PEAK OIL AND OIL VULNERABILITY:

WHAT ARE THE IMPLICATIONS FOR INDUSTRIAL AGRICULTURE AND RURAL COMMUNITIES?

WITH A CASE STUDY BASED IN THE SOUTHERN GULF REGION OF QUEENSLAND

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A thesis submitted to

The Department of Geography and Environmental Science

In partial fulfilment of the requirements for the degree of

Master of Environmental Science

Monash University

2013

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Notice 1

Notice 2

Abstract

Modern agriculture's high levels of production and global markets have been made possible through vast inputs of fossil fuels for machinery, transport, fertilizer, chemicals, crop and processed food production. Consequently, the peaking and depletion of oil, which eventually will be followed by gas, will challenge how we both produce agricultural output and live in rural and remote Australia.

Current analysis estimates that maximum global oil production will plateau before supply begins to decline at a rate between four and six percent per annum by the end of this decade. Despite the imminent decline of global oil production, Australia's academic research and responsive government policy and planning development for this event has been marginal. Agricultural production methods and rural and remote communities will need to adapt to these changes, which will take place in varying ways depending upon production/industry type, location and community resilience. Rural society has already been challenged by decades of neoclassical economic policy, structural adjustment, population decline, environmental degradation and climate change induced drought. Oil vulnerability introduces another layer of change that will seriously alter rural and remote Australia's ability to remain viable.

This research explores the question of oil vulnerability presented by the peaking of global supply both at a macro level and through a case study focussing on a remote community in North West Queensland. It assesses the current academic literature about oil supply (both globally and nationally) and looks at the effects of plateauing oil supplies and predicted decline rates as oil production moves into the depletion phase. This research identifies the role of oil as a primary component of our economy and society; points to challenges rural Australian society will face and gives a timeframe for changes in oil availability. It reviews the literature around the economic role of oil in the Australian economy and its use in modern agriculture. This thesis further reviews the state of peak oil/oil vulnerability analysis and policy development at all three levels of government and finds that it has been very limited or in active denial of the immediacy of this event.

The research then attempts to contextualise both oil vulnerability and the absence of policy signals via case study interviews from a remote rural community, examining its oil use and oil vulnerability. The participants' high fuel usage, limited understanding of the risks associated with oil dependency and minimal risk management confirmed their vulnerability to oil depletion and consequent price increases. They identified that the lack of leadership and information from both state and federal governments limits the capacity for more active community identification and risk management planning. Despite this the participants were confident that the regional resources available combined with their skills, attitudes and self-reliance learnt through living and working in a remote region would enable them to survive substantial structural change.

I declare that this thesis contains no material which has previously been submitted for a degree or diploma in any university and, to the best of my knowledge and belief, this thesis contains no material which has previously been published or written by another person, except when due reference is made in the text of the thesis.

Acknowledgements

Many thanks are due to my current supervisors, Dr Bruce Missingham and Dr Ruth Lane, as well as previously Dr Jacqui Dibden and Dr Vaughan Higgins.

I greatly appreciate their input, commitment and patience over the long gestation of this research thesis.

Special thanks to my wife Sue Cutler for her determined encouragement and patience.

My thanks also to Thea Coventry, Cassandra Cutler and Dr Christian Wicke for their advice and assistance with review and editing.

Much appreciation is also extended to the interview participants who were very generous and welcoming in their time, information and assistance.

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1.0 Introduction

The social critic, James Howard Kunstler's comments that,

> …we know we have to go somewhere. We know that something like history is leaving us behind. We have no idea how to get to a new place. And we're spending most of our mental energy gaping into the rear-view mirror, which is the last place to look for your destination… (Kunstler, 2010).

His words illustrate a dilemma that exists in social planning. The social and scientific recognition of human-caused global environmental degradation, resource depletion, and water use and population pressures upon the environment is now increasingly juxtaposed against our desire for comfort and for progress and growth. The difficulty of conceivable plausible futures becomes increasingly undesirable to comprehend.

The widespread community aspirations and concerns for the environment that emerged in the 1970s and the goal of environmental sustainability articulated from the late 1980s (World Commission on Environment and Development, 1987) have been significantly subsumed within the notion that, for both the affluent first world and for developing nations, continual growth is desirable, inevitable, absolute and that human drive, ingenuity and market forces will not only ensure universal wellbeing but also will resolve all the perverse and negative outcomes that result from maintaining a very active, consumptive and technologically focussed global economy (Simon, 1996, Lomberg, 1998, World Bank Group, 2009). The cheap and increasing supplies of energy sources, mainly fossil fuels, is taken as a given by large proportions of business and society more broadly, and any future supply constraints are believed to be decades away and solvable by enhanced recovery methods or replacement with non-fossil fuel sources, such as wind or solar. In this case the cake we want to eat and have, more closely resembles a magic pudding.

Contemporary analysis of oil reserves and production indicates that assumptions based on continuously increasing supplies of fossil fuels, particularly conventional oil, cannot be maintained. Since 2005 oil production has reached and maintained a plateau of production, within a 4% band-width. This points to a maximum production peak, with a subsequent drop off in supply for the global economy, occurring sometime before the end of this decade. Our current global economy is dependent upon cheap liquid fuels and the production of goods and services based around hydrocarbon dense chemical feed stocks. This creates vulnerabilities for transport, just-in-time productions systems, chemicals, fertilizers and most of the oil derived products that we use daily. Whilst changes in energy supply will drive changes in how our economy values and uses energy, with increased efficiency and lower hydrocarbon use (Zeibots and Bell, 2010), an abrupt transition from a state of ready supply to one of constraint (Murray and King, 2012) will challenge both society and its economy in making that transition.

This event is consistent with the concepts of global ecological overshoot and civilisation collapse in environmental literature, pointing to significant thresholds, tipping points and asymmetrical events that will test our continued expansion beyond the limits of the earth's ecosystems to both absorb and repair

(Homer-Dixon, 2007, Meadows et al., 1972, Diamond, 2005, Meadows et al., 2004). Whilst industrialised nations have made progress in responding to environmental challenges such as air pollution, ozone depletion and aspects of river health, there are still significant increases in carbon output, climate change induced environmental shifts, as well as localised environmental (and economic) disasters.

Paralleling the study of ecological systems, in part as a result of the oil shocks of the 1970's, is a body of analysis and literature that critically assesses energy availability, usage and its role in the economic workings of modern industrialised civilisation. Elements of this analysis have focussed around three main areas, although there is overlap between each. These are: energy supply, energy content - being the available net energy to deliver work - and the role of energy in relation to growth and operation of our globalised economy. Each area overlaps in varying ways, and while they can be studied individually, such analysis can lead to a shallower understanding of each issue and the holistic effect upon 'futures thinking' (Poldy, 2003). A small but significant area of literature has been developed around a fuller analysis of the actual role of energy in our society, economy and ecosystems, which has begun to be assimilated into futures thinking (Youngquist, 1997, Smil, 1994, Smil, 2008, Beddoe et al., 2009, Cleveland et al., 2000, Pimentel and Giampietro, 1994, Tainter et al., 2003). Contemporary analysis has expanded to include that of geological, resource and capacity limits, including gas, coal, minerals, fertilisers, water, society's ability to deal with complexity and the notion of the near absence of major new technological concepts (Greer, 2009, Beddoe et al., 2009, Gever et al., 1991, Youngquist, 1997). In the first decade of this century the notion of 'Peak Everything' - that we have reached the maximum production of nearly all resources - began to truly emerge (Heinberg, 2009).

To date governmental policy has inadequately accepted or responded to the reality of depleting resources, although individual attempts have been made on varying scales. Partial attempts to set a new responsive direction can be found around global energy use (International Energy Agency, 2008, Industry Taskforce on Peak Oil & Energy Security, 2010), at varying community levels, mainly municipal, (City of Darebin, 2009, City of Maribyrnong, 2007, City of Portland, 2007, Krumdieck, 2010, City of Stirling, 2012) and the peripheral literature of the developing peak oil/transition movement (Hopkins, 2008). Various government and military studies have recognised aspects of the 'new' policy required, but have yet to make an appearance in mainstream government departmental thinking, including in Australia.(Dodson and Sipe, 2010, Steele and Gleeson, 2010).

