WORLD OIL PEAKS NEXT DECADE
CONSEQUENCES FOR RENEWABLE ENERGY

B.J. Fleay
Institute of Science and Technology Policy
Murdoch University
Murdoch WA 6150
AUSTRALIA

BACKGROUND

US oil production in the lower 48 states peaked in 1970 allowing the Middle East producers to use oil as a political weapon in the Israeli-Palestinian dispute. We had the 1970's oil crises. There was never an oil shortage and several large discoveries in Alaska, the North Sea, Mexico and elsewhere were waiting in the sidelines. By 1973 the world had consumed only one eighth of its oil endowment, some 250 billion barrels. The crises were about, politics and power.

The industrialised countries reacted by minimising their use of cheap Middle East oil, by developing more expensive oil in the rest of the world, by substituting gas and coal for oil and by pursuing energy efficiency. Interest in renewable energy and energy efficiency blossomed.

Economic growth slowed and a huge oil supply excess developed by the early 1980's. Consumption declined by 10% between 1979 and 1986 and high oil prices collapsed. Oil consumption has since reached the highest levels ever despite, halving in the former Soviet Union. The supply excess was nearly all back in production by the mid 1990's and another 600 billion barrels has been consumed. We are about three years away from consuming half the world's endowment of cheap-to-produce conventional oil and from the peaking of non-Middle East production. This time there are no Alaskas or North Seas waiting in the sidelines.

INTERPRETING THE DATA BASE

The world is now sufficiently explored for reliable estimates of ultimate recovery of conventional oil to be made and the timing of the production peak estimated. Three retired petroleum geologists, Colin Campbell and Jean Laherrere from Europe and L.F. Ivanhoe from the US, are, leading the debate on this issue in oil industry circles. Campbell and Laherrere are backed by Petroconsultants, leading Geneva-based petroleum industry consultants, who possess the only comprehensive database on the performance of all the world's significant oil fields. No other analysts have ever had this luxury.

Hydrocarbons range from natural gas, through light and heavy liquids to solid tars and bitumens. However, the light free-flowing oils comprise over 95 per cent of production, mostly from a few giant sized oil fields at, very low cost. This is known as *conventional oil* and includes increased yields obtained by water flooding and gas pressurisation to force out more of the oil-in-place.

It is this oil that powers our contemporary transport find industrial systems.

By contrast non-conventional oil derived mainly from deposits of tars, bitumens, heavy oils and shales is expensive to produce. Tars and bitumen are mined, then heated and processed with chemicals to produce an oil which requires further refining to produce the equivalent of crude oil. Heavy oils require fluidising in situ by steam or chemical mean- to permit extraction in the normal way. The massive scale of these operations, their high energy consumption and environmental problems work against significant cost reduction. The energy consumed in production is high, the net energy yield very low.

Furthermore, oil is in deep geological formations and only statistical estimates of oil-in-place and of the percentage that can be economically extracted can be made. There are no rigorously enforceable standards on definitions, assessment and reporting of reserves. Reporters can choose expedient criteria to suit their convenience. The art of good marketing is never to ten a tic, but never tell all the truth. Hence reported reserves must be regarded as political statements and interpreted with care (Fleay 1998, pp. 7-9).

A feature of Campbell and Laherrere's work is their rigorous attention to these issues of definition and statistics and their critique of the failings of others in this regard. The authors of many earlier estimates of conventional oil reserves are being forced to revise them downwards. A consensus is converging on the

1800 to 2100 billion barrels range. These and other issues are well covered in Campbell & Laherrere (1995), Campbell (1997) and Fleay (1998). See also Campbell & Laherrere (1998).

DISCOVERY

FIGURE 1 shows conventional oil discovery to 1996 by decade. Discovery peaked in the early 1960's, has been below annual production since 1980 and now is less than one quarter of production. Clearly there is only a limited amount left to find and a reliable estimate of ultimate discovery can now be made.

About 70 per cent of conventional oil was found in 360 giant oil fields, less than one per cent of all fields (Campbell &- Laherrere 1995, p. 1). Giants are fields which held more than 500 million barrels on discovery and sophisticated techniques are not needed to discover them. They are usually found first because they are large, produce the cheapest oil and have a long life. About 2400 billion barrels remains to be found.

