# Australia's future oil supply and alternative transport fuels

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

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*General Introduction*:
There exists a direct relationship between energy consumption and GDP growth with also a direct relationship between energy consumed and the energy profit ratio of that energy.

This has the potential to lead to economic and structural changes of great significance. According to an increasing range of oil supply modelers this depletion (peak oil) will commence in this decade and run its course over this century. Australia's conventional oil peaked in 2000 and is in well documented decline with this nation increasingly dependent upon imports in an increasingly volatile world market. The high energy intensive structure of current industrial agricultural practices, cost of personal and business transport, centralisation of services, and decline of infrastructure rural and urban Australia will see increased pressures upon its already stressed social, rural and industrial frameworks. This will occur at the time we will be experiencing the environmental outcomes of climate change.

Current planning fails to recognise the potential for energy depletion, and whilst the validity of the depletion model will not be proven until into a depletion situation, recognition of potential outcomes will allow for scenario planning that will explore difficulties and opportunities that may be acted upon, allowing for a more immediately responsive action in a time of potentially rapid change; as rapid energy depletion has the potential for systemic and disruptive social stress. Historically, oil shocks have led to inflationary pressures from rising energy costs with resulting decline in employment and development opportunities, the effects of this depletion event will be many orders larger and longer.

A range of writers believe that alternative energy technologies are not able to deliver the economic returns offered via fossil fuels in relation to energy profit ratio, flexibility and multiplicity of use and in relation to scale and development timeframes.

The second half of the 20$^{th}$ century has seen the increase in use of crude oil as the basis for a range of fuels, chemicals, pesticides and pharmaceuticals that has driven expansion in both population and in first world economic activity; with subsequent flow on in regards to environmental costs. Economic growth has increased to the point where the world consumes around 85 million barrels per day, predominantly in the industrialized countries. Economic growth is influenced strongly by industrial society's ability to maximize the energy benefit from the use of those energy resources via reducing costs of production, increasing efficiency of consumption and/or improving the flexibility and benefit of use (Poldy 2003). There exists a direct relationship between energy consumption and GDP growth with also a direct relationship between energy consumed and the energy profit ratio of that energy (Fleay 2003; Poldy 2003).

This submission assesses the increasingly influential argument that modern industrial civilization is entering a period of change defined by the depletion of its major liquid energy sources (particularly conventional oil), coupled with the inability of alternatives to replace depletion, leading to a rapid decline in available net energy as a driver of economic growth, and the impact in rural and regional Australia. This has the potential to lead to economic and structural changes of great significance. According to an increasing range of oil supply modelers this depletion will commence in this decade and run its course over this century. The high energy intensive structure of current industrial agricultural practices, cost of personal and business transport, centralisation of services, and decline of infrastructure rural Australia will see place increased pressures upon its already stressed social and industrial systems.

Strategic planning for Australia has yet to reflect the potential for our economic and social frameworks to be severely effected by rapid decline in available net energy world wide. Current planning fails to recognise the potential for energy depletion, and whilst the validity of the depletion model will not be proven until into a depletion situation, recognition of potential outcomes will allow for scenario planning that will explore difficulties and opportunities that may be acted upon. If we take the peak oil and depletion argument seriously then recognition and action will allow for thinking and strategies to be put in place allowing for a more immediately responsive action in a time of potentially rapid change, as rapid energy depletion has the potential for systemic and disruptive social stress. Historically, oil shocks have led to inflationary pressures from rising energy costs with resulting decline in employment and development opportunities. A range of writers believe that alternative energy technologies are not able to deliver the economic returns offered via fossil fuels in relation to energy profit ratio, flexibility and multiplicity of use and in relation to scale and development timeframes.

## THE PEAK OIL DEBATE AND SIGNIFICANCE TO ENERGY FUTURES.

### *Introduction: The role and development of energy resources in industrial development.*

Modern industrial society has owed in a great part its rapid material development to the availability of fossil fuels that could be readily transformed into the fuel stocks for transport, electricity production, plastics, pharmaceuticals, pesticides and fertilizers, often at the expense of poorer countries who still rely on lower energy density supplies such as wood, charcoal and dung (Yergin 1991; Smil 1994; Fleay 1995; Youngquist 1997). Needs for energy transference (the ability to maximize energy outputs) has driven the development of technologies that have intern driven access and consumption of further energy reserves, and as a result expanding both the research and production base, allowing further expansion or improvement in consumption technology. This can be seen in the technical progression of energy consumption from lower density and quality forms to higher and more flexible forms. For example, in England shortages in the supply of wood in the 16th century led to the use of coal, which eventually required deeper mining, requiring the development of the technology of steam engine driven pumps. This technology and its improved energy transference assisted in kick starting the development of the industrial age. Subsequent technologies have derived from the development of technologies built on that energy platform of oil and coal. Current oil discovery, extraction and refining technologies would not have been possible without the energy platform of coal-based technological development (Youngquist 1997).

Oil has become from the mid 20th century for the western industrial economies the primary energy source for industrial energy use, with oil supplying 40% and natural gas 22% of total energy supply, with transport using around 60% (of liquid fuels) and the remained being for mining, agriculture, accommodation and heating, manufacturing of plastics, pharmaceuticals, fertilizers and pesticides (Fleay 1998; International Energy Agency (IEA) 2002). Current consumption measured in barrels of oil runs around 82-5 million per day or 29 billion barrels per annum (Bakhtiari 2005). Every aspect of industrialized life involves the consumption of fossil fuels with the resulting production, distribution and consumption infrastructure has become so seamless[1] as to be virtually invisible to the greater majority of end users (Youngquist 1997), leading to systemic failures to fully comprehend the role of energy as a driver of GDP growth and to make appropriate plans for any changes in energy supplies either in terms of quantity or quality (Gever 1991; Fleming 2001; Poldy 2003; Fleming 2005).

[1] Seamless: the integration and implementation of industrial development via the universality of cheap energy into transport, products and industrial activity. In western industrial civilization energy is part of everything we do and consume in that it is necessary to turn materials into objects, intentions into activity. It's involvement in our lives has become integrated as not to be noticed.

*b. Peak Oil-Oil dependency; supply and depletion models*

The debate upon the depletion of oil supplies began in the 1920's with Otis Smith, head of United States Geological Survey, who in 1918 predicted that U.S production would begin to decline within 2 to 5 years (Korpela 2002). Estimates for the total amount of conventional oil worldwide have been made by both petroleum engineers and energy economists since 1942, with the total individual estimates of the Estimates Ultimate Recoverable (EUR) for conventional oil[2] now numbering over 100 (Andrews 2003). EUR represents the total amount of an oil bearing field that can be removed (produced) aggregating individual field EUR's provides a cumulative figure from which ultimate world production can be estimated. This process has been complicated by a range of problems, including variability of reporting methods, definitions of what constitutes conventional oil, uncorrected revisions to earlier estimates and doubtful revisions upwards by oil producing nations and by oil companies. [3]

The debate about oil depletion was invigorated in the mid 1950's by the work of M. King Hubbert.[4] Hubbert developed a mathematical model and method of estimating the point of oil production where output would reach the maximum rate of production and then go into decline (Hubbert 1956). Hubbert's model predicted that an oil producing field followed a defined production pattern of maturity and decline that roughly followed a 40 year cycle. According to the Hubbert model a field rose in production to reach a symmetrical peak then declined in a predictable production curve (see Figure 1). Hubbert produced a number of models, in one of which the Lower 48[5] states fields of the United States would reach a peak in 1970 and then decline at a rate of approximately 3% per annum.