The current policy mechanisms for policy development, such as climate change, conceives such challenges as arising both out of, and also being managed within, a readily available, energy rich and continually expanding industrial future (Garnaut, 2008, Stern, 2006). While various bodies of scholarship have challenged these assumptions, the literature is not adequately developed and has yet to enter mainstream government or institutional policy. Conceptions of the future, even in a significantly climate stressed vision are still framed within assumptions of ample available energy to adjust to changes. Major directed studies

such as those of Stern and Garnaut, where they actually raise energy supply issues, do not provide a comprehensive assessment of these issues. Current Australian policy development around both carbon trading and energy policy have yet to recognise that the energy availability that forms the basis of their policy frameworks will most likely be radically different. Questions around the form of such schemes and their viability need to be raised prior to their implementation, as it will be increasingly difficult to adapt such policy outcomes within a changing and increasingly energy constrained future.

A common vision for rural (including remote) Australia is based upon assumptions of continued growth and expanding productivity in a bountiful natural environment as a means of producing wealth and sustaining rural communities. The reality is that this has been possible because of a range of factors including technological development, advances in production methods from scientific research and application and the use of fossil fuels for motive power, fertilizers and chemicals (Fleay, 1995, Gever et al., 1991). This allowed Australia to increase gross output, develop new markets and provide a wide range of products based around food and fibre. The development of Neoliberal ideology and its influence upon theory, policy and governance, combined with the flow-on effects of energy use and developments in technologies and agricultural science has led rural Australia away from the agrarian socialism of the past into models that have changed the frameworks and patterns for rural society (Lawrence et al., 2010, Lockie and Bourke, 2001, Lockie and Higgins, 2007, Cocklin et al., 2001). In Australian agriculture, this has shifted the planning and policy emphasis away from interventionist policy towards market based frameworks and reduced government support. This has in part brought about changes to rural communities and their physical environments through service reduction, population decline (including numbers of farmers), increase in farm sizes, declining terms of trade for producers, leakage of youth from communities and increases in the average age of farmers remaining, as well as numerous other changes (Hugo 2005, Lawrence, 1987, Lawrence, 1990, Lawrence and Gray, 2000, Lockie and Bourke, 2001). Government policy on rural Australia, though clearly recognising these changes, continues to adopt the approach that no re-assessment or change is required. It is based on the assumption that increased agricultural productivity growth and the resulting anticipated flow-on income increases to rural communities, will mediate many of the problems associated with rural decline.

Very little, if any, policy consideration has been given to the implications of the peaking of world oil supply for both agricultural production and rural and remote communities. While some research has been undertaken examining the effects of peaking oil supply on urban society, very little research, beside the early work by Fleay, has been conducted on its effects beyond the urban fringe (Fleay, 1995, Dodson et al., 2010). This has, in part, allowed policy to be framed and constructed on the assumption of an energy dense economic future. Consequently governments continue to avoid decision-making that might assist societies to adjust to an oil vulnerable future (Steele and Gleeson, 2010).

Given both the on-farm and beyond farm gate uses of both oil and natural gas in agricultural production, and the transport needs for rural and remote communities for services and social activity, cost rises or supply disruption present particular challenges to non-urban Australia and the domestic urban and international markets that the production of agriculture services. The question of what the implications of the peaking of world oil supply and resulting oil vulnerability will mean for rural and remote Australia is both highly important and significant.

This research thesis focuses upon the oil vulnerability of rural and remote Australia, using a case study based upon the isolated cattle and mining community of the lower gulf region of North West Queensland (214,000 sq. kms), where I worked from 2007 to 2011. It also considers issues of global scale (peak oil), national scale (policy and research) and state and local government (oil vulnerability adaptation strategies and plans).

Oil vulnerability will be reviewed through an investigation of the current literature related to what is the current status of the world oil supply, the current production profile and possible dates and rates of decline for supply. Then I will review the key areas of energy vulnerability for Australian agriculture, examining its dependence and levels of fossil fuel inputs usage, use of fertilisers, long chain farm gate to kitchen food production/supply systems, and the wider economic disruption and impacts on markets. I will consider the concept of vulnerability as set out in the literature and how this can be applied in the context of peak oil driven economic and social stress. I will also review any integration of oil vulnerability into Australian research and policy development and consider this in the context of community vulnerability and adaptation.

It is my intention that this research will assist our understanding of the peaking of world oil supply, its implications for our economy and industrial society and how that vulnerability could apply to both agricultural production and rural and remote society. It is the hope that this work will form part of an increasing body of research that will better inform policy and governance leading to the possibility of more accurate and responsive policy and planning outcomes.

The following research question frames the research:

What will be the possible effects of oil vulnerability upon Australian agriculture and rural/remote communities?

This thesis is organised into six chapters in addition to this introduction. Chapter 2 explores the literature on vulnerability, examines definitions and provides a lens through which the vulnerability in the North West Queensland case study can be viewed; investigates the data around the key driver of change in the context of this research, peak oil; describes the linkage between energy and economic activity and explores the use of oil and gas in industrial agriculture. Chapter 3 presents the conceptual framework and discusses the key

concepts of vulnerability and how this may be applied to society, agriculture and the case study region in relation to peak oil and oil vulnerability. Chapter 4 sets out the chosen methodology and explains the rationale for a case study in North West Queensland. It describes the case study region in terms of geography, scale, isolation, climate, industry and aspects of the community that are likely to shape both local understanding and responses to peak oil. Chapter 5 analyses the Australian Policy context, assesses the policy landscape in relation to: (a) energy supply, with particular reference to liquid fuel and the Liquid Fuel Emergency Act, (b) critiques understanding and analysis, especially in relation to economic frameworks and perspectives, (c) reviews existing policy at national, state and local levels and (d) analyses our vulnerabilities resulting from that combination of policy. Chapter 6 presents the case study research, how oil vulnerability is understood and could be manifested in that community. Chapter 7 concludes by discussing the implications of the results, and attempts to set out both policy recommendations and discusses possible further research areas. The real and imminent advent of peak oil has been gaining increasing acceptance through both an emerging body of peer reviewed literature and data indicating maximum production has plateaued since 2005.

Given that the decline of oil supply will have economic and social ramifications that will flow through our interlinked global economy it is surprising that it has not been taken more seriously as a risk management consideration. This is due, in part, to the fact that academic research on the issue has not yet reached a level where it can fully inform and influence policy development, although this does not explain the avoidance of the issue that policy making has shown. Country Australia will see both similar and different manifestations of this event than will their urban counterparts. A fuller understanding of the implications of peak oil on economies, before the effect of peak oil forces change, may assist in achieving more focussed, timely and appropriate responses. Linking peak oil adaptation responses to climate change planning will assist in transition, and with a good measure of hope, cooperation and well thought-out action a sustainable and fulfilling future may be achievable.

2. Background

2.1 Peak Oil

Defining peak oil is a key component of this research thesis, in that, as an economic and social driver it rates on scale of impact (from global to local), immediacy of event (timeframes for response and mitigation measures) and scope (being multi-sector) as an economy-changing event of a phase transition type. These effects, whilst not threatening numerous ecosystem functions as directly as climate change, will affect global economic, social, geo-political and environment changes and feedbacks on a decadal long scale. The fact that peak oil has not received greater policy and planning recognition, particularly regarding response and possible migration, will most likely be the subject of further academic analysis and societal dialogue into the future. However some of the lack of engagement in our society stems from (a) poor understanding

of energy and the nature of oil production (also including other fossil fuel), (b) the availability of oil discovery and production data leading to restrictions in the development of analysis of depletion models and future supply forecasts, including the publication of over optimistic production levels and field decline rates, (c) limited understanding of Energy Return on Energy (EROI) invested and the linkage between net energy, oil supply as a significant energy source for the global economy and the relation to Gross Domestic Production (or economic activity). Therefore, public awareness of the research surrounding 'point maximum supply', plateau and predicted decline, including depletion (decline) rates is essential for the assessment of the nature of the event being studied in this research thesis.

This thesis will not attempt to provide either a more detailed or general description of the physical manifestation of crude oil, field structures, discovery history or production and related topics then is given below. For more detailed analysis the works set out in the reference list provide some excellent interpretations of peal oil related topics (particularly (Deffeyes, 2009, Goodstein, 2004, Heinberg, 2003, Yergin, 1991, Youngquist, 1997, Aleklett, 2012).

Oil has enabled much of the economic activity of the post-war period (Aleklett, 2012, Fleay, 1995, Goodstein, 2004, Heinberg, 2003). It has provided a flexible, energy rich hydrocarbon fuel stock essential for not only the internal combustion engine but also a range of plastics, fertilisers, pharmaceuticals and the just-in-time long chain economic systems that now form the basis of our complex industrial civilisation. The integral nature of oil in sustaining industrial society and activity has resulted in it becoming an invisible although essential driver of modern culture.

