasts were possibly too optimistic, and that this should be of major concern to governments around the world. Further more, they admit that for

[39] Bahree, B. 2004. "Demand for oil could one day outstrip supply", *Wall Street Journal*, 9 Sept. 2004.
[40] ASPO December 2004 item 455.

production to continue to 2030 in response to growth in World demand, it will need to be met by capacity that is yet to be built[41]. ASPO conclude from the report that:

> It is very important to note that the IEA now accepts the notion that there is a peak in oil production, even if there is uncertainty as to the date. The rage is from 2015 to 2033, coming even sooner if all the assumptions are not fulfilled. It follows that Governments are now on notice that they must make energy plans for the future that accept peak oil as reality[42].

The IEA's peak date of 2030 also depends on very large reserve figures quoted by OPEC members. In the 1980s after the nationalisation of their oil wells quotas for OPEC members were set according to each country's stated crude oil reserves. When quotas began, most members claimed that their reserves were almost double those that had previously been stated by the international oil companies that initially discovered and developed them. This is despite the absence of technological or geological evidence to support the revisions at the time.

In April 2004 Saudi Arabia announced that the Kingdom's recoverable petroleum reserves have now more than tripled, and that they have the capacity to quickly double oil output and sustain such a production surge for as long as 50 years[43]. Furthermore, the world should not expect the crude oil price to exceed US$28p/b. However, the announcement has since been found to be no more than posturing for the markets. Only four months later – in August – OPEC president Purnnomo Yusgiantoro and Venezuelan Energy Minister Rafael Ramirez admitted that OPEC had reached the limits of its production capacity; and subsequently the price has nearly doubled.

In 2003 only five Middle East OPEC members supplied one-quarter of the world's oil but by 2010 OPEC, and principally those major exporters in the Middle East, will dominate world crude oil production. No independent analysis of their reserves is permitted, but it is believed the official figures of ultimate recoverable reserves, totaling 694Gb, are highly suspect. Campbell argues that the total is closer to 370Gb,

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[41] ASPO 2004 special report "IEA accepts Peak Oil: An analysis of Chapter 3 of the World Energy Outlook 2004, http://www.peakoil.net
[42] Ibid, introduction
[43] Kennedy, T. 2004. Saudi Oil is Secure and Plentiful, Say Officials. In Arab News 29th April 2004.

and factoring in total future discoveries of around 60Gb, suggests that they are 36% depleted. If they were to maintain current production rates, their reserves would begin to decline between 2015-20; however, given that they are expected to make up for the decline in the rest of the world, their longevity is negated. He also notes that as there are limits to production rates especially from ageing fields, even though greater demand may exist, the rate of extraction is not likely to be raised much above the current level, hence an imbalance between supply and demand is inevitable.

Production in the Former Soviet Union (FSU) peaked in 1987 at 11.4 Mb/d and had fallen by nearly 50 percent by 1996, in part due to economic circumstances but also in part due to depletion at developed sites. Recently production has increased slightly and it is possible that the earlier peak may be reached within the next few years before slipping back into permanent decline[44]. The Caspian Sea has four giant fields which total around 20Gb of oil or condensate, ownership of which is in dispute. IEA production figures rely heavily on increased production from the FSU, however, recent articles by Russian oil and gas industry experts in the The Moscow News suggest that production may start to decline by 2006[45], and that by 2010[46] the FSU may stop exporting due to its own domestic energy demand. Based on reserves and foreseeable production rates, the FSU cannot be considered capable of offsetting world decline and is likely to give greater credibility to the lower end of IEA estimates.

Being a finite resource and a spatially explicit geological phenomenon, there is no smooth curve of availability for oil. For most regions of the world, no oil will ever be recovered, regardless of how much money is spent. In the Middle East, nearly[47] 400Gb were found by the drilling of about 3,000 wildcat bores. In Europe, by contrast, it took the drilling of about 20,000 wildcats to find less than 100Gb.[48]

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[44] ASPO Item 212
[45] The Moscow News 2004, "Russia's Oil Exports Reach Maximum, Decline to Start in 2 Years – Official", 07-12-2004, GAZETA.RU
[46] The Moscow News 2004, "Russia may Stop Exporting Energy Sources by 2010, 07-12-2004, GAZETA.RU
[47] Based on Campbell's calculation of 370 Gb of ultimately recoverable reserves.
[48] Illum 2004, p.32.

Conventional economic wisdom suggests that as a resource becomes scarcer and its price rises, low concentrations of the resource become economic reserves. However, in the case of oil this is not usually the case because there is a sharp cut off in the reserve that is defined by a geological or water boundary. Colin Campbell compares oil reservoirs with coal deposits and writes:

> "A coal deposit covers a wide area having huge 'resources' but only at places with thick seams or ease of access do the 'resources' become 'reserves' to be mined. It is largely a matter of concentration. Thus, if prices rise or costs fall then lower concentrations become viable 'reserves'. It is the same with mineral mining. Oil is different because it is a liquid which collected in certain places. It is either there in profitable abundance or it is not there at all. The oil-water contact in the reservoir is abrupt. So it is not a matter of concentration. The notion of huge resources being converted to 'reserves' as needed is deeply embedded in economic thinking, but it does not apply to conventional oil.[49]"

The conventional economic optimism that endless crude oil can be found and recovered because the price rises, or technology improves, does not hold true.