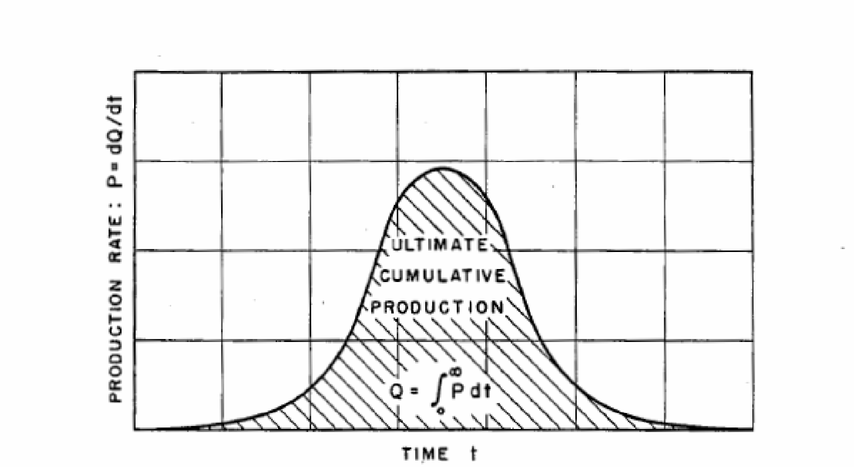


Figure II – Mathematical relations involved in the complete cycle of production of any exhaustible resource.

Figure 1

Hubbert Curve for the Lower 48 states (Hubbert 1956)

Reaction to this model, particularly within the petroleum industry, was dismissive, especially given the low price and seemingly endless supply of oil in the 1950-60's. With a recorded decline in production for the Lower 48 being

[2] "Conventional oil refers to all oil produced from reservoirs through a well bore using any primary, secondary, improved, enhanced or tertiary methods. Conventional oil is generally not considered to include heavy oil, oil shale, tar sands, or natural gas liquids, the production of which typically involves mining or additional processing of the oil in place. It is this conventional oil that is "cheap" to extract and use, and that has contributed to the historical importance of petroleum on a global scale" (Hallock et al 2003).

[3] In 2004 Shell revised its filed estimates 25% downwards. http://news.ft.com/cms/s/5db1c8c0-7652-11d9-8833-00000e2511c8.html

[4] Hubbert is spoken of thinking about resource depletion in the 1920's. http://www.energybulletin.net/9242.html

[5] Universally use oil industry term to denote all U.S. oil and gas fields excluding Alaska and Hawaii.

measured by the early 1970's Hubbert's method was vindicated, and in part led to the confidence of the OPEC nations, especially Saudi Arabia to apply the 'oil sword' in the form of embargoes and restrictions in 1973 and 1978 (Simmons 2005; Dees Undated). The United States has gone from a supplier to the world to an importer of over 60% of annual consumption. This has had significant implications for the US balance of trade, with the US using over 19 million barrels per day, leaving the US, as with any oil importing nation, increasingly dependent upon global prices (Korpela 2002). Following this Hubbert's method gained some acceptance, with Hubbert extrapolating his model to ultimate world production using two sets of data to derive predictions of a world peak in 1995 and 2005 respectively (Deffeyes 2005).

Hubbert included caveats in his predictions recognising that both political and geological circumstances could effect the prediction of a peak date (Andrews 2003). Trainer (Undated, P. 3) notes that Hubbert was able to model from a situation of good quality and more readily available data given "… the inflection and tapering of the clear and smooth US production curve… ", whilst "…similar conclusions seem elusive when the erratic world supply curve is examined". Therefore, it has been argued that Hubbert's US model does not fit the more varied and less regulated circumstances of global discovery and production (Lynch 2002). Issues of the quality of data, as well as economic factors (consumption rates) and political concerns (production delivery) will affect the total worldwide EUR and the peak date. Hubbert's method however is important in predicting the form of both the discovery and production cycles in relation to oil fields. This method has demonstrated that fields will rise to a peak then go into a decline and can be plotted under a curve (Deming 2000; Hirsch 2005c). This has been substantiated in analysis of field production data analysis worldwide and has demonstrated that the concept of an oil field being able to produce at maximum capacity until empty is false.  Use of the ratio of reserves to production (R/P) where total supply is divided by the annual consumption rate ignores the physical attributes of oil well physics and depletion patterns[6], leading to estimates of 40 to 50 years supply of oil left until oil runs out (Korpela 2002; Goodstein 2004). This has created the impression that there exists a significant period of time during which oil will be supplied at present or increased production rates, and also time for the development of replacement supplies and/or technologies, such as tar sands or renewable energy sources.

### *c. Hubbertians*

Hubbert's model fell from favour, despite the accurate prediction for the Lower 48 fields and the oil shocks of 1973 and 1978, when new oil fields were discovered and exploited. The development of new large oil provenances of Prudhoe Bay, Alaska and the North Sea brought on large volumes of oil and assisted in driving down the world price of oil for almost two decades. Hubbert's model was however taken up by a number of (mainly retired) petroleum geologists who concentrated using the Hubbert model to estimate the total recoverable reserves for conventional oil. Key amongst these are the modelers Campbell, Leharrere, Ivanhoe, Youngquist and Duncan, Deffeyes and others. The publication by Campbell and Laherrere of article in the Scientific American, in March 1998 interest and debate around the issue of EUR and peak date has grown considerably.[7]

### *d. Hubbert's model and individual field estimates*

Using Hubbert's model a range of estimates has been made for the total world EUR and resulting peak date ranging from 2005 (Deffeyes 2001)), 2007 (Duncan 2003), 2006-7 (Bakhtiari 2004), 2010 (Campbell 2002), 2015 (Laherrere 2003).  Available field data has been drawn into the Hubbert model to form a composite picture of total world EUR[8].

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[6] (Hirsch 2005b)

[7] http://dieoff.org/page140.htm In 1998 a Google search for peak oil would bring up less than 20 hits, now the same subject will record over 14 million.

[8] Questions regarding total EUR for oil have further been blurred by varying definition of what form oil is measured by. The Hubbertian definition centers around the description of conventional oil, being liquids developed via the standard drilling/oil recovery process, and does not include  tar sands, oil shale, bituminous oils, and the relatively new process of Thermal Depolymerization. Confusion regarding what constitutes EUR had initially clouded discussion but a general consensus of the parameters of conventional oil definition has evolved, particularly amongst the Hubbertian modelers. Conventional oil is the easiest and cheapest to both produce and refine and as a result provides the best economic return for the oil industry and the

Estimates for total EUR and resulting peak dates have at times been revised according to the authors depending on both improved and additional data and modified by annual average world consumption (total EUR divided by annual global consumption). Hallock et al (2003, P. 1674) note that the "... predictions of the timing of the peak of world production of conventional oil have shown sensitivity to assumptions about the behavior, or shape, of the production curve over time, …especially (EUR) but did not explicitly examine constraints on production imposed by '…physical, technological or socio-economic factors, or the influence of domestic consumption on the export capability of oil producing nations". Deming writes that Hubbert himself noted that the curve was not always symmetrical, but however always represented the total of oil to be produced (Deming 2000). Trainer also has raised concerns regarding the lack of public access to the necessary data used, the relationship of the Hubbert model to total world supply and demand and supply influences (Trainer 2004).