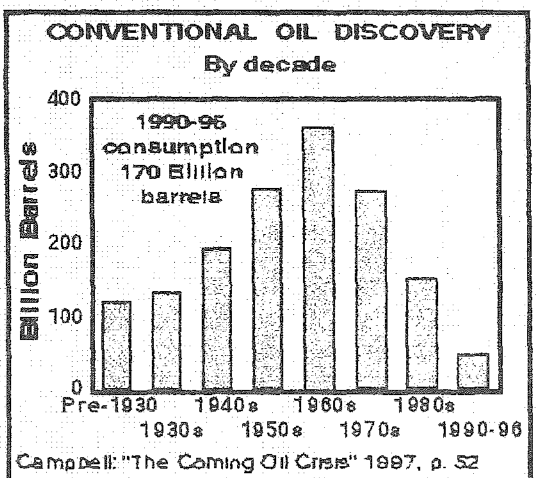


FIGURE 1

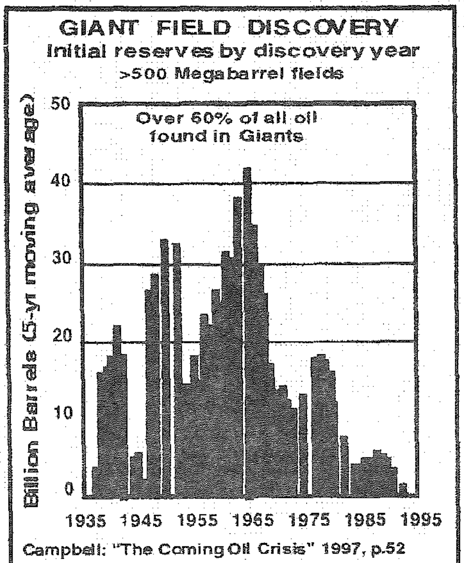


FIGURE 2

The wave of exploration after the 1970's oil crises did not find any new major petroleum provinces, despite exploration reaching new heights of sophistication and efficiency. Giant discovery peaked in the early 1960's and has slumped since 1980, see FIGURE 2. Few giants are left to discover (Campbell 1997, p. 28).

Most conventional oil has been and will continue to be produced from giant oil fields. Fields found more than 20 years ago produce 90% of today's oil and 70% comes from fields over 30 years old (Campbell Laherrere 1995, p. 13). Most are ageing and many are in decline. The biggest and least depleted of the giants are in the Middle East which has nearly 60% of the world's remaining conventional oil.
In this presentation of the data periodic revisions of reserves are, backdated to the year of discovery. Most published data for annual changes in reserves includes both revisions and new discoveries with revisions accounting for three quarters of additions since 1980, giving a misleading picture on the quantity of new oil actually being discovered. See Figure 3 in Fleay (1998). Backdating focuses on current discovery rate.

ENHANCED RECOVERY

Most oil fields only yield about 35% of the oil-in-place, while the best achieve 60% and in the more free-flowing natural gas fields yield is up to 80%. Some say that enhanced recovery techniques can in-crease. oil yields closer to 60%. These techniques include steam flooding, injection of miscible fluids and fracturing the formation, i.e. changing the physical properties of the. oil and of the formation, inherently expensive and energy intensive operations.

However, the lower yields are mostly from fields with heavy viscous oils and/or tight formations while higher yields occur where the oil is fight and free flowing, or the formation is more porous. These are the main reason for variations in yield.

Enhanced recovery is in the non-conventional class.

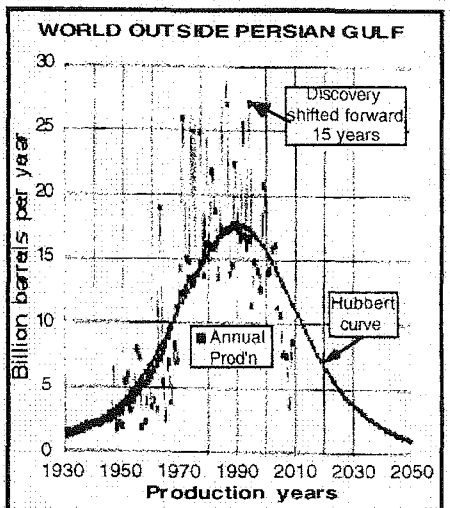
Campbell says many yield increases attributed to enhanced recovery are in fact statistical artifacts - the increase is partly due to a simultaneous change ill reporting front say low 90% probability estimates to ones closer to the median or 50% probability, shifting the goal posts (Campbell 1997, pp. 69, 124). The issue is discussed further in Fleay (1998).