In Australia, John Akenhurst the Managing Director of Woodside Australian Energy wrote:

> …OECD [crude oil] reserves amount to just 11 years of production. Australia's proven reserves amount to just over 10 years of current annual production. – …the general view within the industry [is] that Australia has low oil prospectivity and fields yet to be discovered are of small to medium size and becoming more technically demanding… As a result the international oil majors have almost ceased oil exploration in Australia.[50]

It is not expected that Australia will ever find another field to match the productivity of the Bass Strait regardless of how much investment and exploration a rise in price is

[49] Campbell, C. in Illum 2004, p.35.
[50] Akehurt, J. 2002. "World Oil Markets and the Challenges for Australia", Woodside Australia Energy & ABARE

expected to promote. This is because the geological processes that favour the formation and concentration of crude oil did not occur extensively in the Australian region over the past millions of years as compared with the Middle East.

No amount of complaint about native title, sovereign risk or overbearing regulation can alter this geological fact. Nor can any amount of subsidies and concessions by governments.

### 2.4 Trade policy

Given declines in local crude oil production, within a decade or two most of Australia's petroleum will need to be imported, principally from the Muslim Middle East and Muslim Indonesia. However, in the predicted oil-scarce future it is possible that some crude oil markets may not be open to Australia at any price, especially if preferential trade agreements begin to emerge, such as between China and Iran, Former Soviet Union (FSU) and the European Union or USA and Venezuela. The recently signed free trade agreement with the USA will not help Australia, but instead will accentuate the problem.

In 2001 the US Department of Energy recognised that by 2020 the US would need to import over two-thirds of its oil, with the Gulf countries supplying more than two-third of the world's stock because of dwindling supplies in the rest of the world. The US will also face serious natural gas shortages by 2010, if not earlier. The free trade agreement has removed controls over foreign investment by US corporations in Australian energy producers (less than $A500 m) and given the strength of US demand in effect grants to the US preferential access to Australia's energy resources.
With the major oil-consuming countries having considerably larger economies, the impact on Australia's international competitiveness could be highly adverse.

## 3. Non-Conventional oil supplies

The oil that will be phased in as the current conventional fields decline is commonly referred to as non-conventional and deep ocean oil. These deposits have much higher exploration, extraction and processing costs, and many have high environmental costs.

Technology has reduced production costs at some sites, but for the most part they remain undeveloped because they are not viable until a *major* price rise. The example of Canadian tar sands is often quoted, with production costs declining between 1978 and 1996 from $26/b to $9.60/b[51]. What is not quoted however is the huge environmental cost, the amount of natural gas that is used to liberate and refine the tar into crude oil, and most importantly, the fact that these figures refer to those few sites where extraction was least costly once economies of scale were achieved, hence it is not an average cost but a minimum cost that cannot be sustained.

Most reserves of non-conventional oils will have much shorter lives than the conventional oils they replace (see Figure 1 and Table 3). At current and forecast crude oil consumption rates they buy only a few extra years.

To date, all the deep ocean oil discovered is expected to yield approximately 3.25 Gb/a (less than 12% of current global consumption), with rapid decline also expected to begin by 2010.[52] The prognosis is similar for the Canadian tar-sands mentioned above. Although reserves of 179Gb exist to be extracted, ASPO[53] calculates that there is not enough natural gas available to realise this. They expect that given available natural gas, only 14.4Gb could be extracted, the equivalent of $1^{1/2}$ years of North American crude oil consumption, and even this would be spread out over twenty years or more. It is expected that new technology will be developed to yield more oil using less energy in the process, but it is expected that these methods will be even more expensive, environmentally costly and still likely yield only a “trickle” compared to North American demand. In the process jobs will be created and some companies may become very rich, but a solution to a shortage in deliverable crude oil it is not.

Similar problems face the Queensland shale oil ventures and it seems at this date that those projects have collapsed. In summary, they required huge amounts of energy and water and had the potential to cause disproportionate environmental cost for the small yield in manufactured crude oil. This should not be considered a failing of investment considering extensive government support or of technology, but just the geological

[51] UN 2000 World energy assessment p.143
[52] ASPO item 205
[53] ASPO item 298

reality of the deposits and their inability to match concentrated fields of high quality crude oil such as those found in the Bass Strait.

It should also be noted that the production and distribution of non-conventional oils requires billions of dollars in investment more than conventional oil because they are usually in remote locations and are of such qualities that they require extensive refining, as is the latter case for Queensland oil shale. Furthermore, Stuart plant in Queensland was unable to eliminate toxin dioxins from its emissions. No modern regulator could consciously grant a permit for a plant emitting significant quantities of cancer-producing pollutants[54].