The term peak oil has come to mean the point where either or both conventional oil (easy to find, produce and refine) and/or non-conventional oil (deep sea, tar sands, heavy oil, less and more costly) reaches its maximum ever rate of production and thus supply. In 2001 the petroleum geologist Colin Campbell defined peak oil as:

"The term Peak Oil refers the maximum rate of the production of oil in any area under consideration, recognising that it is a finite natural resource, subject to depletion." [1]

The concept that we could map the maximum production of oil production by assessing the accumulated data upon the production profile of the lower 48 U.S oil fields was put forward by M. King Hubbert in 1956 (Hubbert, 1956). Increasingly research has refined the Hubbertian linearisation method to include analysis of future large scale projects and giant fields to build an improved picture of future production capacity. Whilst there is now no serious debate upon the existence of the peaking of supply there is some debate upon maximum production levels and resultantly the date of maximum production. Peak production is currently being evidenced by a plateau of production, however this may be influenced to some degree by

[1] http://www.peakoil.net/Default06.html

the global economic crisis and its after effects (Hook et al., 2009, Hamilton, 2009a). The peak of world oil supply is an event that will occur only once and the opportunities for collecting information beforehand are limited. The knowledge gained from this thesis could be useful in the development of adaptation models for other regions and communities.

2.2 Peak and plateau

Prediction of the shape of the oil production peak is difficult to estimate and may only be known accurately from a historical perspective. Various methods have been used to estimate maximum rates of production in order to develop a production profile of individual fields, regions and ultimately a national production profile. As data this can be digitalised to form a graph that rises to a peak point of maximum production and then, as oil fields are finite, a rate of decline can also be defined. Both increase and decline are modified by a range of factors that are subject to individual interpretations, physical values, timeframes and availability of (reliable) data leading to varying assessments as to amounts and points of maximum production. Further this analysis can be affected by the categorisation and inclusion of differing types of energy sources, such as conventional and non-conventional oil types. Individual fields will see varying levels of depletion, due to factors including their own field dynamics, whether on or off-shore, development rates, age and quality of each field, its infrastructure, oil price and so forth. Deep water off-shore wells are often depleted sooner as production is pushed to achieve a higher return over a shorter period to off-set much higher development costs than on-shore fields (Deffeyes, 2005, Deffeyes, 2009, Fantazzini et al., 2011, Goodstein, 2004, Aleklett et al., 2010).

Further, peak production profiles differ for regions, and whilst offering some indications of future production/depletion trends, they do not follow a uniform pattern, which makes global interpretation difficult. For example, Hirsch notes, that North America and Europe are both "…reasonably contiguous and bounded…" and developed using commercial criteria they show different production peaks; with America displaying a sharp peak before plateau, whilst Europe entered an immediate plateau (Hirsch, 2008, P.889).

IEA data of conventional oil production presents a plateau moving in an average band width of 4-5% (see Figure 1.) with an apparent production cap of 75Mb/d commencing around 2004/5 (Fantazzini et al., 2011, Hirsch, 2008, Hirsch, 2011, Hook et al., 2009, Jakobsson et al., 2009, Robelius, 2007).

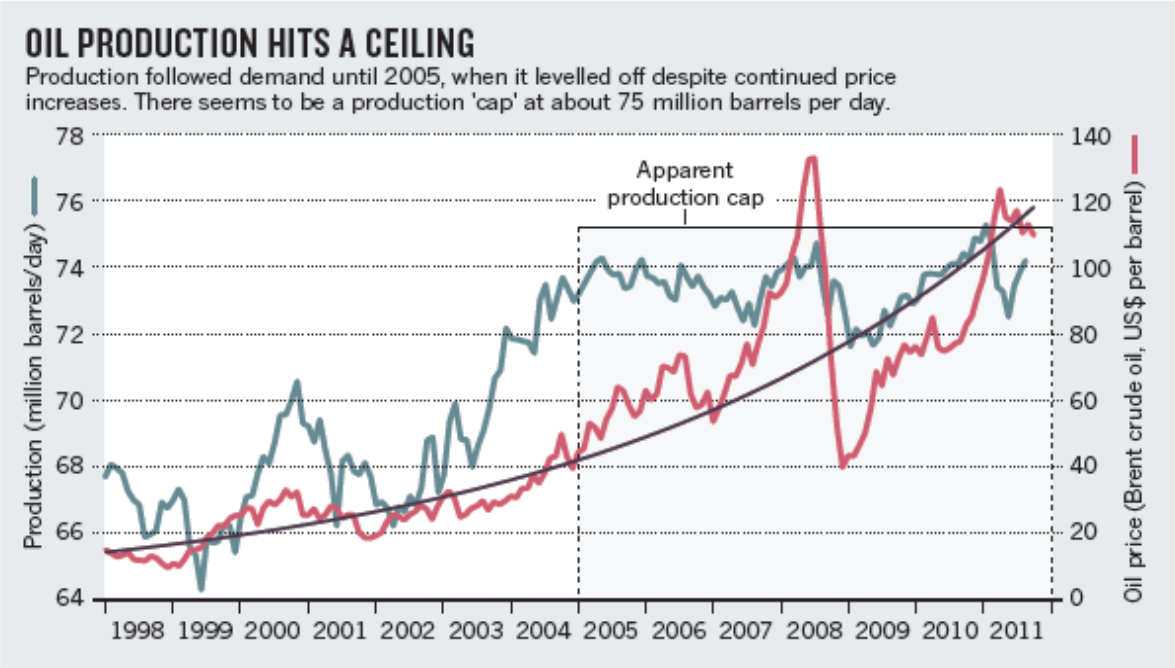

Figure 1 Oil production plateau.[2]

Murray et al presents this as a "phase transition", that is, when the price of oil has virtually no impact upon increasing production (Murray and King, 2012). Consideration of the profile of the production plateau is important for planning because it gives understanding of the shape and therefore production curve we will have travelled across. Hirsch and others initially conceived peak oil as having a sharp peak similar to the profile of the U.S. production. It is now expected that the production and decline profile to be similar to that of Europe, displaying a period of undulation (in part influenced by economic considerations) followed by a relatively sharp rollover and a monotonic decline (Hirsch, 2008). Estimated periods for the length of the plateau are limited but centre around the period for roll-over within the time frame of 2012 to 2020 (Bureau of Infrastructure Transport and Regional Economics, 2009, Hirsch, 2008, Hirsch, 2011, Hook et al., 2009, Owen et al., 2010, Robelius, 2007); however as the authors note, the exact date of decline cannot be accurately predicted due to multiple variables. To date we have seen approximately 7 to 8 years of plateau, with high prices offering strong market signals for increased production in existing and yet to be developed fields. Whilst an upturn in discovery and production is possible, given the IEA estimates of the peak (2006) and decline of already discovered oil, this is also unlikely in the longer term (International Energy Agency, 2010).

[2] Murray and King, 2001, P. 434

Estimated date of roll-down from plateau	
Author	*Date*
(Bureau of Infrastructure Transport and Regional Economics, 2009)	*2017*
(Hirsch, 2008)	*2013-15*
(Industry Taskforce on Peak Oil & Energy Security, 2010) Skrebowski	*2015*
(Jackson, 2007)	*Beyond 2030*
(Miller, 2011)	*Before 2020*
(Owen et al., 2010)	*2015*
(Robelius, 2007) (lower estimate)	*2012*
(Sorrell et al., 2010)	*Before 2020*
(Zittel et al., 2013)	*Between 2015 and 2020, possible maximum global production reached 2012*

Table 1 List of published estimated roll-over dates

2.3 Decline potential

Estimates of the potential date(s) for the roll-over, which is the point where supply can no longer be maintained, generally sit within a band between 2010 to 2020 (Bureau of Infrastructure Transport and Regional Economics, 2009, Hirsch, 2008, Industry Taskforce on Peak Oil & Energy Security, 2010, Miller, 2011, Owen et al., 2010, Robelius, 2007, Sorrell et al., 2010, Aleklett et al., 2010), although more distant dates have also been predicted (Jackson, 2007). (Figure 2) A recent (2013) study by the Energy Watch Group[3] sees a rollover somewhere between 2015 and 2020, with world oil production declining by 40 percent by 2030 (Zittel et al., 2013). They consider total world fossil fuel supply to be close to the maximum point of global production, possibly by 2020 in the mid to later part of this decade, with a total peak at 2012. These dates are built from varying methodologies but are consistent to this time period. Although the

[3] www.energywatchgroup.org

Global Financial Crisis has lowered demand it has also led to, at least initially, reduced field development and subsequently limited impact upon the possible roll-over date. Hirsch estimates that the GFC has only pushed back the date by months (Hirsch, 2011). High prices in the 2005-2011 period has not seen increased production either from existing or yet to be developed fields for conventional oil.