*e. Higher EUR estimates*

A basis for estimating continued economic growth and the timing of any increased development for possible alternative energy sources has been, in part, based upon estimates of higher oil reserves as published by organisations like the United States Geological Survey (USGS) (Aldelman 1997). However concerns exist regarding the probability of these resources either existing or being produced due to technological and production cost restraints. Reserve growth is the increase in available oil due to improved efficiencies in extraction technology and revisions of earlier estimates and is a keystone of more optimistic estimates of total world reserves.

Production patterns for individual oil fields (and regions) with fields following a bell shaped curve to a peak and into decline has been accepted as an industry standard from the 1970's, with general but not universal acceptance of Hubbert's mode of the rise and decline of the Lower 48 fields (Duncan 2000; Hallock 2003), with significantly higher resources being estimated. The United States Geological Survey (USGS) report, World Petroleum Assessment 2000-Description and Results (Ahlbrandt 2000) sets world EUR at 4500 billion (Gb) barrels at an 5% chance of discovery ranging down to 2000 Gb at 95% probability of discovery; that is that there is statistically a magnitude bigger chance of finding less than more. At the 5% probability point, a peaking date of 2037 is predicted; a date often cited by economists and governments as allowing adequate time for the market to develop substitutes(Martin 2005).

USGS modeling is based around the assumption that continued reserves (oil available) growth can reach the significantly higher figures than those believed to be obtainable by the Hubbertian modelers. These higher figures are questioned by Zittel et al in relation to being; (a), based on examples of growth referenced back to prior upward revisions of existing fields, which was caused by initial underestimation of older and larger fields, often when methods for reserve estimation was simpler and less precise and being; (b), based upon Lower 48 oil fields where the growth of oil reserves was higher than other regions, due to the requirement of the United States' Security Exchange Commission for initial conservative estimates of the reserves of fields developed which later allowed for oil companies to provide upward estimates that discovery of new fields was taking place; rather than higher estimates of existing fields was being offered (Zittel 2004; Hirsch 2005c). This leads to an impression that the amount of oil in those fields has increased through further discoveries when this has not been the case, and that, based on this assumption further opportunities exist for discovery in regard to new global supplies.

Concern has been expressed by a range of reviewers[9] about the upper figures being based on both a 5% probability (that is a 1 in 20 chance) of discovery[10] in potential oil producing regions that are both very challenging for discovery

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economy, excluding environmental and health costs, although generally non-conventional oil also includes a higher greenhouse gas and impurity removal cost (Youngquist 1997; Goodstein 2004).

[9] Andrew, Zittel, Hallock, Deffeyes, Leharrere

[10] Andrews and Udal cite Colin Campbell responding to the USGS figures as"…you might as well say there's a 5% chance of my being a frog."

and production[11] and have so far not met estimated targets for discovery leading to the predicted reserve growth (Hallock 2003). Further, to meet the reserve gap between the lower 95% probability figure more than double the past level of world production to date would be needed to come on stream, highly unlikely in a mature discovery environment that peaked in the 1960's.

The use of new exploration and production technology developed in the latter half of the last century has both maximized the enhancement of oil produced from existing wells and identified the remaining major oil fields via greatly improved oil provenance mapping (Hirsch 2005b) ( See Figure 2). Andrews et al (2003 P.4) note that new discoveries need to be "tracking higher … to meet the USGS' mean 3000 billion barrel EUR oil projection", let alone the higher 5% projection. This technology is both mature and well integrated into oil and gas exploration and production and as a result there is little room for technology to lead to significant reserve growth.

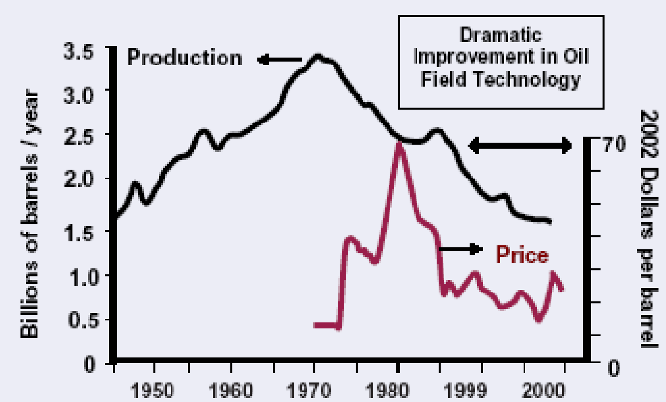


Figure 2. The decline of U.S. Lower 48 oil production was not reversed by large changes in oil prices or the dramatic improvement in oil field technologies.

Figure 2

(Hirsch 2005b P.5)

The US Energy Information Administration (EIA) and the International Energy Agency (IEA) have also presented higher reserve figures, including projections of world-wide demand and production growth; however their cases for continued growth are based upon the 5% probability figures as supplied by the USGS report without critical analysis of those figures (See Figure 3). Zittel points out that that the construction of these organisations is a three tiered building, the supporting ground floor being the USGS study, with the EIA building the second floor with optimistic growth production figures and the third being supplied by the IEA extrapolation continued high demand growth based on the

[11] Deep sea and artic fields.