It is unrealistic to expect that non-conventional oil can be supplied from these sites and sources at prices comparable to the conventional oils to which society is now geared. Globally, large government subsidies to explore and develop non-conventional oil have had very little success.[55]

## 4. Alternatives

As the gap between supply and demand for oil grows and prices rise, there will be increasing pressure to move to alternative energy sources, particularly with regard to transport fuels and energy inputs to industry and agriculture. The question now addressed is whether a smooth transition to such alternatives is possible and economically feasible.

Faced with a high reliance on a dwindling resource, it is often assumed that alternative fuels will enable a modern society to adjust and to maintain business as usual. As will be highlighted in this section, no alternative fuels are available or are expected to be available in the near future in sufficient volumes and at prices comparable to conventional oil. This does not mean that there are not alternative fuels, but apart from increased cost, many also require as much energy to produce, store and distribute as they can ultimately deliver to users, or more. Given current technology this is the case for hydrogen and for ethanol if farm inputs and opportunity costs are

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[54] G. Edwards, 4 Dec. 2004, pers. comm.
[55] Illum 2004 p.74

considered in Australia. As most transport energy in Queensland is consumed in urban areas, on-farm production of bio-fuels which may help farmers offers no solution for Australia's current transport profile.

Most of Australia's agricultural machinery and commercial fleet runs on diesel. However, Australia's indigenous reserves of light crude oil are not suited to the manufacturing of diesel and heavy lubricating oils. This means that the diesel-powered agricultural and commercial sectors of the Australian economy are reliant on imported heavy crude and therefore disproportionately exposed to a rise in crude oil price or a disruption in its supply.

Straight diesel can be substituted by diesel-alcohol blends, bio-diesel produced from vegetable oils, and with some modification, natural gas. Some of these are addressed in greater detail below.

### 4.1. Natural Gas

Natural gas can be used as a substitute for petrol in the form of condensates from wet gases to produce liquefied petroleum gas (LPG)[56]. It can be stored, transported and used as a transport fuel when it is compressed as a high pressure gas (CNG) or cryogenically cooled to -161 degrees centigrade (as LNG). Natural gas can also be purified to its principal component methane ($CH_4$) and used as a gas directly in internal combustion engines or transformed into liquid methanol and used as a gasoline extender or replacement.

LPG and methanol (derived from natural gas) are best suited to the current transport fleet and fuel distribution network while CNG and LNG are better suited to transporting bulk natural gas or in large fleet vehicles such as buses and trucks because of the useable energy as a ratio of storage size and complexity. Gasoline from crude oil, methanol/ethanol from natural gas or bio-mass and low pressure LPG from crude oil or natural gas contain considerably more energy per on-vehicle-tank than

[56] Wet gases such as those used for the production of LPG contain high levels of propane and butane in proportion to methane. Most natural gas in Australia is not wet gas. LPG can also be won from crude oil during refining.

natural gas. Hence natural gas in its compressed or liquefied form limits a vehicles range to 40-50 percent of that for gasoline. LPG and methanol blends can achieve a gasoline comparable range of 75 to over 100 percent depending on engine design.

It is expected that by 2008 production of LPG from wet gas and from the refining of crude oil will peak in Australia. Thereafter the bulk of our LPG will come from imported crude oil and from North West Shelf natural gas.[57] It should be noted that propane and butane, the principal components extracted from natural gas to create LPG, are only around 5 per cent of the total volume of natural gas, so this high energy-density fuel well suited to road transport can only be considered as a smaller percentage of Australia's total natural gas reserves. Furthermore propane, an essential ingredient, is deficient in many sites where Australia extracts natural gas. To compensate, Australia must import considerable amounts of propane and export its excess butane, thus reducing LPG's ability to contribute toward Australia's energy self reliance.

In 2001 Australia produced around 3.5 million tonnes (Mt) of LPG, amounting to approximately 107.5 PJ/a[58], of which 58 percent was used in transport and storage, and another 22 percent in manufacturing. There is little scope to expand indigenous supplies of LPG especially to meet the quantities required to replace our current demand of 975PJ/a, principally derived from oil, for road transport energy.

The bulk of natural gas produced in Australia is already allocated to end users including industry, electricity generation and residential reticulation. In the year ending October 2001 Australia produced 1,405 PJ of natural gas. Of this 200 PJ was exported and this volume is expected to rise as world demand grows and the commodity becomes more valuable. To use natural gas in Australia as a replacement for current crude oil demand would require production to nearly quadruple: that is, to double to meet expected growth in traditional areas such as industry, electricity and households and then nearly that much again for replacing gasoline and diesel. This approximation takes into account growth in transport fuel demand, and also the extra energy that is required to process and transport gas, and/or its conversion to either

[57] ABARE, 2003. *Australian Liquefied Petroleum Gas Supply Research Study 2000-2020.*
[58] ABS, 2004. Year Book – Energy Production.