As well as this, as decline becomes apparent, producing countries, dealing with growing populations and declining reserves may withhold production in an attempt to maintain homeland political stability resulting in a steeper production decent (Hirsch, 2011, Owen et al., 2010, Brown and Foucher, 2010).

From the literature, it is reasonable to make the following assumptions, being that:

That (a) conventional oil levelled out in terms of production around 2005/6 and (b) is travelling (along with non-conventional oil production) across a saw-toothed plateau that will (c) go into decline at a rate of between 4-6% per annum, (d) likely before 2020 (International Energy Agency, 2008, International Energy Agency, 2010, International Energy Agency, 2011b).

Further, that we are increasingly entering a period of fossil fuel availability with a declining EROI and higher environmental impact and greater reliance on sources from regions that are geopolitically unstable and that are environmentally difficult and sensitive to damage. These factors combined with declining reserves will have a significant drag on the global economy.

Analysis of peak oil prior to the plateau period initially focussed upon the peak production date and, like mountain climbers, they had their eyes set resolutely on the summit. Now resting at the top admiring the view they have noticed the summit has an undulating top with the far side shrouded in cloud. Some climbers believe decent down the other side is near whilst others believe the climb continues. The analysis presented in this thesis points to a drop off in production that is not too many years forward into that cloud, with above and below ground production factors, time and consumption clearing the view forward and defining the topology.

This improved, although limited, peer reviewed literature has analysed published data to clarify the production situation. Whilst much of this analysis will remain unnoticed by policy and planning development, it offers a challenge to the more optimistic view of our oil production future.

Whilst dissenting opinions exist in relation to the event of oil occurring these are generally dismissed. Oil is a finite resource, oil fields deplete as bounded by the laws of physics and oil is consumed at an increasing rate. Debate around the date of peaking of supply, including the use of the Hubbertian model for determining EUR has been limited. Both Lynch and Deming refute EUR and peak dates offered by the Hubbertian peak oil modellers, offering criticism of Hubbert's initial assumptions, questioning the accuracy of 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)). Maugeri offers optimistic future production figures, but these presume very optimistic production levels and flawed analysis of data (Maugeri, 2012). 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 and Lynch, 1997). Whilst oil price increases have led to production increases via the opening up of previously uneconomic fields and the production of previously uneconomic resources, such as tight oil and tar sands, this has led to only led to the prolongation of the production plateau described above. Ultimately, unless the rates of development of these resources increased markedly, which is very unlikely, the depletion of the conventional oil fields will swamp the production outputs of the nonconventional resources. For example the boom of tight oil and gas fields in the United States is now being revealed to be short lived, with very high depletion rates and with a significantly reduced total production capacity leading to 6-10 year production boom (Hughes, 2011a, Hughes, 2013, Heinberg, 2013). The laws of physics trumps economic theory as the fundamental guiding determinant of all that physically happens in the universe, oil production is not exempt, no matter how much wish that it was.

2.4 Economic significance

Neo-classical economics tends to focus upon models that primarily recognise only labour and capital and to view economic growth as a product of technological innovation (Hamilton, 2011, Ayres and Warr, 2002, Foran and Crane, 2006, Solow, 1956, Reynolds and Baek, 2012). Warr et al note that empirical research has not yet reached consensus on directionality in relation to the role of energy in the economy (Warr and Ayres, 2010). As a result, the role of energy is often not effectively included in the consideration of how the economy works. Models instead focus on labour and capital, with increases in economic growth being viewed as a product of labour, capital and technological innovation. A range of contemporary writers have challenged this concept, instead emphasising the role that energy plays as an enabler in the delivery of work (products and services) in the economy (Ayres, 1998, Ayres and Warr, 2002, Cleveland et al., 1998, Cleveland et al., 2000, Foran and Crane, 2006, Hall et al., 2003, Industry Taskforce on Peak Oil & Energy Security, 2010, Linderberger, 2002, Ayres, 2007). While technology does play a role in economic growth, a far more significant role in economic growth (usually measured as GDP growth) is due to increased inputs of energy rather than the interaction of capital and labour (Hall et al., 2001, Kummel, 1982, Murphy and Hall, 2010, Ayres and Warr, 2010).

If there is a direct link between energy use in the growth of GDP, and it is then accepted that energy use is a fundamental component of that equation, then any changes to energy supply will have economic impacts, either negative or positive on growth and on volume and price. Recent papers published by Hamilton reviewed the relationship between the recent high cost of oil and the economic crisis and

concluded that it played a contributing factor in its occurrence (Hamilton, 2009a, Hamilton, 2009b, Hamilton, 2011). Price increase effects are more likely to be ten times greater than that of traditional economic reasoning (Murphy and Hall, 2010, Hamilton, 2000). This is consistent with a recent working paper out of the International Monetary Fund that found that:

> … real economies have many and highly interdependent industries, and several industries, including car manufacturing, airlines, trucking, long-distance trade, and tourism, would be affected by an oil shock much earlier and much more seriously than others. The adverse effects of large-scale bankruptcies in such industries could spread to the rest of the economy, either through corporate balance sheets (intercompany credit, interdependence of industries such as construction and tourism) or through bank balance sheets (lack of credit after loan losses). (Kumhof and Muir, 2012, P.20-21).

Hirsh also writes that: "…world oil shortages will degrade world GDP and that unity is a reasonable assumption for the relationship between percent decline in world oil supply and percent decline in world GDP, i.e., a 1% decrease in world oil supply could conceivably produce a 1% decrease in world GDP." (Hirsch, 2008, P.888)

Recent econometric modelling by Kumhof and Muir's found that:

> …While a low income elasticity may appear like a blessing in an environment where oil output can grow without constraints, it actually makes the problem of supply constraints all the more severe. The reasoning is simple-minded, but nevertheless approximately true because very low price elasticities limit the extent of substitution away from oil. Namely, if it really only takes a one third of one percentage point increase in oil supply per annum to support additional GDP growth of one percentage point, then it must also be true that it would only take a one third of one percentage point decrease in oil supply growth to reduce GDP growth by a full percentage point. And the kinds of declines in oil supply growth that are now being discussed as realistic possibilities are far larger than one third of one percentage point. (Kumhof and Muir, 2012, P.20)

Given that the potential annual global oil field decline rates could be around 4% and greater, this presents real challenges to the global economy. Increases in the cost of oil as price rises means an increasingly greater component of GDP will be redirected to energy supply, with a level around 5% beginning to challenge growth (Li, 2012, Industry Taskforce on Peak Oil & Energy Security, 2010). The combination of declining EROI for conventional and non-conventional oil as well as lower EROI for alternative fuels poses a real challenge for future economic growth. While the research in this area is both initial and limited in influence, the engagement of the IMF, albeit via working papers, will inform and challenge traditional economic thinking in relation to the role of energy in our economy and points directly to the economic risks of peak oil that frames this research.

2.5 Alternatives

The progression from lower to higher sources of energy has been the general pattern of western industrial energy development (Smil, 1994, Smil, 2005, Smil, 2006b). 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 net energy supplied (Guilford et al., 2011, King and Hall, 2011). Alternative fuels are generally cited as the policy solution, but little attention is paid to the amount of net energy they can deliver as a replacement.

However, this poses problems in relation to competition for agricultural land for food production at a time when modern agriculture is struggling to keep pace with global population increases and food demand (Cribb, 2010). Crops grown for biofuels are better suited for broad acre farms, limiting options for smaller holdings; the so-called oil/diesel trees have yet to be adequately proven and have long production lead times. The ability to produce on-farm biofuels will also be subject to the same constraints of weather, fertilizer cost, locust plagues and the multiple other challenges that knit farmers' brows yearly. As fuel prices rise this does not preclude that biofuel crops may provide an option for some farmers and rural communities to develop locally produced liquid fuel supplies, however the viability, volumes and land use/food production issues have yet to be adequately investigated. Varying studies point to alternative fuel/drive chain options, but on examination they are neither energetically or economically viable on a large scale (hydrogen and electric car), present significant environmental and hydrological challenges or produce limited replacement volumes (CSIRO Future Fuels Forum, 2008, Foran, 2009, Diesendorf et al., 2008, Krumdieck, 2010). This could mean a significantly constrained travel and transport society. In rural and remote regions access to fuel for social transport, machinery for agricultural production and delivery to markets, and for provision of community services such as ambulance and fire, are key to maintaining the economic and social viability of rural Australia; especially as they are already being stressed by market philosophies and forces and are facing increased pressures from climate change. Yet there has been minimal consideration of the future challenges for rural and remote living, food production and related industries. How declining reserves are distributed will need increased consideration, especially in response to government legislation, such as emergency liquid fuel acts (East and Bailey, 2008). Any future rural fuels mix will be of multiple types, sources and of increased complexity and accessibility.