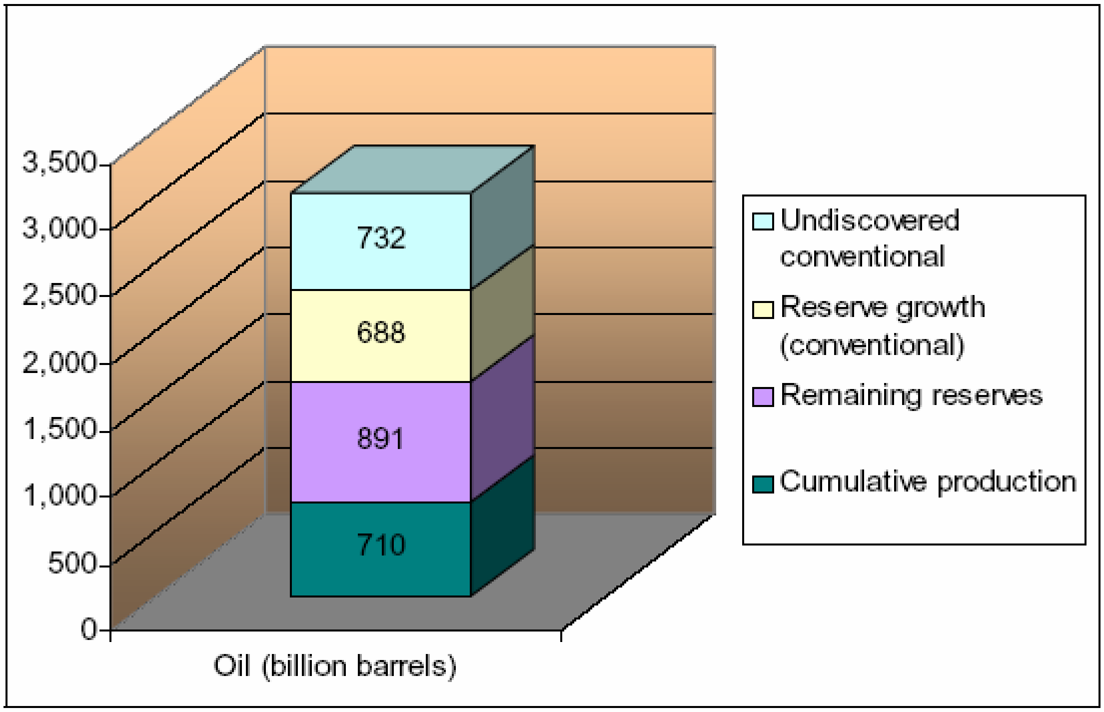


Figure 3

World conventional endowment of oil according to the USGS estimates

Source: USGS 2000 Table. ES-1 http://energy.cr.usgs.gov/WEcont/chaps/ES.pdf

lower floors (Zittel 2004). Both the 5% probability and the shaky assumptions of the USGS figures place the whole validity of this predictive framework into serious doubt. EIA and IAE figures are used in government planning in terms of estimating both remaining fossil fuel reserves and future economic growth projections ((NECP). 2004; Prime Minister and Cabinet 2004; Akmail 2005; Martin 2005) and as a result have a major influence upon strategic planning for future energy management options.

### *f. Alternative predictions*

Not all analysts accept the Hubbert model for determining EUR. Both Lynch and Deming refute EUR and peak dates offered by the Hubbertian modelers, offering criticism of Hubbert's initial assumptions, questioning the accuracy of Hubbert's predictions, noting variations between estimates and actual production delivered, as well as questioning the application of the Hubbert model to world production figures (Deming 2000; Lynch 2002; Lynch 2004) Lynch's main concerns are that the Hubbertian model places emphasis upon geophysical constraints at the expense of traditional economic arguments regarding demand driving research and substitution. For example shortages of conventional oil will encourage the move to the development and use of alternatives, including LPG, tar sands and the more technically challenging reserves such as deep-water and polar oil reserves (Aldelman 1997).

Kaufmann and Cleveland (2001, P. 3.) also question the validity of the Hubbertian model arguing that the evolution of development and production in the lower 48 states "…co-evolved with the production in a way that traced a seemingly symmetric bell-shaped curve over time." (Kaufmann 2001). Kaufman and Cleveland also query the economic model, arguing that the market mechanisms will not receive adequate signals (resource price increases) in time to bring on alternative options to replace oil; they argue that depletion will not occur in an orderly and smooth pattern but will manifest itself via sharp rises in oil prices. This is a primary concern raised by the Hubbertian modelers that at and post peak of conventional oil declining production will not be matched by either replacement sources of fossil fuels or by alternative energy technologies.

### *g. Hallock et al. A comprehensive recent review of the peak oil debate.*

Perhaps the most comprehensive assessment of the various models has been undertaken by Hallock et al in the journal Energy in 2004. They reviewed the main models, datasets and demand scenarios to make a finding based on a range of possible EUR figures and peak dates. Their methodology deals effectively with the dilemma of the two extremes of both EUR and peak dates as defined in the 'peak oil debate'. Hallock et al modeled the 47 major oil producing nations (using Hubbertian depletion modeling methods), built from the estimates of global EUR (1.9, 2.9 and 4 trillion barrels), and, using the Energy Information Agency's 2 scenarios of demand growth, put these configurations through 3 evaluation models by capping the rate of production p.a. at 5.0%, 7.5% and 15%. Annual growth was then reduced for each country annually by the decline rate. This produced a peak date varying between 2004 and 2037. Whilst the Hallock et al work applies greater modeling rigour to the issue it brings us no clearer to establishing a clear conclusion to the peak oil debate.

### *h. Peak nations*

World peak will not be fully defined until after the date that the production supply cannot grow further, despite discovery of new fields, technology or improved political circumstances. As with the debate around climate change, society is only able to verify predicted trends after the event unfolds and the data is collected. That individual fields and regions reach a peak mid point (at between 40 to 60%) of production after which the field goes into declining output, is both well documented and accepted (Duncan 2003; Heinberg 2003; Koppelaar 2005). Totaling these fields can give a rough estimate of the world supply situation, with Duncan finding that of the world conventional oil producing nations over 55% are past their peak and in varying stages of decline. Of the worlds leading producers two of the 3 are post peak, with 4 of the 11 OPEC nations in decline, being Libya, Venezuela, Iran and Indonesia. Two of the worlds 3 largest producers (historically) the United States and Russia are also post peak (Duncan 2003). Whilst the peaking oil producing nations whilst not does not establish the peak oil argument it does indicate a trend towards the mid point in oil supply, something that should not be occurring if the optimistic higher figures of the USGS are correct.

### *i. Discovery and drilling rates*

Adequate future supply in the form of undiscovered reserves should be addressed by increased exploration and drilling activity. The success of this can be measured by the formula of barrels (or cubic feet for gas) per foot of well drilled. Mature oil provinces have shown increasingly declining barrel per foot rates despite increased oil drilling efforts. Trainer points to both the steady decline in the discovery rate per foot of drilling and in the decline in barrels discovered (Trainer 2004). Optimistic arguments for increasing recovery point to supply demand leading to increased exploration, drilling and discovery, as is the premise of the USGS analysis. Shortages of natural gas supplies in the late 1990's and early part of this century have led to increased drilling for declining returns (Simmons 2002; Clemente 2005; Moran 2005). Global exploration for oil in the 1980's doubled but actual discovery has halved, with the rate of discovery falling to a rate of 10 barrels per foot (Heinberg 2003). Whilst other factors may impact upon barrel per foot rates; declining rates coupled with improved exploration technology and experience, along with the high cost of drilling, has limited activity in doubtful exploratory zones. Declining rates indicate diminishing returns of exploration investment, pointing to the unlikely attainment of the discovery potential as indicated in the 5% probable figures of the USGS study.

### *j. Saudi Arabia.*

Middle East supplies, particularly those of Saudi Arabia have been seen as providing both longer term reserve growth as well as meeting supply infill to offset short term production and processing shortfalls (Yergin 1991; Ahlbrandt 2000; Deffeyes 2005). Simmons recently has cast doubt on the potential for Saudi Arabia to meet the longer term needs of oil supply for the world, having reviewed historical papers for the Society of Petroleum Engineers on the Saudi fields and argues that they are showing signs of depletion in terms of water incursion and increased production costs (Simmons 2005). If this is the case then it further argues against the higher figures of the USGS World Petroleum Assessment 2000 (Ahlbrandt 2000).