LPG or methanol. To use gas for transport, let alone the projected demands in traditional areas, is likely to deplete Australia's reserves much sooner than the present forecast of 2025, with a theoretical quadrupling reducing peak production to 2010 and then rapid decline thereafter. (Decline will be rapid because gas, being freer flowing, can be extracted at a higher rate than crude oil). It should be noted that most of Australia's natural gas fields are already in decline, and that the discovery of gas in the North West Shelf region has only delayed an inevitable crisis in supply, at least in the west of the country.[59]

To use natural gas for transport would likely increase the price further, and this would flow on to other industries and products that rely on it as an energy source or feedstock. Amongst other things this would include electricity, smelting and the production of agricultural fertiliser.

Methanol produced from methane offers considerable promise in extending and supplementing Australia's current transport fuel demand until a more permanent substitute (possibly hydrogen) is fully integrated into the economy. One hundred per cent methanol can be used in many vehicle engines but even as an 85 percent additive to both petrol and diesel it has been successfully used in many countries. Methanol has properties similar to those of ethanol but its production can initially rely on fossil fuel (natural gas) as distinct from biomass as is the case for ethanol. Vehicle conversion costs are lower than they are for conversion to LPG or CNG and LNG, and power output in most of our current transport fleet would be comparable to gasoline up to an M85 ratio. Furthermore, if engines are designed to run on high methanol ratio fuels, such as with racing cars, they will in fact be more efficient than gasoline because of a far higher octane rating and the ability to compress more fuel into the combustion chamber per compression cycle. With little modification methanol can also use the existing fuel distribution infrastructure, unlike the gas options that will require major conversions and upgrades.

Methanol can be produced from coal seam gas and biomass such that these can be substitutes for natural gas as a feed stock. Methanol is also an alternative feedstock to

[59] Fleay, B.J 2003. "Natural Gas: Magic Pudding or depleting resource."

hydrogen for fuel cells and could therefore be part of the transition toward a hydrogen economy. However, as previously discussed, Australia’s limited natural gas reserves will not allow for the production of methanol in volumes that can replace gasoline made from crude oil on a 1:1 basis. As a road transport fuel alternative, methanol would be viable only in conjunction with a major reduction in energy demand, and as an extender of current gasoline volume.

Non-conventional sources of natural gas may play a major role in the future. The vast coal resources of Queensland could be used for *in situ* gasification which is used and is being investigated overseas. Deeper coals and lesser quality coals could be used. Large volumes of gas hydrate are present below the sea floor in many parts of the world. They are indications of large resources of gas hydrates within Australia’s Exclusive Economic Zone. There are technical difficulties in recovering these gases and the economic recovery of these gases lies in the future.

There is little doubt that gas will play a far greater role in Queensland’s future, regardless of its source. Given this fact, strategic decisions must be made now as to how this resource is developed and allocated such that it may be part of a smooth transition as oil becomes less available or affordable.

### 4.2. Bio-fuels

Biomass-based bio-fuels such as ethanol and bio-diesel can also be a substitute, but at higher cost (refer to Figure 3), and in far smaller amounts than the gasoline and diesel Queensland is now consuming. Although the direct production cost is similar to that of gasoline and diesel when crude is at US$30 per barrel, the opportunity cost of converting agricultural land to energy production along with fertiliser, pesticides and mechanised farming energy inputs drives the cost up.

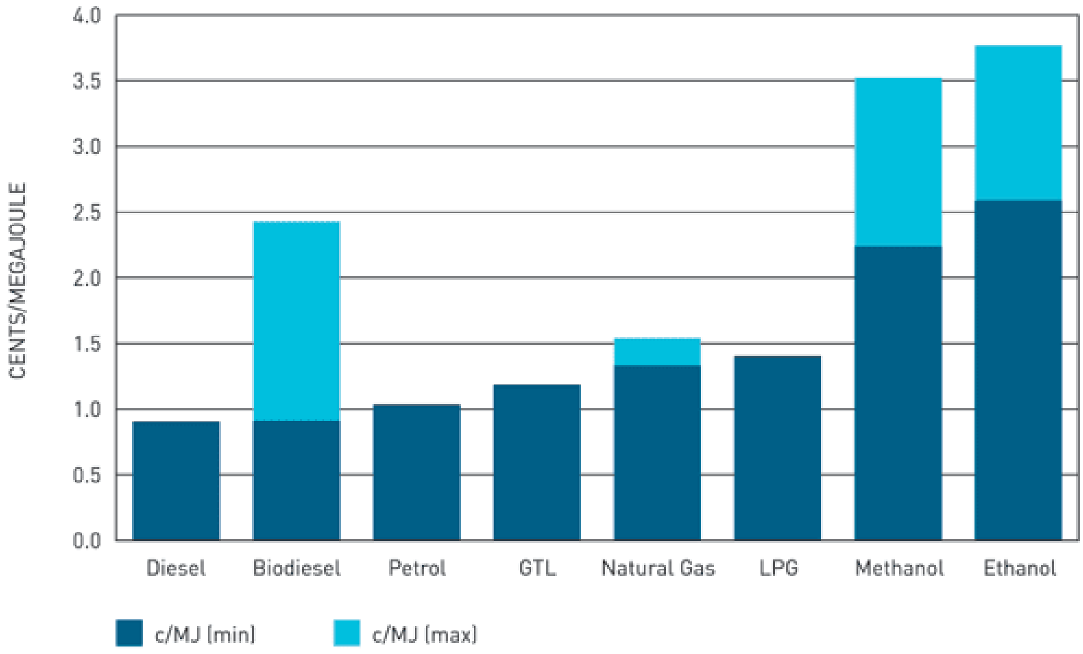


Figure 3: Indicative energy costs of transport fuels (net of tax) based on US$35 a barrel and A$1 = US$0.7.
Source: Australian Government: Department of Prime Minister and Cabinet[60].