2.6 Australian situation

Due to its ability to meet most of its domestic needs from local oil fields Australia was buffered from the oil shocks of the 1970's because it could draw upon its own reserves of light sweet crude which is suitable for local transport fuels and was able to supply some demand on the world market (Commonwealth of Australia, 2007); 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 (approximately 128 million barrels per annum in 1968). Consumption in 2009 was around 329 million barrels per annum (Department of Resources Energy and Tourism, 2010, Geoscience Australia, 2010). However, according to ABARE statistics Australia's fields

reached peak point in 2000 and have been in decline since (Akehurst, 2002, Robinson and Powrie, 2004). Production has fallen from 650,000 barrels a day to less than 430,000 barrels a day since mid-2002 (Geoscience Australia, 2010, Geoscience Australia and ABARE, 2010). 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 and Poldy, 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. 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, while 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 and Poldy, 2002, Zeibots and Bell, 2010).

The role of energy and particularly that of conventional oil, as a key driver of our economy and the society/civilization it supports is often poorly understood. In economics it is usually viewed as an enabler, more in the sense of a lubricant rather than a primary power source of economic activity. Resultantly notions of transferability of energy drivers or that of the dematerialisation of the economy in relation to oil have gained acceptance (Li, 2012). While economic growth can be stimulated through measures of efficiency, quality and changes to energy service demand, ultimately the lowering net energy return of energy has an increasing effect upon the economy's ability to do work, its resilience and annual GDP. Hirsch notes that any period of extended roll-over or plateau would give planners only a short timeframe for mitigation measures, but given current policy blindness to the issue any response time is unlikely (Hirsch, 2008, Hirsch, 2011).

Both Australian agriculture, and the rural communities that service it, are dependent and vulnerable to shifts in the direct availability, cost and flow on impacts of changes to oil supply. Adaptation will mean significant long-term change that is best anticipated well prior to the event. Therefore rigorous academic analysis of both the timing and roll-over of the production plateau, combined with analysis of the risks and vulnerabilities of both sectors and communities are necessary. Changes made during depletion will be far more difficult to initiate as potentially reduced and expensive energy supply will decrease the available capacity in the economy for any adaptation measures. Policy development and implementation may assist in setting in place responses prior to depletion, but future policy development will need to be undertaken in the context of those future changes to energy availability and quality. It will need to be developed anticipating, as best as possible, that structural change will be taking place in a period of significant stress and change. Given the decadal long timeframes needed for structural change in agriculture, identification of a range of factors will be crucial, including the timing of the roll-over of the plateau, the identification of

how fossil fuel interdependence in industrialised agriculture is manifested, and the vulnerabilities inherent adaptive capacity that rural communities have and will have to deal with.

2.7 Energy use in agriculture

Industrial agriculture uses fossil fuels for the production, processing and transport of agricultural commodities which has enabled significantly increased volumes and diversity of food/products and allowed for the development of a wider mechanism and structure for distribution to global markets. The development of chemical fertilisers, pesticides and the development of mechanisation both before and beyond the farm gate led farmers to increase scale, crops, harvesting outputs and transport mechanisms. New and significant production industries have been developed increasing the product range and scale.

Whilst changes have occurred in the structure of rural living with the development of improved roads, better vehicles and cheap fuel as well as enhanced communications, enabling commuter, tree/sea changer lifestyles and the development of organic farming, boutique crops and farmers markets, much of rural Australia is still engaged in larger scale industrial agriculture (Barr, 2005, McKenzie, 2006). Mechanisation has made the physical act of production less demanding but has locked agriculture into a dependence on high energy, primarily fossil fuel inputs. Modern industrial agriculture requires an input of between seven and ten calories of oil for every calorie of food produced (Giampietro, 1994, Pimentel and Giampietro, 1994, Pimentel and Giampietro, 2008, Pimentel et al., 2005). While a proportion of this is post-farm gate, with four tenths consumed at the household/supermarket level, the integrated systems of industrial food production binds the farmer to the consumer via long-chain production and supply systems as well as global economic markets. The resilience of the long chain systems in modern agribusiness to oil shocks and prolonged price increases has not been fully researched and presents a significant risk to the viability of current rural production (Dodson et al., 2010, Gever et al., 1991, Pfeiffer, 2006, Pollan, 2006, Sloan et al., 2008). While greater efficiencies may be achievable, in a post peak world it will be a matter of maintaining income or at best diminishing income loss rather than efficiency leading to an expansion of agriculture. In a time of declining farm incomes, expenditure for practice or technological change may be difficult or impossible; especially as many of the gains of practice change for energy reduction have already been achieved. The accessibility and cost of energy is a key issue for the economic viability and sustainability of rural communities. Dunlop et al found that energy use in Australian agriculture has risen 30% in the last 50 years, while crop production had increased fivefold due to increased energy input, noting that: "… dependence on mechanisation implies increasing consumption of energy in absolute terms" (Dunlop et al., 2004b, P.49), which aligns with Fleay's finding that farm technology has made significant efficiency gains (Fleay, 1995).

Slone et al also found that:

> While costlier energy encourages producers to use less energy and energy-intensive inputs, antecedent improvements in energy efficiency make less certain the manner in which future increases in the price of oil may stress producers, encourage adaptation and accelerate reductions in energy use. Further, improved factor productivity has been achieved far more through progressive increases in agricultural output than through decreases in associated energy inputs. This fact highlights an agricultural oil vulnerability which exists despite greater energy efficiency: as high-yielding cultivars are especially reliant on appreciable energy inputs (as through fertilizer, chemicals, irrigation), even relatively small decreases in energy use may cause disproportionately large declines in farm output and, thus, degeneration in energy efficiency trends. This dynamic would both compound and be compounded by the marginal incomes of farmers. (Sloan et al., 2008, P. 7-8)

Direct costs, such as fuels, will place pressure on 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, who may be able to absorb increased costs). Further, as the costs of inputs are passed on down the supply chain, consumer consumption patterns may change leading to shifts in markets and product consumption. Small farms and especially farmers with high debt levels (particularly after years of drought) will be further pressed via increased input 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, 2003).

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 et al., 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 young people move to cities and larger regional centres 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 oil vulnerability will entail.

Planning for a future of both increased price of oil and possible liquid fuel constraints in Australia, in relation to our industrial agricultural system would look at three main areas, being: (a) timeframes and possible changes to oil based fuel stocks (for chemicals, fertilizers and liquid fuels), (b) the vulnerability of industrial agriculture to peak oil driven energy shifts and (c) what mitigation and adaptive measures would be possible. Research would need to look at farm energy use and how changes to farming practice might build resilience to cost pressures and/or shortages. Methods for developing on farm biofuel production, especially for broad acre farming with high liquid fuel inputs, would ensure a continued sure supply for farm production machinery, as well as having the potential to develop local industry based around bio-fuel based technology. This could include modelling of potential changes to markets, both internal and international. Further analysis of the long-chain food production system, from farm gate through to delivery and sales systems at the shop and supermarket would identify risks and allow for planning of risk mitigation. Research and analysis of risks for rural communities would assist in identifying areas of vulnerability and assist in the development of options for rural communities to build resilience and response measures.

2.8 Rural Australia

Rural Australia has seen declining economic viability with related social difficulties, including an aging farming population and loss of youth to the cities (Cocklin et al., 2001, Dunlop et al., 2004a). This has been further exacerbated by the closure of services such as bank branches, chemists and local health care resources leading to centralisation of many regional services, necessitating increased travel by private transport (Black, 2005, Burch et al., 1999, Maher, 1994, Smailes, 2000). 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 industrialisation of farming (Cocklin et al., 2001). Economic factors have tended to result in the concentration of both upstream and downstream value adding processes, leading to a declining balance of trade for farmers for commodities, larger energy intensive farming processes and centralisation of support services, either community, government or industry service (Black, 2005, Burch et al., 1998, Burch and Rickson, 2001, Gray and Lawrence, 2001, Lockie and Higgins, 2007). 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 the farm, via improved transport, pesticides and the development of downstream industrial food processing; they recognise the change but not the role of cheap energy as the background driver of that change (White 1949; Gever 1991; Tainter 2003). Flowing on from this is the failure to recognise the vulnerability of modern agriculture to increases in energy costs via its dependency of that fossil fuel framework, although this applies to most of industrial based society (Fleay, 1998, Fleming, 2005).