WORLD PRODUCTION PROFILES

US petroleum geologist, MK Hubbert, pioneered the use of the logistic equation to describe the discovery and production profiles for oil and natural gas in major oil provinces. The equation is widely used in population studies and for resource evaluation. In 1956 he successfully predicted the time and magnitude of the 1970 peak of US oil production in the lower 48 States.

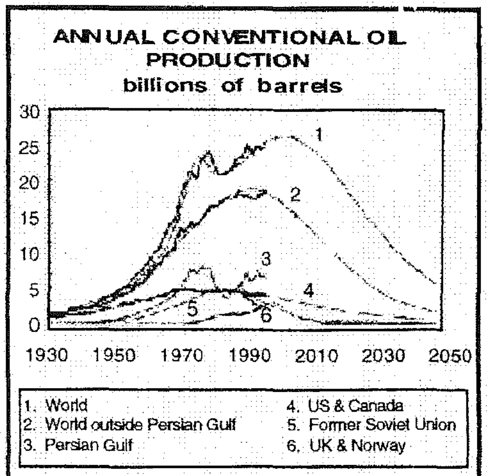
The production and discovery profiles are normally bell-shaped for oil provinces and the peaks occur near the mid-point of ultimate economic production or discovery. The peak of discovery precedes the peak of production. Laherrere has extended the use of the logistic equation to those situations where there, are multiple peaks of discovery and production. He breaks down the multi-peaked curve into the sum of several bellshaped Hubbert curves each reflecting major political and economic impacts or several phases of discovery and development.

FIGURE 3 illustrates these points for world conventional oil outside the Persian Gulf. The plot of discovery has been shifted forward 15 years to illustrate how the peak profile of production to 1995 is mimicking the profile of discovery with a 15 year time lag. A Hubbert curve from 1930 to 2050 is also plotted for an ultimate, production of 986 billion barrels, consistent with Campbell &- Laherrere's 1800 billion barrels. estimate for ultimate world production of conventional oil.



Laherrere Fig 2.5 in Fleay & Laherrere 1997

FIGURE 3



Campbell & Laherrere: Scientific American 3/98, p. 81

FIGURE 4

FIGURE 4 shows world and some regional production curves for conventional oil to 1996 and Hubbert projections to 2050 for an ultimate world production of 1,800 billion barrels (Campbell & Laherrere 1998). The curves for the world and the Persian Gulf region are double peaked reflecting the impact of the 1970's oil crises. Increasing the world ultimate to 2,300 billion barrels only shifts the mid-point of production to about 2010. Political and economic events will have a major influence on the pattern of Persian Gulf oil development. Predictions would be hazardous.

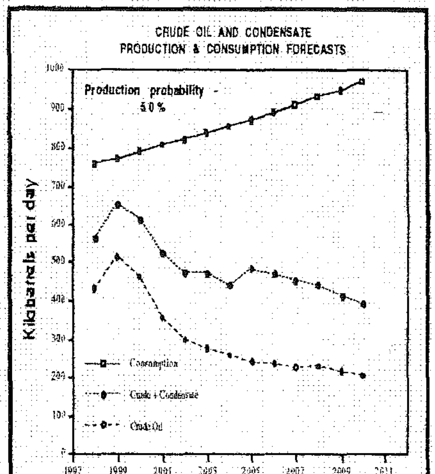
The International Energy Agency (IEA) has adopted Campbell and Laherrere's views that physical constraints ultimately limit the amount of oil that, can be produced. A report to the G8 Energy Minister March 1998 Summit accepted evidence on physical oil field performance that conventional oil production outside the Persian Gulf would peak about year 2000 with the world peak occurring about 2013, based on a US Geo logical Service estimate of ultimate extraction of 2300 billion barrels (IEA 1998). Campbell says the USGS is revising this estimate down to 2078 billion barrels, equivalent to a midpoint of about 2006-7 (Campbell 1998).