In many cases it requires considerable energy to produce the bio-fuel. Studies suggest that there is a net positive energy value in ethanol of 24-34 percent[61], i.e. for every 100 units of energy created 64 units were sacrificed. These figures are based on the fertile and well watered prime agricultural regions of the USA and are not applicable to the bulk of Australia's marginal agricultural lands.

Australia consumed around 50,000 Ml in petroleum products in 2002-03, with 18,875 for automotive gasoline and 13,888 for automotive diesel[62], together approximately 65 percent. Ethanol can be made at a rate of approximately 350 litres per tonne of feed stock from sugar cane molasses or cereal grains such as wheat or sorghum. Most of Australia's agricultural land is suited only to low yielding cereal crops, such as wheat which produces approximately 1.5 tonnes of grain per hectare. It would require somewhere near 142,857,143 million tonnes of feed stock grown over 95,238,095

[60] http://www.dpmc.gov.au/publications/energy_future/chapter4/8_alternative.htm .

[61] Shapouri, Hosein, James A. Duffield and Michael S. Graboski. 1995. *Estimating the Net Energy Balance of Corn Ethanol*. p.14.

[62] ABARE, 2003. *Australian Commodity Statistics*, Item 312.

million hectares to replace 50,000 Ml of petroleum products. For comparison, in 2001-02 the total area of all Australian crops was 24,000,000 million hectares, so even if all crop land were given over to producing ethanol, it would still only produce a quarter of current needs. To fulfil the gasoline and diesel demand would equate to approximately 62 million hectares, or almost three times the size of the total cropped land in Australia. Hence, even a mere 25 percent substitution ratio, that is an E25 blend where 25 percent of gasoline and diesel demand is offset, would still use up almost all of Australia's crop land unless there is a dramatic reduction in demand for transport energy.

### 4.3. Hydrogen and electric vehicles

There has been an expectation that hydrogen will replace petrol and that there will be a smooth transition to hydrogen. However, the informed scientific and engineering communities are generally less optimistic. The IEA acknowledges that hydrogen is only an emerging possibility and has a capability of replacing only a small percentage of current transport by 2030. Hydrogen would best be suited to public transport and large commercial fleets. With respect to large scale passenger car application, the US Department of Energy, after billions of dollars of research, claimed this year:

> "Bridging the gaps that separate the hydrogen- and fossil-fuel-based economies in cost, performance, and reliability goes far beyond incremental advances in the present state of the art. Rather, fundamental breakthroughs are needed in the understanding and control of chemical and physical processes involved in the production, storage, and use of hydrogen… Such breakthroughs will require revolutionary, not evolutionary, advances." [63]

It should also be noted that hydrogen is a carrier, not a source, and must be manufactured and this in itself requires more energy than can be subsequently recovered unless large-scale solar technology is used and life cycle costing is extensive. In the USA, based on current technology:

[63] 2004. *Basic Research Needs for the Hydrogen Economy*, US Dept. Energy. p.4.

> "It is estimated that if only 4% of automobiles in California were powered by hydrogen fuel cells, the generation of hydrogen from water would require all of the state's existing electricity generating capacity…[64]" [and each car itself would cost near $1 million per unit principally because of the price of platinum used in the construction of fuel cells, and the light weight materials used in body construction][65].

If Australia were to consider a transition to a hydrogen-based economy, it would need to start building power stations or solar arrays today, secure large volumes of clean water today, build expensive exotic-material storage and delivery systems today, and begin to train personnel today, to manage and maintain what the top scientists at the laboratories of Los Alamos USA still do not fully comprehend. These challenges are valid regardless of whether hydrogen is burnt in a combustion engine or used in a fuel cell to generate electricity.

Most commentators, including the IEA and US Department of Energy, acknowledge that a hydrogen economy still requires a dramatic reduction in transport energy demand.[66]

Even if one confines attention to *standard* electric cars with batteries charged from fixed infrastructure, problems also arise. Although the technology is relatively mature for lead acid batteries, more advanced energy storage systems are expensive and involve rare and potentially environmentally hazardous materials. Electric cars present issues of fleet replacement and local manufacturing. Should there also be a rapid increase in electric vehicles, it would result in a greater demand for fixed electricity generation. Regardless of limitations, electric vehicles are likely to be a partial solution at least in urban areas.