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). Many farmers depend on supplementing farm income with off-farm income (Cocklin et al., 2001). Off-farm income has doubled since the 1980's (Black, 2005) with almost half the 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 industrial agricultural system from 45% (U.K.) and 60% (U.S.) respectively; while in Australia in the 1950's it was 4 times higher than what is received today (Cocklin et al., 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 centres. Tourism now provides income through 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 et al., 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 through government and economic policy), both government and commercial, leading to the closing and centralisation to regional towns (Gray and Lawrence, 2001, Argent and Rolley, 2000). Local government now services larger regions and 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 possibly leading to a re-localisation 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 centralised feeder model. Reducing fertiliser, pesticide and fuel costs may necessitate a move to less environmentally intrusive agricultural practices, with benefits in relation to energy and water use (Pimentel et al., 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.

The mutually intertwined supply and market systems of Australian agriculture are no different. This offers significant opportunities for inflationary costs to be served up at the kitchen table. This is not to argue that agricultural production should be viewed through the lens of just energy, it is, as are other major productions systems, a complex matrix of vertically integrated production, and marketing structures, local

conditions and farmer preferences and choices. Risk will be dependent upon a range of factors beyond energy, including markets, agribusiness preferences, individual farm and farmer viability (including impacts of climate change), government policy and (in)actions, consumer preferences and a range of other and often poorly understood variables. Dodson and Sipe note that farmers are price takers, vulnerabilities exist and that any assumptions about farm sector homogeneity and capacity "…to absorb institutional changes driven by a transformed energy environment must be sensitised to local institutional and geographical conditions" (Dodson et al., 2010, P.300).

Work by Dodson et al (Dodson et al., 2010, P.301) has identified that possible changes due to oil vulnerability may bring about the following changes:

- changes to the distribution of agricultural types within Australia's regions;
- changes to the intensities of agricultural land uses;
- shifts in the primary mode of transportation of agricultural products, such as from road to rail;
- restructuring of settlement patterns – concentration or dispersal – as communities adapt to higher transport costs; and
- abandonment of some land types or sub-regions if production and transport costs became prohibitive.

2.9 Summary

Peak oil as an event as described above is now well recognised via peer reviewed literature and via authorities and relevant organisations, such as the International Energy Agency. The matter of the time frames for the roll-over dates and the ability to replace conventional oil is still being debated, but solid literature and data exists to point to a reasonable possibility of significant disruptions to supply and cost increases within a timeframe of a decade or less. Flow on costs both economically and socially have the potential to be greater than identified by conventional neo-classical economic thinking.

Industrial food production is energy intensive and changes in availability and cost will have impacts for food production both in Australia and globally, both before and after the farm gate. The review presented by this thesis both identifies this energy cost and Australian agriculture's poor understanding of both energy uses in agricultural (and food) production and finds that there is very limited academic or policy investigation, research or risk management planning being considered or undertaken.

3.0 Conceptual Framework

3.1 Introduction

This research is framed around the concept of oil vulnerability and seeks to explore what that means in the context of the research case study (area and community). Some theoretical work has been undertaken for a number of peak oil task force studies recently and a larger overall academic body of literature is extant which looks at energy in relation to net energy and the economy from which broad extrapolations can be drawn, but not at the individual or community scale. Interrogations of the issue through interviews with local people, those who live, work and participate in the North West Queensland community offers a way to bring some of that higher level understanding into a definable and palpable context and from there explore vulnerabilities and possible adaptation measures.

Understanding of oil vulnerability can be built up from the literature around oil, the peaking and supply of oil, economic theory, thermodynamics and ecology, but in nearly all cases has either been removed or only applies a theoretical lens over possible implications for communities, such as road transport vulnerability or peak oil task force reports (Dodson and Sipe, 2006, Krumdieck, 2010). This research thesis is an attempt to investigate potential effects, implications and options for the community of this case study.

3.2 Conceptual framework.

The conceptual framework for this thesis is the propositions that:

1. The event of the peaking of world oil supply can be demonstrated through literature as a measurable event and that we are currently moving across a production plateau of both conventional and non-conventional oil. This plateau will end sometime this decade with an annual supply production reduction globally in the order 5-6% per annum. The energy content and economic benefit will not be replaced by other energy sources (alternatives and non-conventional oil) at the same volumes, cost or available timeframes.

2. That decreased volumes of conventional oil as well as increased costs and declining net energy of replacement energy sources will have a direct and negative impact on economic activity and GDP globally and regionally.

3. The event of the peaking of world oil supply will create outcomes that may be defined or conceptually framed under the heading of “oil vulnerability” and will be manifested in various forms. It is likely, given future supply constraints through the depletion of conventional oil globally (including Australia) that this will be by means of supply disruption, fluctuations in the price per barrel of oil, eventual shortages and both significant economic disruption and geopolitical tensions. This will create a higher order of vulnerability for both global and regional economies that will led

to sets of economic driven social perturbations that form the basis of outcomes defined as vulnerability.

4. The level of understanding of and engagement with the issue in the area of relevant research, policy development and planning will have both an indirect and direct bearing upon the capacity of response measures both globally and regionally. This is demonstrated in the case study area in terms of both vulnerability and adaptive capacity.

5. That rural Australia will face economic and social challenges and that these challenges will be defined by a range of local conditions, including location, regional industry sectors, population, and local community capacity, including levels of existing vulnerability. For this research it investigates oil vulnerability in relation to (a) direct use of oil (and gas) products directly, fuel, fertilizers, chemicals; (b) wider implications through markets and economic conditions.

6. This was researched via a case study in the Southern Gulf Catchments region of North West Queensland. This involved a qualitative approach via interviews with a small cross section of the community, via sector groups upon both fuel use and understanding of the issue of peak oil and any adaptive responses.

7. Findings and recommendations drawn from the literature review and case study put forward recommendations in relation to research and policy directions and analyse the role that local government may play in bridging local adaptation at local, state and national scales.

In this context this research provides direction on an event of great impact and significance and opens new ground for further research and development.