However, the IEA is still under the illusion that non-conventional oil can painlessly substitute for conventional oil.

The next decade should see the transition through the peak of world oil production. Decline will be exponential with supply halving about every 25 years, based on oil field performance data in Petroconsultants data base (Campbell & Laherrere 1995).

AUSTRALIAN OIL

Production of Australian crude oil and condensate (liquids stripped from natural gas) is expected to peak in 1999 and decline rapidly thereafter, FIGURE 5. See Fleay (1998) for further discussion.



Production: BRS 1998, pp. 52 & 54
Consumption: Petroleum Gazette 2/1998, p. 29

FIGURE 5

NATURAL GAS

Campbell, Perrodon & Laherrere (1996) estimated that the ultimate production of the world's conventional natural gas would be 9,250 terra cubic feet (Tcf), with about one quarter produced by 1995. They say other earlier estimates range from about 8,00012,000 Tcf. Discovery and assessment of natural gas has not yet reached the mature stage of oil.

Peak production, the mid-point, is likely to occur between 2025 and 2035. The IEA estimates that natural gas production in North America, Europe and the Asian regions will peak during the second decade of next, century (IEA 1998). See Fleay (1998) for further comment.

THE TRANSITION BEGINS

The collapse of oil prices in 1986 put the multi-national oil companies through the financial ringer, cost cutting mid downsizing has been the order of the day, particularly in exploration and development services. Furthermore, the latter activity has been confined to the progressively more marginal high cost world outside the Persian Gulf. Organisation of Petroleum Exporting Countries (OPEC) finances have also been savaged, the Arab billions have shrunk dramatically since the mid 1980's.

Since 1986 60% of both consumption growth and replacement of production falls in declining oil fields has been met by turning on wells shut down in the early 1980's when supply outstripped demand by a large margin.

This surplus is nearly all back in production and the industry, after downsizing, now does not have the physical and financial resources to develop sufficient new capacity in the high cost non-Persian Gulf world. Record low oil prices since mid-1998 following slowing economic growth that began in Asia has compounded the companies problems and stretched the budgets of OPEC countries. Saudi Arabia borrowed US$5 billion from Abu Dhabi in 1998 to balance its budget.

Saudi Arabia has two million barrels per day excess capacity. The Saudi's late in 1998 exploited this situation to shift production, exploration and new development to the low cost Persian Gulf away from the rest of the -world where production, exploration and development costs are much higher. The Saudi's Sheik Yamani says this approach will strengthen the Saudi's and Persian Gulf producers financial positions in the immediate future. It will be at the expense of the multinational oil companies over the next five years and shift production and development to the Persian Gulf producers. The multi-national companies face contraction and mergers are the order of the day (Petroleum Review 1999). See Fleay (1998) for more details.

The industrialised world's strategy since the 1970's has been to minimise dependence on Persian Gulf oil. This strategy has almost rum its course. Next decade only the Persian Gulf can provide additional new, supply and then only until around 2010 when world conventional oil production is also expected to decline. The next decade will be the transition from plenty to scarcity.

This time, unlike in the 1970's, the world has to face the consequences of oil depletion.

OIL PEAKS

Consequences for renewable energy

The first part above outlined the case for the peaking of both conventional cheap-to--produce oil from non-Persian Gulf sources in 2000-1 and for the world as a whole around 2010. The second part outlines some conclusions on the broader consequences of oil's decline then focuses on perspective's for renewable energy. Oil's decline presents both opportunities and threats to renewable energy.

Oil provides 40% of the world's energy and transport consumes 60%. Agriculture has been transformed since the 1930's such that a large proportion of the world's population can now only be fed by direct and indirect use of petroleum fuels in agriculture. Reducing population and ending agricultural dependence on these fuels must have first call on petroleum next century (Fleay 1998, pp. 41-5, Smil 1997).