### 4.4 Coal and Syngas

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[64] Gilchrist 2003, Coontz & Hanson 2004. "Toward a hydrogen economy" in *Science* vol. 305 13 Aug. 2004.
[65] ibid.
[66] See Cassidy, John, 2004. "Pump Dreams: The political scene", *The New Yorker* 11-10-2004.

Significant research is being undertaken to develop technology to use coal in such a way as to eliminate harmful emissions or reduce them significantly – Clean Coal Technology. Coal has many advantages as a fuel. It is relatively plentiful and cheap to mine. The technology being developed will only work successfully if geosequestration works – research is still at an early stage. One of the directions being taken is to utilize the hydrogen in coal as a fuel rather than the carbon. Many scenarios of the hydrogen economy have a staged progress with hydrogen being produced initially from fossil fuels (gas and coal ) before the combination of solar energy and water becomes the source of hydrogen. Coal gasification produces syngas ( a mixture of carbon monoxide and hydrogen) which can be converted to liquid fuels such as methanol. A poly-generation plant could produce clean fuels, chemicals and electricity. The Queensland Government already supports this research through the CRC for Coal in Sustainable Development, the Centre for Low Emission Technology and Coal 21. This is still technology in development.

Given the infancy of this technology, and the hurdles that are still to be overcome, it would be prudent to acknowledge that potential exists but is not likely to be a replacement for our current crude oil demand. There is no doubt that many alternative sources of energy and modes of transport can be developed and become operational within the very near future. However, no range of options can fulfill the role that cheap and reliable crude oil has played over the past eighty years.

## 5. Implications

There is no easy or painless solution to the imminent mismatch between economic supply and the demand that is deeply embedded in Queensland’s policy settings. Demand management, however, does not sit comfortably with growth-orientated markets, so the responsibility will fall squarely on government, primarily the State and local governments that are responsible for land use and transport planning.

There is no doubt that the world’s oil supplies will soon begin to decline, and there is very little disagreement that this will begin within the next 10 years. As the price of crude oil and natural gas rise, more will be found, and non-conventional crude oil will be produced, but none of these will be in the quantities and at prices to which Queensland's economy and social structure are accustomed.

It is unlikely that an oil economy will remain within 20 years or even sooner. It is urgent that plans be put in place to ensure that essential supplies of energy are retained for agriculture, industry (especially the chemical, plastics and fertiliser industries) and mass transit systems. Land use and infrastructure must be planned today for a very different future. All the future options that can be imagined require a dramatic reduction in the use of energy for transport. In 2000-01 Queensland was the third larges energy consumer in Australia at 1020PJ (20% of the national total), growing at 3.8 per cent per year since 1973-74. Queensland consumes almost all of its oil energy on transport; and in a globalised world, Queensland's private transport is expendable.

The planning of suburbs and social amenities must occur in the knowledge that people will not be as free to travel long distances as they could in the past, unless that is on public transport. Public transport systems will require major upgrades, whilst suburbs should be focused around transport corridors and in closer proximity to centres of employment. The construction of freeways and tunnels for private cars should be considered un-economic.

Tourism in Queensland will suffer unless alternative transport solutions are considered. Should there be a contraction in overseas visitors, a contraction in interstate air travel and a contraction in discretionary household expenditure on long-distance holidays generally, then it is difficult to imagine a future for remote locations such as Airlie Beach, or even the tourism-based economy of the Gold Coast. Many tourism sites were developed when transport was cheap and the population could afford to be highly mobile. This is not likely to be the case in the future.

The viability of mechanised industrial agriculture in Queensland based on the current oil economy is questionable and will likely require fundamental changes as fuel becomes more expensive and harder to obtain, and as commodity markets change. There could be opportunities to grow goods destined for city markets closer to consumers thus reducing the transport energy and more distant enterprises producing for even more distant markets may no longer be competitive. This could raise serious questions for the valuation and zoning of lands, especially in urban areas and capital city hinterlands.

The most effective option available to Queensland is reduction in the demand for oil-derived energy and to achieve this requires a comprehensive rethink of urban, rural, social and commercial legislation and policy.

There is little doubt that major dislocation and upheaval will occur within the Australian economy and especially within geographically vast Queensland over the next 20 years and beyond. The degree to which these changes are considered positive or negative will depend on how soon society accepts that a crisis is on the horizon, and to what degree all levels of government and industry can work together to create a post oil society.

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### 1.1. Australian oil production/consumption (Michae1 Gutteridge 2005)

Australia consumed 52,908, million litres of refined petroleum products[1] in 2003-04. Since 1960-61 this amount has gown on average by 2 per cent each year and is expected to continue growing at this rate until at least 2010. In 2003-04 approximately 80 per cent was locally produced and the balance was imported, either as feedstock for refineries or pre-refined products. Around 5 per cent of Australian refined product was re-exported to the region.