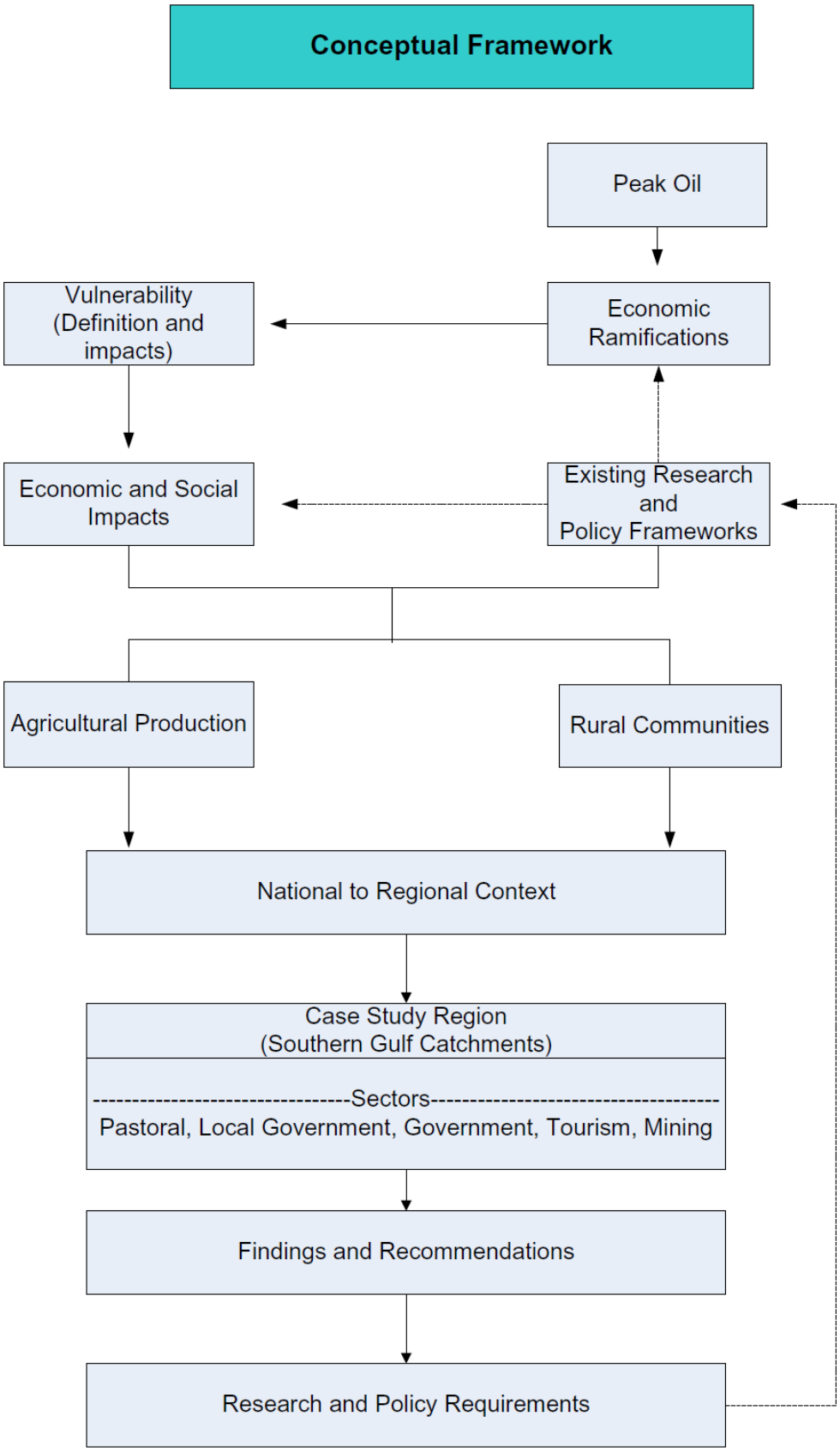

Figure 2 Conceptual Framework Schematic

3.3 Oil Vulnerability

Oil Vulnerability has been chosen as a phrase and as a concept in this research to define social and economic outcomes from the effects that will be felt globally by global (and national) supply of conventional oil reaching its maximum supply and entering a phase of both production and supply decline. Attempts have been made to define societal states in a post peak world, many of a post apoplectic nature and generally speculative, although those that consider options for adaptation may offer valuable conceptions. These include theoretical and philosophical frameworks such as transition, permaculture and adaptation (Fleming, 2005, Holmgren, 2009, Homer-Dixon, 2007, Hopkins, 2008, Trainer, 2011). Terms have been used to describe such social states and in part draw upon literature around prior societal collapse (Tainter, 1988), foreboding change and disruption and do little that provides useful theoretical mechanisms for investigation and description of those possible changes; although Kunstler's descriptor of a "… Long Emergency" offers a concept of change and response in terms of risk and management (Kunstler, 2005).

The use of the term oil vulnerability originates in Australia, and was first used in the Queensland government Taskforce report, "Queensland's Vulnerability to Rising Oil Prices" (Queensland Government, 2007) and has gained limited usage mainly via the research work upon potential stress from increased fuel prices undertaken by Griffith University, limited use in regional studies and reports, including in New Zealand (Krumdieck, 2010), and in local peak oil writing. Research conducted at Griffith University into the effects of oil shocks on Australian suburbs and transport systems further linked the issue with the peak oil nomenclature and the term 'oil vulnerability' subsequently passed into wider usage; although use of 'peak oil' is more commonly used in academic publications dealing directly with oil field depletion (Dodson and Sipe, 2006, Dodson and Sipe, 2005). In 2010, the journal of the Planning Institute of Australia, Australian Planner published an entire issue entitled: *Special Issue On Cities and Oil Vulnerability*. Apart from scattered publications (Runting et al., 2011, Taygfeld, 2006, Brannock, 2011), submissions and theses (Mohr, 2010), academic research and literature on oil vulnerability is limited given the potential scale and effect of this event. It is, as a label, a useful descriptor as it combines the listing of oil and vulnerability together identifying a particular state, that of being vulnerable or at risk in some way to oil. In environmental science it is sometimes used to identify coastal risk to oil spills. However there is no accepted commonly identified usage associated with the nature of the economic and social events that the peaking of global oil supply will bring, so in for the purpose of this thesis, it is the nomenclature used. The literature deals with four main constructs around risk and outcome, being those of vulnerability, exposure, sensitivity and resilience. It is useful to identify through the literature these concepts.

3.4 Vulnerability

The concept of vulnerability is often applied to concepts of impact and capacity to adapt in relation to natural disasters, increasingly in relation to climate change impacted or driven phenomena, or susceptibility to a range of social disadvantage based definitions, encompassing the risk or impact that an

event or perturbation can have upon an environment, system (including economic), process, population or community or individual, organisations, frameworks or process or even an object or objects (Alwang et al., 2001, Blaikie et al., 1994, De Lange et al., 2010, Turner et al., 2003).

The often cited definition of vulnerability is that from the IPCC Third Assessment Report which describes vulnerability as:

> The degree to which a system is susceptible, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation, to which the system is exposed, its sensitivity and adaptive capacity (International Panel on Climate Change, 2001) .

Vulnerability is generally driven by external factors such as perturbations and stresses, which may take the form of environmental events such as cyclones, floods or drought or factors from within the social/economic sphere such as economic shocks, policy impacts or political change or turmoil (Adger, 2006b, Folke et al., 2005, Gallopin, 2006, Young, 2010). However it is generally centred around a system's capacity to be harmed by a threat or action (Adger et al., 2004, Turner et al., 2003, Schröter et al., 2005), and is usually presented in a negative form (Adger, 2006a). Adger et al write that definitions vary across disciplines, areas of study and emphasis in relation to both how it is defined and constituted (Adger et al., 2004). Societal-economic and environmental systems are all interlinked and bound and any separation between them is arbitrary, given the complexity of the systems, integration, timeframes (and scales) and interdependence (Adger, 2006a, Berkes and Folke, 1998). Vulnerability in the area focussed around our social/economics/environmental characteristics, linkages and outcomes is better understood and researched, albeit with specific case variants, with some form common meaning, language and metrics, (Adger, 2003a, Adger, 2006a, Cutter, 2003, Fussel and Klein, 2006, Kasperson and Kasperson, 2001). In relation to human systems, vulnerability relates the internal characteristics of the social system in question, including its inherent capacity (resilience) to adapt to external shocks and has been defined in terms of "social vulnerability (Adger et al., 2004, Adger and Winkels, 2006, Holling, 2001). King et al note that vulnerability remains difficult to quantify and that:

> Community vulnerability is also an extremely complex concept. For a start vulnerability includes resilience and the ability to recover from a disaster, both as a corollary and as a parallel of vulnerability. (King and McGregor, 2000, P.55)

Gallopin et al argue that the most suitable analytical unit for the consideration and research of both vulnerability and adaptation is that of social-environmental systems (Gallopin, 1991, Gallopin et al., 2001). This is a scalable geographic unit that enables analysis of data that recognises the interplay and interdependence of human social/economic activity and the form, functions and processes of the biophysical systems in "mutual interaction". Social-environmental systems (SES) units should be viewed as

linked, both between the social and environmental but also between systems at varying scales, which Gallopin describes as “non-decomposable”, but notes that it is possible to single out individual components for study (Gallopin, 2006, P.294). There may also be varying scales, overlaps and mismatches between social/economic units and scales and that of environmental units. An example of this is the riparian catchment model used by Catchment Management Authorities in Australia for environmental data collection, assessment and planning and that of social/economic units found in economic centres around settlements, infrastructure or governance boundaries (such as local government) that may cross over a range of environmental systems or subsystems. A system’s vulnerability to exposure can happen at a multiple of scales depending on the nature of the event and those characteristics can have complex interactions. Holling describes these in terms of hierarchical structures, that is, that in relation to scale and significance one can nest within another, either impacted via larger scale perturbations that impact various internal components or where one or a number of the nested lead to changes in the larger SES (Holling, 2001). For example increases in the price of oil may impact upon a farmers ability to plant a crop, have that crop that is produced delivered to market, for the producer to produce that food product at a reasonable cost and the ability or interest in the market to purchase that product due to flow on economic ramifications. Vulnerability is further modified by the systems exposure and sensitivity to that shock.

3.4 Exposure

Exposure is the nature and extent that a system is exposed to stressors, drivers or change (Adger et al., 2004, Adger, 2003b, Kasperson and Kasperson, 2001, Young, 2010). Smit et al see exposure and sensitivity as practically inseparable, in that the outcomes from both relate to the linkages and dynamics of their interrelation (Smit and Wandel, 2006). That is, the nature of the exposure (intensity, scale, timeframes) is linked to the measured adaptive capacity (sensitivity) of the system. A community that has lower community social capacity, being the inherent economic, social and environmental strengths, may see population loss after a major event; as with significant bush fire events. Exposure manifests in temporal forms, the number, nature and occurrence of stressors, such as flooding, the spatial relationship of exposure (global, national, regional, and local) and the interactions of the stressors. Exposure may come in the form of single events, such as natural disasters, or in longer term multiple shocks, such as repeated economic downturns, energy supply disruptions, repeated periods of dry and so forth.