The explosive growth of road and air transport is essentially a product of the oil age. Oil has made 20th century urbanisation possible. In addition petroleum is the feed stock for herbicides, plastics and synthetic fibres. It is critical to the economics of long distance trade and is a key fuel in mining and construction.. Petroleum is all pervasive in our industrial civilisation.

Furthermore, the oil from giant oil fields in their prime, over 60% of all conventional oil, has been extremely cheap to produce. The direct and indirect energy, inputs required to produce around 60 barrels of this oil is equivalent to only one barrel, i.e. an energy profit, ratio (EPR) of 60 (energy output divided by inputs). No other fuels can match this performance, either from the past nor are ever likely to in the future, including non-conventional oils and renewable energy (Fleay 1998). Production of oil from Canadian tar sands, for example, consumes energy equivalent to two barrels of oil for every three produced, an EPR of less than two (Youngquist 1997, P. 436).

Oil products as fuels have a high power-weight ratio, are easy to store and transport, and can be dispensed with high precision, Properties that make it the eminent fuel for transport. These issues and the limited scope for alternative transport fuels are discussed further in Fleay (1998).

The last 50 years have been unique, the era of abundant cheap oil, the era when our present transport systems were constructed based on this oil. It takes 4050 years for a new energy source to displace older ones. Those that can replace oil should be in their early development stages now.

However, existing renewable energy technologies cannot replace the role of oil in contemporary transport and industrial agriculture. The EPR, portability and flexibility of conventional oil in its prime are far superior.

There is not available nor in sight fuels that can replace oil as we have known it, both in quantity and economic performance, especially for transport. Remaining oil will become progressively less effective as supply sources become more marginal. The consequences are profound.

THE CLIMAX OF FOSSIL FUELS

We are at the climax of the fossil fuel age, not just of oil but also of natural gas and coal, despite the very large economic reserves of the latter. The economic quality of these fuels is as important as their quantity.

Oil's transport role also makes it special. Coal initiated the modern era by fuelling rail and sea transport, but it was quickly superseded by oil as a far superior fuel.
By contrast massive investment would be needed to change back to coal. The real cost of transport will increase and the decline in the scope and scale of present transport systems is inevitable and will set the economic agenda for the 2Ist century, beginning next decade.

While consuming this jewel in the fossil fuel crown, we have been rapidly depleting the world's high grade minerals, mostly using petroleum fuels to mine, process and transport them.

Economic mineral grades are a function of the quantity and economic quality of the energy needed to mine and process the ores, mediated by efficiency improvements and new technology. Free available energy limits the scope for technology and innovation to offset the eventual need to mine lower grade ores. But the sheer scale of operations eventually overwhelms technology. The decline of oil will adversely impact on the grades of ores that are economic to mine. Conventional gas can only fill a post-oil bridging role for a limited period. When will technology lose the battle?

So the 2Ist century will also see both a deterioration in the economic quality of fuels used in mining and upwards pressure on mineable ore grades, a double whammy. Youngquist (1997) describes the inevitable control of the Earth's resources over nations and individuals in his book *Geodestinies*. This is of particular importance for the future of renewable energy.

GLOBAL ECONOMY CONTRACTS

We are all urged to participate in the global economy. Exporting is said to be the highest economic achievement, the path to survival. Yet a global economy cannot east without abundant cheap transport. And cheap conventional oil fuels the world's transport systems.

The global economy is already at its climax, it must soon stall and begin to contract, possibly within a decade. A shift to greater local self-sufficiency will inevitably follow. By 2050 little will remain of the global economy we know today.

Nearly 50% of the, world's oil will come from the Persian Gulf by 20 1 0 with 80% exported, most likely at a higher price than now. The world's dependence on Persian Gulf oil will be a source of political and economic instability. Most countries' capacity to import oil will be limited.

LABOUR INTENSIVE WORK PREVAILS

Labour productivity has increased dramatically since coal fired steam power was harnessed to labour. The greatest gains have occurred since 1920 as oil and gas began to replace coal and electric, power became common place. This pattern must surely reverse as high quality petroleum becomes more expensive..