### *k. Australian situation.*

Due to it's ability to meet most of its domestic needs from local oil fields Australia was buffered from the oil shocks of the 1970's drawing upon its own reserves of light sweet crude suitable for local transport fuels and to supply some demand on the world market, some of which Australia traded for the heavier crude suitable for tasks such as diesel fuel, lubricating oils and heavy oils for bituminous road surfaces. However according to ABARE statistics[12] Australia's fields reached peak point in 2000[13] and have been in decline since (Akehurst 2002; Robinson 2004). Production has fallen from 650,000 barrels a day to less than 430,000 barrels a day since mid-2002.[14] BP's statistical review of world energy determined that Australia's proven reserves are sufficient to meet our needs for only the next 14 years at current production rates (Bourne 2003). This is consistent with the lower figure of oil supply constraint (2020) identified in CSIRO's Future Dilemmas report (Foran 2002). The CSIRO report models Australia's oil consumption to grow from 30 million tonnes currently to more than 50 million tonnes by 2015, presuming continued growth rates at the present level and does not include the potential for new technologies or fuel use efficiencies[15]. This presents Australia with the situation of declining supplies of high quality light sweet crude, suitable for both local supplies to the petrol engine market, whilst losing availability of supply to the international market to offset the cost of importing oils suitable (in a global situation of increasing price) for the transport and agriculture sectors (Foran 2002). Australia's transport system uses 75% of oil consumed and given its size, dispersed rural populations and state capitals, poor soils and energy intensive agriculture shortages of liquid fuels and feed stacks for agriculture and industry will have flow on costs in terms of supply disruptions (petrol shortages and rationing), inflationary pressures and flow on economic dislocations. The Future Dilemmas report indicates that radical energy use reduction measures have been offered, but suggest that whilst a 50% reduction of energy use "…could provide the physical precursors for an energy and greenhouse lifestyle where feasible and achievable rates of technical progress might stabilize primary energy use from fossil fuels…" but notes that this would be difficult "…for any government in a modern free market economy, concluding that "…most nations do not have the knowledge… (and)…control to attempt any profound change…"[16]. Alternatives such as coal to liquids replacement is a possible option but faces challenges in terms of EPR, greenhouse gas production and timing of infrastructure development, despite optimistic predictions from the industry itself.[17]

### *l. Conclusion*

The Hubbertian model is of significance as it predicts that: (a) oil field(s) production rises to a peak and declines, (b) offers a method to predict EUR and peak date, and (c) predicts via this data indicating when supply will be no longer able to meet demand. This method can be applied from individual fields to global production levels. It has been demonstrated as effective in relation to measuring the countries that have peaked and are now in decline, including

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[12] ABARE 2004, Australian Energy: national and state projections to 2019-20, August http://abareonlineshop.com/PdfFiles/PC12776.pdf

[13] This includes LPG. Geoscience Australia estimate that crude oil reserves, not including LPG, peaked in 1994. (Taylor 2004)

[14] **The Age,** Josh Gordon, Economics correspondent, Canberra, April 9, 2005 **We're running out of oil, says Costello.** **http://www.theage.com.au/news/Business/Were-running-out-of-oil-says-Costello/2005/04/08/1112815725885.html?oneclick=true** "Treasurer Peter Costello has delivered a blunt warning that Australia is running out of oil as existing fields near the end of their productive lives."

[15] Future Dilemmas note that efficiencies tend to be taken up by increased consumption.(Foran et al 2002)

[16] Ibid. Such options range from Lovin's Natural Capitalism method through to Trainer's The Simple Way.

[17] Cooperative Research Centre for Coal in Sustainable Development (CCSD), Media Release 05/03, November 22, 2005

Australia. Given the role of cheap conventional oil a shortfall in supply will have serious ramifications for the global economy and growth.

## ENERGY PROFIT RATIO AND ALTERNATIVE FUEL SOURCES.

### *a. Introduction:*

To maintain the level of economic growth in a declining fuel situation we will have to maintain the same level of net energy inputs to replace declining that net energy supplied[18]. Alternative fuels are generally cited[19] as the policy solution but little attention is paid to the amount of net energy they can deliver as a replacement. Alternatives, in regards to energy, is a general term that means different things to different people, but usually covers the both the non liquid fossil fuel group as well as the energy capture methods of renewables such as solar, wind, tidal, biomass (Gever 1991). It can also include nuclear and usually hydrogen. Two crucial factors are generally overlooked in relation to these alternatives in regards to replacement of fossil fuels; these being the current Energy Profit Ratio (EPR) of those alternatives and their potential declining EPR in a fossil fuel depletion situation (Fleay 1995).

### *b. Energy Profit Ratio*

Energy Profit Ratio[20], or the formula for ascertaining the net energy available of a fuel source, provides an effective and standard measure for determining the ability of energy sources to do work for society (Gever 1991; Fleay 1998; Fleay 2003; Poldy 2003; Tainter 2003; Cleveland Undated). EPR provides an accounting measure for energy that standardizes the measure of energy left after costs of production are subtracted and can determine what economic benefit that energy source can deliver. For example, the difference between a barrel of oil produced in a large newly producing field will be higher than that of an old field[21] experiencing increased costs from declining well pressure (having to now pump oil out), increased water incursion (separation, disposal and corrosion costs), removal of increased impurities, or having the cost of deep sea exploration added to production costs (Cleveland 1993; Youngquist 1997; Simmons 2005). The measure of EPR applies to alternative fuel sources for conventional oil, be they non liquid sources of fossil fuel or alternatives. Further analysis of the real EPR modeled using potential depletion scenarios is required.

### *c. Natural Gas*

Natural gas is seen as providing a bridging fuel to alternative energy sources and has helped create a sense of having an ample backup that can replace oil shortfalls should they occur, both in the global and Australian context (Foran 2002). Gas has increased in consumption in the 1990's, particularly for power generation, as it has a lesser greenhouse gas output than coal when directly used to drive turbines for electricity production. Figures for total world supply range from 300 to 1400 trillion cubic feet (Heinberg 2003) and it supplies 23% of world energy use (Simmons 2004).

Given Australia's strong trading links to the United States and the role their economy plays in relation to the global economy, the U.S. situation is pertinent to our situation. U.S. gas supply saw an onshore peak in the 1970's and decline, was supplemented by coal-bed methane and deep water fields and which now has been in decline since 2002 (2-4%, p.a. in 2003; 1-4% p.a. in 2004) (Moran 2005). Canada is committed under the North American Free Trade Agreement (NAFTA) to supplying the equivalent of its own consumption (currently 87% of the U.S. gas requirements) even if its reserves were to decline (Clemente 2005). This is creating significant concern in Canada, especially in the energy rich Alberta province (Turner 2005). Canada's natural gas supplies are post peak with a predicted decline of 26% between 2000 and 2010 (Clemente 2005).

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[18] Ibid

[19] For example: (Krockenberger 200; Prime Minister and Cabinet 2004; Hirsch 2005a).
[20] The term more generally used in the United States is Energy Returned On Investment (EROI).
[21] In the Lower 48 field the EPR has fallen from 20 (barrels to produce 1 barrel) in 1970 to 10 in 2000 (Cleveland et al 2000; Foran et al 2002).