Conventional crude oil as feedstock for petroleum products grew rapidly in Australia from 986.7 MMbbl in 1970-71 to a peak production of 2,689 MMbbl in 2000-01. In 2001-02 production declined to 0.95 percent of the peak. In 2002-03 it was 0.93 per cent of the previous year and in 2003-04 it was 0.85 per cent of the previous year implying accelerating decline. Figure 1 presents historical data from 1965-66 through to 2003-04. From 2005 through to 2010 consumption is forecast to continue to grow at 2 per cent annually, and then through to 2020 at 1 per cent annually. This is in line with Federal government, CSIRO[2] and IEA[3] forecasts.

Production decline is calculated at 12 per cent annually 2005-2010 and then at 10 per cent through to 2025; this is based on issues outlined below.

> -Federal government downgraded commercial reserves of crude and condensate by more than 50 percent in 2004[4] to 1.49 billion bbl remaining commercial reserves. This is the amount that falls below the curve through to 2025. Geoscience Australia downgraded *production to reserves ratio* from 11 years in 2004 to 5 years in 2005 however it is assumed that there will be some new discoveries and improvements in extraction that will allow smaller production volumes beyond 2010.

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[1] not including natural gas
[2] CSIRO 2002, *Future Dilemmas: Options to 2050 for Australia's population, technology, resources and environment*, CSIRO, Canberra
[3] Landwehr, M, and Marie-Lilliu, C, 2002. *Transportation Projections in OECD regions: Detailed Report*, IEA, Paris
[4] Oil and Gas Journal, 20 December 2004, p. 18

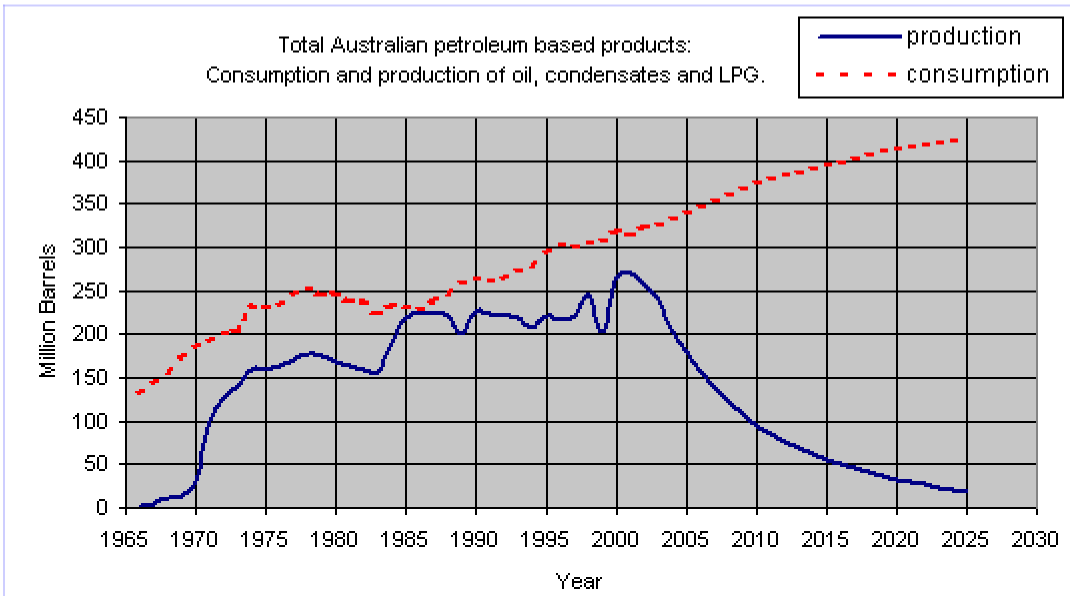


**Figure 1:** Australian consumption and production[5] of petroleum based products excluding Natural Gas. Note the dip in 1998-99 is not a shortage of domestic resources, see footnote[6]

-BHP/Esso (Bass Strait)[7] forecast 17 per cent annual decline through till 2008, Santos downgraded reserve estimates (Mutineer-Exeter)[8] off Western Australia by 40 per cent in 2005 and Shell (Carnarvon Basin)[9] downgraded.

-Woodside Petroleum/ABARE study states; "...Australia is facing a rapid decline in liquid petroleum production over the next decade. Liquids self-sufficiency is expected to decline from an average of 80-90% over the past decade to less than 40% by 2010."[10] In the light for downgrades this forecast would appear to be overly optimistic. Woodside's proved plus probable oil

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[5] Production proportions in 2003-04: crude oil 63.5%, condensate 22.1% and LPG 14.2%

[6] The Asian economic crisis, and the low Australian dollar against the US resulted in record low prices for oil, coupled with shutdowns for maintenance and the explosion at the Longford refinery in Victoria, saw turnover for the oil and gas extraction industry fall by $1.0b (10%) to $8.7b. See ABS Australian Mining Industry, 1998-99 (Cat. no. 8414.0). Note also that there was little decline in refinery through-put and domestic consumption did not decline; hence crude and refined product was sourced externally or drawn from stocks. It is important to note from the graph that 1998-99 downturn in production in that

[7] BHP Billiton Petroleum, 2004. Operational & Financial Review October 2004. (39% reserve replacement 2003-04 with largest drop in Australia.) and Myer, Rod 2003, BHP hit as Strait oil shrinks, Sydney Morning Herald, January 30 2003.