We have increased our productive capacities by substituting resources for human labour. Yet that substitution has gone too far, over-using such resources as energy, materials, water, soil and air. Aggressive increases in lalx3-tir productivity, constitute a rather questionable program at a time when more than 800 million people are out of work- We are making ever fewer people more "productive", using up more resources and effectively marginalising one-third of the world's workforce (von Weizacker et at pp. xv, xx & xxiv).

Labour intensive economic development will become the trend, not the substitution of capital and energy intensity for labour. The world is not short of labour, rather it is high quality energy and other resources that are scarce.

THRIFTY USE OF ENERGY AND RESOURCES

The use-once-and-throw-away society has reached its end point. Neither the high quality energy nor material resources exist to support its continuation. Indeed a reduction in primary resource consumption will be forced upon us by declining oil, despite an increasing population..

The primary focus of economic development will rapidly shift to meeting peoples essential needs by:

- Pursuing resource and energy use efficiency.
- Shifting to labour intensive economic work.
- Making things to last and be recyclable.

- Making most things locally, mostly using local resources to minimise waste in packaging, facilitate recycling and limit the need for transport.
- Refurbishing rather than discarding, or demolishing.
- Using technologies that work with nature, not ones that strive to dominate or fight nature as this waste resources.
- Less emphasis on comparing countries on international standards and bench marking in favour of local diversity matched to local conditions and resources.
- Avoiding conventional economic growth.
- Integrating these processes with ones that fulfil the psychic and spiritual needs of people, building vibrant caring communities, the key to success.
- The end of consumerism.

Achievement of such thrift must come mainly by structural change of social and economic systems in addition to application of the principles at the household and enterprise

Real progress will not be made down this path until the imminent decline of oil is recognised, the necessary shifts in -values takes place and appropriate legal arid tax reforms follow that reward efficiency rather than throughout

Only time I tell the scale and scope of surviving large scale centralised production, long distance trade and transport.

Maintaining social and economic cohesion is essential during this transition to avoid extreme environmental degradation arising from social disorder which would further undermine the carrying capacity of the earth. A caring approach is needed. Petroleum fuels are needed to power present agricultural and transport systems, while strategies to stabilise and then reduce population take effect. A long transition to agricultural sustainability is unavoidable, (Fleay 1998).

Renewable energy will have a major role to play, but ultimately in a transformed economic and social context. Advocates of renewable energy need to anticipate both the new, opportunities that will arise and the new, constraints that will emerge while seeking to exploit opportunities in the present industrial system. Exploring the characteristics of this transition and of the emerging paradigm is now a major strategic task for renewable energy.

MINERALS AND METALS

Renewable energy technologies, e.g. photovoltaics, wind generators, solar hot water systems, all embody significant use of nonrenewable metals, glass and plastics, including in the end-uses of electricity and of hot water. In this sense these technologies are, not "renewable". The renewable energy industry needs to identify how the impending increase in die real cost of energy and metals affects the cost of both renewable and nonrenewable energy, the balance between them and the ability of customers to pay.

A greater focus is needed on the application of both energy and resource use efficiency integrated with renewable energy applications.

TRANSPORT

Few renewable energy technologies have practical application to present day transport. Can the economics of photovoltaics support transport, in both energy and dollar terms, either directly or for generation of hydrogen as a fuel?

The most likely application is for local travel by electric bicycle type vehicles where the vehicle weight is minimal. There is already a considerable range of Japanese electric bicycles.

30% of car trips in Australian cities are less than 3 km and can readily be done by walking and cycling. Bicycles will play an important part in the early adjustment of urban life as oil declines. Integration of bicycling with public transport can considerably enhance, its passenger catchment area, as is the case in Holland.

AGRICULTURE IN AUSTRALIA

Petroleum inputs play a major part in Australian agriculture - nitrogen and phosphorus fertilisers, herbicides, mechanised cropping and transport. The soils are among the most nutrient deficient in the world, the rainfall unreliable.

In Western Australia there is a massive dry land salinisation problem arising from the clearing of native vegetation earlier this century for farmland. Diversification of crops to more deep-rooted perennials strategically located in the landscape to control saline ground waters is under way along with radical changes to cultivation practices. A State Salinity Plan is evolving. Similar problems exist in the rest of Australia.