Australia has yet to reach its peak point for natural gas, the peak date appears to be around 2025 to 2030 (Fleay 1998; Fleay 2002; Foran 2002). Given our dependence on automobile travel, just in time industrial mechanisms and the high fossil fuel inputs to Australia agriculture the role of natural gas will be of increased significance as our conventional oil reserves decline. Foran and Poldy have modeled a transition from oil to natural gas for vehicle transportation either via Condensed Natural Gas (CNG) or the gas to liquid process of which they write "…is a reasonably easy one as much of the technology exists today…" and see the transition 50% complete by 2020 and 95% by 2050 (Foran 2002). However two factors will present difficulty for the Australian economy. First, Australian gas is traded in the international market and therefore subject to world pricing. Declining reserves for other nations (especially the United States) will increase the value, and via this the price for Australian consumers. This would, as we are now seeing, offset the trade deficit, especially as our oil reserves deplete, but make the gas replacement transition far more difficult. If we were to reserve suitable supplies solely for the domestic market we would lose the considerable export market as the oil to gas transition would consume by 2020 half of Australia's gas exports with the transition process itself consuming the other half (Foran 2002). At a time of depleting conventional oil reserves, in a market of volatile prices this will place stress on the Australian balance of trade and have serious implications for the agricultural industry (as discussed below).

Secondly natural gas supplies 85% of the domestic heating and cooking market (as well as for food production and industry) (Fleay 2002). Increasing costs would place pressure on costs to consumers, especially those on lower incomes.

*d. Tar sands and shale oil.*

Tar sands have been put forward as an ample replacement for declining oil reserves, especially for the United States and Canada (Deming 2000). Various estimates of reserves range between 10 billion [22] and 17 trillion barrels[23], based on oil sands under active development[24]. Alberta tar sands currently produce around 1 million barrels per day and are expected to rise to around 6 to 8 million barrels per day, although again estimates vary but seem be in the order of 2 million bd[25]. Total reserves offer 6 years of global supply and daily production estimates indicate that this source will be only able to offer a small contribution to global daily consumption, currently around 84 million barrels. Exploiting tar sands is a mining process involving large scale earth moving and processing involving massive amounts of energy (stranded natural gas) and water and means both local and global environmental damage, especially as Canada is a signatory to the Kyoto protocol. Venezuela tar sands are able to offer around and other 1 million barrels per day by 2010 (Gielen 2005) with total global supply from tar sand of 8 m to 10 million barrels. Shale oil faces huge energy cost and environmental limitations and has yet to prove an economically viable resource both here and in the US, and is unlikely ever to do so (Youngquist 1997; Andrews 2005; Koppelaar 2005).

*e. Other cited alternatives.*

As the supply of conventional oil as a source of cheap energy to drive the economy declines non renewable energy sources may take on a greater percentage of the energy mix. Solar, tidal, biofuels, wind and hydrogen are cited in the media and green press as offering the path forward or transition from fossil fuels[26]. Whilst in terms of greenhouse gas reduction it is recognised that alternatives in generating energy (mainly electricity) will perform better it is little recognised that the level of economic activity and resulting material comfort that can be provided via

[22] (Koppelaar 2005)
[23] Alejandro Barbajosa, Energybulletin, http://www.energybulletin.net/4385.html , and "Will oil from tar sands enable the global supply to be maintained.", http://www.feasta.org/documents/wells/contents.html?one/panel1.html
[24] Thomas Quinn, The Plain Dealer, 14/10/05, accessed via wwww.energybulletin.net. I have seen reserves of 1.7 trillion but these seem unrealistically high. (Youngquist 1997)
[25] Harry Brubaker, Emerging source of oil not from wells, but sand. Philadelphia Enquirer, 2 December 2004. Accessed via wwww.energybuleting.net . Julian Darley, Post Carbon dispatch #3 "Tar Sands and the Price of Oil", 16 October 2004, Global Media.
[26] Ian Lowe, ACF President, address to the National Press Club, October 19, 2005

alternatives is restricted. Such technologies and processes fail to meet the industrial 'grunt' provided by conventional oil in terms of having a lower EPR, in flexibility of use ( e.g. for use in scalable engines) and multiplicity of use (e.g. plastics, fertilizers, pesticides and pharmaceuticals).
None of the key alternatives for conventional oil, whilst playing roles in any future energy mix, will deliver the equivalent level of energy platform inputs. The potential for the key alternatives to replace conventional oil are summarized below[27].

*Solar:* Whilst solar could be scaled up to provide some proportion of future electricity supply for Australia it is likely to form a limited role as a supplement to coal fired (or nuclear) power generation. Penetration into the Australian market has been limited by lack of investment and clear and sufficient market signals from the government (Blakers 2003). Solar can provide additions to the power supply grid up to the 10-20% penetration level, but beyond that will need development of alternative and yet to be developed storage technologies (Blakers 2003). Trainer has reviewed the options for solar as a replacement for coal as an electricity supply and has found that in terms of cost solar will be significantly more expensive, will not be able to power the grid at night and is only most efficient at higher latitudes (which in Australia is the areas of lower population) (Trainer 2003). Trainer believes that solar can play a role in a lower energy model for society but will not play a significant role in industrial society at current net energy level, let alone allowing for continued growth.

*Wind:* Similar to solar wind powered energy has the potential to add to the current electricity supply mix but is both limited by constraints in terms of variable supply delivery in terms of available wind supply and lack of clear market signals from government. Trainer documents similar problems with wind concluding that electricity supplied by wind will be minimal (Trainer 2003).

*Hydrogen:* Hydrogen is often cited as providing the 'energy' source that will ultimately replace fossil fuel, with society moving to 'the hydrogen economy' in smooth progression as our 'industrial society' has moved to higher energy density fuels in the past. This is understandable given that past progression to higher energy forms but fails to consider a number of significant flaws in the characteristics of hydrogen. Hydrogen is not an energy source but is a carrier and as such requires the consumption of another energy source to deliver it in a usable form. This may be in the processing of natural gas or even coal, but this is at a negative energy cost. Production of hydrogen from natural gas as happens at present will hasten the depletion of an already regionally declining resource and makes little sense in the Australian context given the existence of a large pool of existing vehicle stock and infrastructure[28]. To crack water to produce hydrogen would consume six times more energy using heat engines (Goodstein 2004), and suffers too many losses in the production and delivery chain to be viable using alternative sources such as wind and solar (Blakers 2003; Trainer 2003). Further delivery infrastructure difficulties in relation to storage, delivery and transport mean that hydrogen will never be viable as a large scale transport or energy delivery fuel and structure [29] (Eliason 2002; Mazza 2004), although it may have some role in decentralized energy system (Fleming 2005). Australia, given its low population density and distances of rural populations, will face difficulties in economy of scale in establishing any form of viable hydrogen economy.

*Biofuels:* Ethanol as a biofuel additive to fuel is a well established technology. However it is usually processed out of traditional agricultural feed stocks such as sugarcane and corn.

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[27]Other alternatives such as enhanced recovery or renewables like tidal, hydro or space solar but these although needy of consideration have limited increased potential and are beyond the scope of this paper. (Gielen et al 2005)
[28] Robinson and Powrie estimate that there are 14 million motor vehicles in Australia and valued at an average $25,000 each, given a fleet changeover rater of 10 -20 years represents a fleet replacement cost of $350 000 million. In an energy constrained economy there would be considerable disincentives for the purchase of new alternative technology vehicles, especially given that until economies of scale were achieved costs would be high and distribution structures limited. (Robinson et al 2004) and also (Cocklin et al 2000).
[29] Gielen et al believe hydrogen may capture 10-15% of the transport market in Europe by 2040-50. They note that 'important obstacles' need to be bridged. This paper obliquely references energy depletion but does not investigate how this will effect the development of hydrogen technology (Gielen et al 2004).