[8] See http://au.biz.yahoo.com/050215/19/3cq0.html or
http://ogj.pennnet.com/articles/article_display.cfm?Section=ONART&C=DriPr&ARTICLE_ID=221607&p=7

[9] Fleay, B. 2005. Australian O&G reserves.
http://stcwa.org.au/journal/150105/1106124615_17030.html

[10] Akehurst, J, 2002. 'World oil markets and the challenges for Australia.' ABARE, Canberra.

reserves were downgraded in 2004 by 20.3 MMbbl giving a 2004 reserves replacement ratio (RRR) of 47 per cent[11] (over 100 per cent is required for growth).

-Australian Petroleum Production and Exploration Association (APPEA) claimed that Australia needed to spend $1 billion a year in frontier exploration (off-shore deep water) just to stand still[12]. However there has been little success despite generous support and concessions from Federal and State governments and also high global oil prices that should be conducive to bringing less profitable plays into production. In the first quarter of 2004 no Australian offshore oil discoveries were reported and 2003 was the worst year for discovery of the past 13 with a major decline in drilling success rate.[13].

-The largest projects coming online in new provinces e.g. ConocoPhillips Bayu/Undan Timor Gap Zone yield a maximum of 42 MMbbl/y of oil equivalents from gas condensates and LPG are exclusively for export[14]. Residual LNG via Darwin is also scheduled for export.

-No oil company or geological report specific to Australia's existing resource basins or frontier areas, to date, has produced adequate data to refute the forecasted decline rate, however all have published data support it. "…the general view within the industry [is] that Australia has low oil prospectivity and fields yet to be discovered are of small to medium size and becoming more technically demanding… As a result the international oil majors have almost ceased oil exploration in Australia".[15]

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[11] ASX Announcement 19 January 2005, Mike Lynn Woodside Petroleum, Forth Quarter Report for period ended 31 December 2004.
[12] APPEA 2002, *Flowline January Issue 10*, National Energy Policy. See also Fleay, B, 2002. *Natural Gas "Magic Pudding" or depleting resource*, Murdoch University Western Australia. See also Powell T.G.,2001, Understanding Australia's petroleum resources, future production trends and the role of the frontiers; APPEA Journ. 2001.
[13] Geoscience Australia 2004, *Australian Petroleum Exploration and development Activity*
[14] ABARE, 2004. *AustralianCommoditie*s, vol 11, no 2 p329.
[15] Akehurt, J. 2002. "World Oil Markets and the Challenges for Australia", Woodside Australia Energy & ABARE

-The Association for the Study of Peak Oil (ASPO) modelling predicts rapid decline[16].

This report suggests that in 2010 Australian domestic production will only meet 25 per cent of consumption and 8 per cent in 2020. Australia will need to import 280 MMbbl in 2010 and 381 MMbbl in 2020 unless action is taken to reduce consumption, or price and supply constraints impose conservation, figure 2.

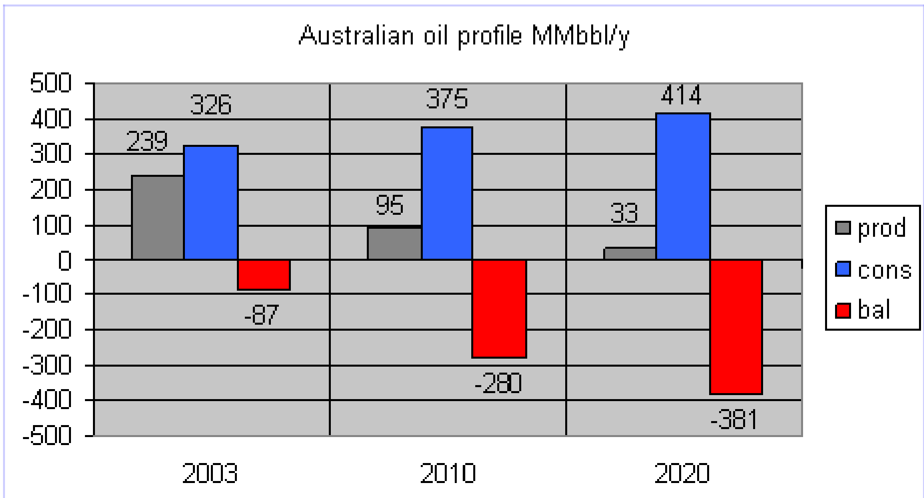


**Figure 2:** Australian oil balance MMbbl/y.

These findings are in stark contrast to the Federal Government's White Paper *Securing Australia's Energy Future* of June 2004[17]. This discrepancy will be addressed in *Chapter 6* of this report.

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[16] ASPO issue 174

[17] http://www.pc.gov.au/inquiry/energy/subs/sublist.html#list see submission from Matt Mushalik 2004, *Critique on "Securing Australia's Energy Future", Focus: Oil & Gas Depletion*