These changes in fanning practices need to incorporate strategies for an agriculture not dependent on oil well before the middle of next century. Renewable energy has an important role here crucial to the capacity of this country to feed itself. What is this role? What technologies are appropriate and what opportunities might arise from emerging new fanning practices? Renewable energy needs to be part of the action.

REMOTE POWER GENERATION

There, are numerous diesel powered power plants, large and small, in regional Australia, many serving mining operations. Within a decade Australia will become heavily dependent on oil imports from the Middle East as the world approaches the peak of global oil.

These plants need to be replaced urgently by renewable energy, eg. photovoltaics, in conjunction with comprehensive energy efficiency programs in the communities concerned, including adopting social behaviour patterns to match the diurnal cycle of solar energy.

REMOTE ABORIGINAL COMMUNITIES

These communities mostly have housing of some kind, often a pumped water supply, diesel electric power a wastewater system of sonic kind and are dependent on cars and trucks for transport. How viable are these systems as oil declines? What alternatives are there, including life styles? What role is there for renewable energy? Re-assessment of these programs is needed.

COMPETITION POLICY

A barrier to renewable energy

Energy efficiency in electric power generation, distribution and end-use requires cooperation between electricity consumers and producers in least cost planning programs. If electricity consumers make significant investment in energy efficiency and reduce power consumption without loss of service then the power generators and distributors can reduce or delay investment in new capacity. This requires a high degree of cooperation between consumers, distributors and generators, but in an environment where constructive competition occurs as well. All parties need to be informed on each others cost structures and institutional and structural barriers to joint action on efficiency. need eliminating. The potential efficiency gains from this cooperation a far greater than when the parties just compete and operate in isolation from each other

Amendments to the Trade Practices Act in 1995 formalised *Competition Policy* in Australia and established its bureaucratic instruments, the *Competition Council* and the *Australian Consumer* and *Competition Commission (AC-CC)*. The legislation virtually made the values of competition in the market place, as embodied in an interpretation of neo-classical economic theory, supreme above all other values. All legislation is being reviewed under this test and to be amended where it is seen to be "anti-competitive".

Community action for the common good, where people cooperate and work together for mutual benefit, is being penalised by this approach, it is socially destructive and generating a political backlash in the form of One Nation. Such one-sided focus on competition is art obstacle to structural change of economic systems for energy and resource efficiency, where competitive cooperation between buyers and sellers is the central economic strategy required and community values have a legitimate place.

We need an *Australian Consumer, Cooperation and Competition Commission* to restore the balance. In economic activity, especially when resource constraints are given their proper weight, cooperation and competition are interdependent, not mutually exclusive as there is a symbiosis between them, but also a needed tension that can be constructive. The growing practice of partnering in many areas of business is an example.

Community and the common good can find a place in this framework.

However, there is an additional important requirement. There must be a free flow of information between stakeholders, minimal commercial confidentiality which must be regarded as a privilege, not a right. After all, neoclassical economics says all buyers and sellers must have complete knowledge of all factors affecting the market for a rational outcome. This is a necessary condition for buyers and sellers to jointly restructure the economic system for it to function within energy and resource limits and is especially important where there are natural monopolies or quasi-monopolies which are characteristic of the energy and transport industries (Fleay 1998).

GREENHOUSE

The standard projections for Greenhouse gas emissions from carbon based fuels to 2100 are the 1994 revision of the Intergovernmental Panel on Climate Change (IPCC) IS92 emission scenarios. Six projections are given for populations ranging from 6.4 to 17.6 billion people, economic growth rates of 1.2% to 2.3% and ultimate life-cycle production of 2050 to 3800 billion barrels of oil and 9500 to 14,500 tera cubic feet of natural gas (Houghton et al 1994, p. 26 1).

Later projections to 2100 by Campbell and Laherrere (I 995) for conventional oil (I 800 billion barrels) and Campbell, Perrodon and Laherrere (1996) for conventional natural gas (9250 Tcf) are lower than any IPCC projections. Significant contributions from non-conventional oil are unlikely on straight economic grounds. These new projections for petroleum fuels are more authoritative, based as they are on Petroconsultants database (Fleay 1998).