As such it is dependent up the current fossil fuel platform and has EPR's that are so low as too make it unviable without government subsidies (Gever 1991; Fleay 1995; Naughton 2001). A recent study by Pimentel and Patzek after assessing all the inputs to ethanol production for corn, switchgrass and wood as well as biodiesel production using soybean and sunflower concluded that corn required 29% more fossil energy than the energy the ethanol produced, switchgrass (50%), wood (57%), for biofuel soybean (27%) and sunflower (118%) (Pimentel 2005). Foran expresses a more optimistic view for methanol produced via wood in Australia, citing methanol produced with an EPR of 5[30], with plantations a massive industrial scale (30 million hectares by 2050)(Foran 2002; Foran Undated; Foran Undated). Australia has 40 million hectares of forest that has potential to be harvested, however exclusions such as rivers, steep slopes, etc may exclude up to 40%, whilst Trainer (2002) notes that such a process may require up to 256 million hectares (Trainer 2002; Trainer 2003). Wholesale harvesting for biofuel would present significant ecological problems in terms of biodiversity loss, and water quality issues. Plantation development as an alternative would lead to use of agricultural land and significant changes to local water hydrology. Given the scale of the revegetation and infrastructure required without a very significant level of government intervention it is unlikely that the Foran model for a biofuel economy would be viable as large scale substitute.

## IMPLICATIONS FOR RURAL COMMUNITIES IN AUSTRALIA.

### *a. Introduction:*

Australian agriculture and its communities have changed from smaller scale production methods and related service structures to larger farms and vertically integrated food processing chains, relocation of support services to regional and capital cities, and a wind down of farm incomes and the viability of rural towns (Cocklin 2001). This has been further exacerbated by droughts, trade policy and environmental damage. Farmers and families have seen an increasingly reduced direct return on goods produced as sales moved further away from their local communities, necessitating off farm work and seeing declining population in communities, especially as children moved to cities and larger regional centers for work and education. Increased energy costs have the potential to further hurt farmers and rural communities in the short and medium term via increased input costs and declining markets. In the longer term continued energy shortages may lead to changed farming practices and a more localized focus for markets, infrastructure and community focus. This will be difficult in the economic situation that energy depletion will entail.

### *b. Difficulties facing rural communities*

Rural Australia has seen declining economic viability with related social difficulties, including an aging farming population and loss of youth to the cities (Cocklin 2001; Dunlop 2004). This has been further exacerbated by the closure of services such as bank branches, chemists and local health care resources leading to centralization of many regional services, necessitating increased travel by private transport. The Cocklin et al (2001) study identified a range of challenges to the rural sector in Victoria (circumstances in rural Victoria can be applied in general to rural Australia) including reducing income, introduction of capital intensive labour saving technologies, declining government support and the growing influence of agribusiness and food retailers driving changes in farm practices, including increased industrialization of farming. Economic factors have tended to result in the concentration of both upstream and downstream value adding processes leading to declining balance of trade for farmers for commodities, larger energy intensive farming processes and centralization of support services, either community, government or industry service (Burch 2001; Gray 2001; Black 2005). These writers do not to assess the role of energy inputs and the flow on effects of changes wrought by technological development both on and off farm via improved transport, pesticides and the development of downstream industrial food processing resulting, recognising the change but not the role of cheap energy as the background driver of that change (White 1949; Gever 1991; Tainter 2003)[31]. Flowing on from this is the failure to recognise the vulnerability of modern agriculture to increases

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[30] For comparison oil, in the 1970's has an EPR of 23, and Methanol [wood] EPR of 2.6. (Gever et al 1991)

[31] A further useful study of energy and society sits in the study of the relationship of energy flows and the development of culture in the broadest sense, that of the way cultures and characteristics develop. Leslie White proposed in 1949 that the evolution of culture (civilization, society) could be defined by its ability to activate and use energy. White wrote, "Other factors remaining

in energy costs via its dependency of that fossil fuel framework, although this applies to most of industrial based society (Fleay 1998; Fleming 2005).

*c. Increased energy use in agriculture.*

The accessibility and cost of energy is a key issue for the economic viability and sustainability of rural communities. Dunlop et al (2004. P. 49) found that energy use in Australian agriculture has risen 30% in the last 50 years, whilst crop production had increased 5 fold due to increased energy use, noting that '… dependence on mechanization implies increasing consumption of energy in absolute terms…" , which aligns with Fleay's finding that farm technology has made significant efficiency gains[32] (See Figure 4 below). Direct fuel costs as a percentage of total cash costs for farming (fuel, oil, grease) varies depending on farming type ranging from 5.5% for the beef industry to 7.9% for wheat and other broad acre crops (Baker 2000; Kingwell Undated).

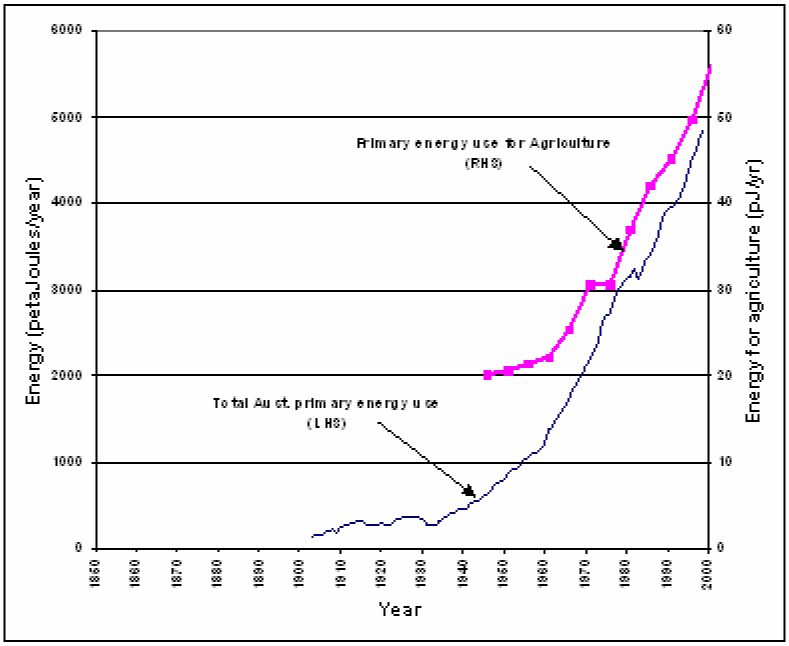


Figure 4

Primary energy use per annum for agriculture and for the whole economy

(Dunlop et al 2004. P. 49)

Fleay (1995) found[33] that fuel was 42% of farm energy costs, with fertilizers (11%), farm transport (12%), and farm structures and equipment (11%) indicating that there are further significant combined energy costs beyond direct fuel and lubricants. Dunlop et al (2004b. P. 102) indicates that there are two looming issues for Australian grains industry, being " … greenhouse gas emissions and the status of world oil supplies, that might have dramatic effects on the availability of cheap energy for the grains industry through their interacting effect on the demand for natural

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constant, culture evolves as the amount of energy harnessed per capita per year is increased, or as the efficiency of the instrumental means of putting energy to work is increased" (White 1949) with social systems defined by technological systems. Analysis of the role and effect of energy flows on society will assist in broad scale adaptation planning (Tainter et al 2003).

32 As with footnote 31, efficiency has led to larger machinery and increased production leading to increased energy use (Dunlop et al 2004b)

33 Fleay uses 1974-5 figures and notes that farming has made efficiency increases in terms efficiency in regards to farming technology and production practices. Although Kingwell notes a Jeavon's Paradox effect of efficiency leading to broader scale farming leading to increased energy/fuel consumption (Kingwell Undated).

gas"[34]. Kingwell (Undated, P.4) further notes that it is"…highly likely that the flow-on or economy wide effects of rising oil prices will have the largest impacts on agricultural industries rather than the direct and first-order effects…of having to pay more for petroleum products and … chemicals and fertilizers." Direct costs such as fuels will place pressure of smaller scale farmers that may not have the credit access to tide them over until cash income from crops arrives (this may also apply to larger farming concerns, but may be able to absorb increased costs). The flow on effects of energy costs to agriculture will place significant strains to rural communities via increased costs to consumers leading to reduced consumption through via pressures as manufactures pass on increased energy costs, leading to further reduced consumption, increased unemployment (both urban and rural), increased local and regional transport costs, as well as the flow-on effects of increasing energy costs on the economy and society leading to inflation and recessionary pressures, devaluation of the dollar, protectionism of agricultural markets by importing countries and investment dollar flight (Kingwell Undated). Bound up in this cost flow-on are the energy inputs to the industrial agricultural food chain beyond the farm gate. Fleay writes that direct energy in the food processing industry (although primarily electricity) is 37%, with transport (28%) and packaging (26%) (Fleay 1995). As an example of energy inputs for agriculture, for the production of 1 calorie of food energy via the modern industrial agriculture food chain 10 calories of fossil fuel energy needs to be expended (Giampietro 1993); offering significant opportunities for inflationary costs to be served up at the kitchen table. Whilst efficiencies may be possible, it will be in a post peak world, a matter of maintaining income or at best reducing income loss, rather than efficiency leading to expansion of agriculture. Small farms and especially farmers with high debt levels (particularly after years of drought) will be further pressed via increased costs. In a time of declining farm incomes, expenditure for practice or technological change may be difficult or impossible. Given that 80% of Australia's farming production is export orientated this will create further dilemmas for primary production in terms of matching supply to demand and long range forecasting for strategic planning (Cebon 2003). Increased costs and the potential for reduction in overseas markets, especially those based around high energy cost transport such as airfreight, may face increasing charges for delivery of their product. This may be offset by a depreciating dollar but will see increased costs for imported farm related goods (Kingwell Undated).

### *d. Role of Natural Gas*

Agriculture in Australia whilst being able to use natural gas as an oil substitute for farming machinery and transport (Foran 2002) will face the situation where in a global market natural gas prices will be placed under increased pressures (including possible competition as electricity generation feedstock (Dunlop 2004)), especially as the US NG supplies decline and Australia reached its gas peak in around 20 years or sooner (Fleay 2002; Dunlop 2004). According to the Fertilizer Industry Federation of Australia, "… fertilizers account for over 12% of the value of material and services inputs used. In 1999 Australian farmers used around 5.25 million tonnes of fertilizer products with a value of approximately $2 billion."[35] This will place pressures on the production of nitrogenous fertilizers as a product refined from NG. The relationship to soil structure, quality and fertility and its role in terms of nitrogen inputs will become increasingly significant.

### *e. Community infrastructure and transport*

Under the current industrial high energy use agricultural model rural communities will also face the decline of related industries geared to the supply and service of agricultural needs, with a further flow on effect to related service industries for the rural community as a whole. Due to greater distances involved in regional living rural communities face greater travel times and increased costs in relation to fuel and vehicle maintenance for basic services including medical, shopping, education and work (Tisato 2002)[36]. Many farmers supplement income is dependent upon off-farm income (Cocklin 2001), with of farm income doubling since the 1980's (Black 2005) with almost half annual income for broad acre and dairy farming being generated beyond the gate by 2001 (Hugo 2005). This is significant given that the balance of trade for the rural community has declined since 1950 with the development of the

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[35] http://www.fifa.asn.au/default.asp?V_DOC_ID=757
[36] In South Australia between 52% and 132% greater distance is traveled by country drivers than Adelaide residents (Tisato 2004).

industrial agricultural system from 45% (U.K.) and 60% (U.S.) to respectively; whilst in Australia in the 1950's it was 4 times higher than what is received today (Cocklin 2001). Cheap fuel prices have encouraged travel for off-farm work as well as the development of life-style living in the rural regions surrounding regional centers. Tourism now provides income via services and asset increases for rural and coastal land, providing for the development of local businesses and off-farm work as well as niche food production and supply (Butler 1998; Tonts 2000). Since the post-war period improvements in private transport, roads and declining real fuel costs have allowed for greater mobility but also have made possible the relocation of a range of services (also via government and economic policy), both government and commercial leading to the closing and centralisation to regional towns (Argent 2000; Gray 2001). Local government now services larger regions and now provides services previously delivered by state and federal government (Daly 2000).

In the longer term increased transport costs and reduced personal travel may lead to a re-regionalisation of rural communities (Pirog 2001; Leahy 2003). Agricultural produce freighted to and from markets will see increased costs leading to a re-localization of agricultural product with the potential for increased balance of trade incomes for farmers bypassing the vertically integrated food processing industry. Regional services will need to be relocated to communities, although in a reduced form, to ensure community basic needs are met. This will necessitate increased populations for regional towns. For example, the model of small schools servicing a local community may again be viable as personal transport and school bus costs weaken the centralized feeder model. Reducing fertilizer, pesticide and fuel costs may necessitate a move to less environmentally intrusive agricultural practices, with benefits in relation to energy and water use (Pimentel 2005). The ability of rural communities to respond to rapid change will necessitate clear and advanced strategic planning, adaptation and community capacity building models and practice.

## CONCLUSION:

Modern industrial agriculture in Australia has developed around the inputs from cheap fossil fuels (Fleay 1995; Dunlop 2004). Any shortages of, or significant increases in the price of, fuels and feedstock (fertilizers and pesticides) will hurt rural production and rural communities directly. Analysis of fossil fuel inputs and flow on ramifications for rural communities is limited with little recognition of net energy inputs and costs. Further analysis would assist in forming a clearer picture of how increased energy costs may affect rural viability and assist remediation and adaptation measures.

## Recommendations:

It is recommended that the likelihood of peaking of world oil supplies and the subsequent inability of industry to meet the demand shortfalls, (either via increased use of heavier, dirtier ($CO_2$) and costly fossil fuels or via renewables) be considered very seriously, and that strategic planning be initiated to best inform society for adaptation actions. To enable an assessment of future energy options it is recommended:

1. *That an accurate, rigorous analysis of the available net energy futures for Australia (in a global context) is conducted. This should be an analysis of all energy options based upon thermodynamically sound principles and be based on the Energy Profit Ratio method to ascertain the level of economic activity and society we can maintain.*

This should be made freely available to academics, strategic planners, NGO's and government to engender informed debate and scenario planning.

2. *That a program of community education based around the roll and properties of energy in modern industrial society (based on the findings of the above mentioned study) be initiated.*

3. *That planning and development of large scale community adaptation projects based on the eventuality of shortages of our primary liquid fuel be developed and initiated.*

End.

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