When you consider the role of oil in transport and the lack of comparable alternatives and the consequences then one must question the realism of projecting massive expansion of coal to replace oil. For the same reason the IPCC projections of a century of economic growth also look hopelessly unrealistic when the fundamental connections between energy and economics is considered and the future of transport. Economic contraction is far more likely as measured by GDP criteria. See Fleay (1998) for discussion on this aspect.

Natural gas is the critical constraint to population growth, being the feed stock for the manufacture of nitrogen fertilisers that are now indispensable to the feeding of some 3 billion of the world's population.

Cheap natural gas production is likely to peak in the decade centred on 2030, perhaps 15 years earlier in North America, Europe and Asia (IEA 1998).

Land degradation is seriously diminishing the productive potential of agricultural land and according to Graham Harris, chief of CSIRO's Land and Water Division, should be on the international agenda on a par with Greenhouse and the Antarctic hole in the ozone layer (Harris 1998).

We can expect the related global issues of population reduction, land degradation, diminishing agricultural potential and the dependence of food production on petroleum fuels to displace Greenhouse gas emissions from the top of the international agenda in the near future.

This is not to diminish the concerns over Greenhouse, but rather recognise the other three issues must occupy their rightful place. The decline of oil will drive the reduction of greenhouse gas emissions arising from fossil fuels use long before governments agree on and implement their reduction to reduce greenhouse gas emissions.. Fleay (1998) discusses these issues further. See also Smil (1993) on the role of nitrogen fertilisers.

REFERENCES

Bureau of Resource Sciences (BRS) 1998. *Oil and Gas Resources of Australia 1997,* BRS Canberra (in press). Campbell, C.J. &- Laherrere, J.H. 1995. *Die World's Oil Supply 1930-2050,* Vol. 1. Petroconsultants S.A., Geneva, October.

Campbell, C.J. 1997. *The Coming Oil Crisis,* Multi-Science Publishing Coy, London &- Petroconsultants S.A., Geneva.

Campbell, C.J. 1998. *Personal communication.*

Campbell, C.J. &- Laherrere, J.H. 1998. *The End of Cheap Oil.* Scientific American New York, March, p. 78.

Campbell, C.J., Perrodon, A. and Laherrere., J.H. 1996. *The World'-c Gas Potential,* Petroconsultants SA.,, Geneva.
Fleay, B.J. 1998. *Climaxing Oil. How Will Transport Adapt?* Theme paper presented to the Chartered Institute of Transport in Australia's National Symposium, Beyond Oil: *Transport and Fuels for the Future,* Launceston Tasmania, 6-7 November 1998. Published with post Symposium Postscript as Occasional Paper 5/98 bv the Institute of Science and Technology Policy , Murdoch University Western Australia. Fleay, B.J. &- Laherrere, J.H. 1997. *Submission to Dept. of Primary Industry and Energy's Green Paper on a Sustainable Energy Policv for Australia,* Institute for Science and Technology Policy, Murdoch University WA. Occasional Paper 97/1.

Harris, G. 1998. Address to seminar CSIRO Land and Water Division, Perth Western Australia, October 26. Houghton, J.T., Meira Filho, L.G., Bruce, J., Hoesung Lee, Callander, B.A.., Haites, E.., Harris, N. & Maskell,
K.. 1994. *Climate Cliange 1994,* Cambridge University Press 1994.
IEA, International Energy Agency 1998. *World Energy Prospects to 2010.*
http.//www.iea.org./g8/world/summary.htjii
Petroleum Gazette 2/1998. Australian Institute of Petroleum, Melbourne.
Petroleum Review 1999. An editorial and five articles, including an abridged outline of a speech bv Sheikh Yamani to the Institute of Petroleum in London late in 1998, commenting on the impact. of falling oil prices and the new strategy of Saudi Arabia.
Smil, V. 1993, *China's Environmental Crisis,* M.E. Sharpe, New York.
Smil, V. 1997. *Global Population and the Nitrogen Cycle,* Scientific American, July.
von Weizsacker, E., Amory B. Lovins &- L. Hunter Lovins 1997. *Factor 4: Doubling wealth - halving resource use,* Allen &- Unwin, Sydney.
Youngquist, Walter 1997. *Geodestinies.* National Book Coy., Portland Oregon.