3.5 Sensitivity

Sensitivity is the degree that the system being affected is modified or disturbed. This can be determined by a wide range of factors including economic and environmental resilience, community capability, levels of repeated exposure to the perturbation (each time reducing capacity to renew or rebuild), strength of governance (Steele and Gleeson, 2010) and level and ability to apply knowledge. Vulnerability is therefore manifested on multiple scales (Turner et al., 2003, Adger, 2006b, Smit and Wandel, 2006). An SES’s ability to manage stress is noted as sensitivity (Adger, 2006b, Folke et al., 2005, Young, 2010), which Adger

describes as the ability or extent to " …which a human or natural system can absorb impacts without suffering long-term harm or other significant state change" (Gallopin, 2006, P. 295). This may involve differing scales and timeframes and may not show consistency across stressors with certain events placing unmanageable stress on a system that induces a state change that does not adversely affect a similar system subjected to the same or similar perturbations. As Young notes, "…a regime may be resilient in the sense that it is more or less immune to the impact of most and yet have an Achilles heel in the sense that it is vulnerable to one or more specific types of stress" (Young, 2010, P. 380). This could take the form of single characteristics such as phosphorus in agriculture, where potential supply limitations could cause significant disruption in production in a system geared to ample supply (Cordell and Frangert, 2009, Gallopin, 2006).

3.6 Resilience

Resilience or adaptive capacity is defined as the "… ability of the system to evolve in order to accommodate environmental hazards or policy change and to expand the range of variability with which it can cope" (Adger, 2006a, P. 270). This is consistent with the concept contained within literature around 'Panarchy', resilience and adaptive cycles, as set out by Gunderson and Holling. SESs can go through periods of disruption that lead to collapse and rebuilding in an altered and/or lower state (Gunderson and Holling, 2002). Smit et al note that this is context specific, varying between countries and communities (Smit and Wandel, 2006). For example, inhabitants in Northern Australia have developed the ability due to distance related isolation, through already existing life-style patterns (stocking up on food and perishable goods, habits of self-sufficiency, location specific property infrastructure) to manage significant periods of isolation (up to months in length) during flooding and impassable roads due to wet seasons and cyclones. However some extreme events may lie outside the adaptive capacity of the individual or community to cope, with long term events such as drought lowering the communities "coping range" (Folke et al., 2005, Smit and Wandel, 2006).

3.7 Institutional and Policy capacity

One component of resilience is preparedness. The concept of predictable surprise is of relevance in relation to both planning and adaption responses; that is, the ability to recognise the event, to plan for its eventual occurrence and to have both timely and adequate adaptation, if not mitigation measures in place. The case of Y2K is commonly presented as an example where a potentially disruptive outcome was recognised as an issue and effective response measures were taken, in the form of both awareness raising and remedial software modification or computer replacement, to the extent that the predicted surprise had virtually minimal affect. This was so effective that Y2K has been considered as fear mongering because it failed to eventuate, and so must not have existed (Grant, 2010). The concept of a non-immediate but possible or even likely event that could or should have been predicted (and thus acted upon) has been expressed as a "predictable surprise"," as:

> …. an event or set of events that catch an organization off-guard, despite leaders' prior awareness of all of the information necessary to anticipate the events and their consequences. Most leaders, from managers to presidents, recognize growing systemic weaknesses in their organizations, in their nations, and in the world that have the potential to grow into a major crisis over time…(Bazerman, 2006, P. 180).

Events such as September 11, Hurricane Katrina and the generalised form and effects of climate change have been described as knowable (Bazerman and Watkins, 2004). Bazerman and Watkins set out how emergency organisations had the ability and the charter to recognise and act in advance of possible events but for a range of reasons failed to do so, and question why informed leaders don't take action when the positive outcomes of taking that action are greater than the costs of inaction (Bazerman, 2006) and believes our leaders are rendered immobile by cognitive, organisational and political factors.

Key barriers identified include positive illusions where societies:

- harbour beliefs that things in the future will be better than they really are or could be expected to be;
- build pictures and conceptual models that avoid evidence that is contrary or give weight to evidence that questions those preconceptions;
- discount the future despite good intentions, tend towards maintaining the status quo; and
- tend to underestimate events that do not have "vividness", that is "…has not been made real'' for us in a manner that has caused us harm or that can be readily visualised (Bazerman, 2006, Watkins and Bazerman, 2003).

For example, someone who has experienced long term or repeated unemployment will be more wary of economic risk, or those with mortgages will be wary of increases in interest rates. Because we both adopt an egocentric approach and that it is virtually impossible to avoid trade-offs we are likely to continue along the path of reaching both peak oil and climate change tipping points without taking evasive or adaptive action (Wade-Benzoni et al., 2002).

Individuals and communities that could have anticipated the need to prepare either in the form of existing mitigation actions, past or current, and/or adaptation capacity to the event were exposed not only to event but also to a range of outcomes that may have been avoided or lessened. The Queensland Floods Commission of Inquiry identified SEQwater to have failed to adequately prepare and respond to the January 2011 South East Queensland floods at Wivenhoe Dam. This could be seen as an example of a failure of duty of care (van den Honert and McAneney, 2011). SEQwater had the knowledge and expertise to have been able to both expect, plan and suitably respond to a range of flood events. Whereas the eventuality of the scale, ferocity and speed of the Black Saturday 2009 bush fires may not have envisaged or even the scale of the 2010 Victorian floods, the possibility that climate change will cause larger scale

events was predictable (especially given periods of extended dry for fire, either in terms of contributing factor or the likelihood of a rapid state change for flooding) should have engendered both risk assessment and response planning prior to the event in a form and process that managed or at least best mitigated against failures in emergency response management.

Young notes the institutional resistance to change, which he terms as “stickiness”:

> Institutions are sticky; they often stay in place long after mismatches between regimes and the biophysical and sociological settings with which they interact become severe and widely understood, at least among specialists. (Young, 2010 , P.379)

Grant points to peak oil as being, in behavioural terms, an aversive consequence that reinforces the behavioural characteristics identified by Bazerman et al as being: (a) a non-recurring event, (b) that has a delay in adverse consequences, (c) has demonstrated a variance in predicted dates and (d) that the averseness of it reinforces avoidance. These characteristics are in common with denial or avoidance behaviours found with climate change but emphasises that we have no experience in dealing with such an event (Grant, 2010). For political responses to drive both community awareness and effective policy development and implementation prior to the event both political processes and related government departmental activity must occur prior to the felt effects of the event, most likely with perceived negative results that would not be fully recognised until the impacts of the event are more comprehensively reached, or if the mitigation measures were successful, not felt at all. This would lead to claims that the response was not required or ill-thought out, as was reported in relation to Y2K (Grant, 2010).

In Australian research and policy framing the term ‘oil vulnerability’ has been used to describe the potential economic and social impacts of energy constraints associated with the peaking of global oil supply. This usage however has been relatively limited to date, perhaps due to the lack of academic research around this subject until recently (Steele and Gleeson, 2010, Dodson and Sipe, 2010). Further, it did not appear in the peak oil literature until the development of the Queensland State government’s report on peak oil risks, perhaps because the author’s sought to avoid the term ‘peak oil' in the report’s title (Queensland Government, 2007). Responses to peak oil/oil vulnerability can be found in the transition movement, permaculture, organic farming and in the writings of Trainer and Fleming (Trainer, Undated, Fleming, 2001, Hopkins, 2008). Proposed is a model, in part built out of the counter culture and responses to the energy shocks of the latter part of last century, which envisages models for truly sustainable low energy communities, where the need to reduce energy inputs for food production and constrained personal mobility lead to a re-localisation of communities, where a leaner, more economically constrained lifestyle is developed. While this transition could be both difficult and disruptive (Greer, 2009, Heinberg, 2004, Kunstler, 2005), it ultimately does not necessarily mean a lower quality of life, but rather one where values of community, connection and constraint will replace those of consumption and complexity. Localisation of production could lead to the rebuilding of rural economies and society where more sustainable models of

agriculture, community and environment are developed (Bailey et al., 2010, Fleay, 1995). North writes, in relation to the arguments of intentional localisers, that: "[m]ore radical change is necessary (given climate change) and inevitable (given peak oil)", noting that models developed out of the counter culture responses to the oil shocks of the last century and to concerns about limits and the environment, will now offer even more responses to an energy constrained future (North, 2010, P.6).

The limited academic research into this issue, compared to the depth and breadth of research around climate change, has meant there is not yet a good understanding of the potential pattern of actualisation of this event or of its potential societal effects. (Dodson and Sipe, 2010). As Dodson and Sipe note, the "…analytical, institutional, political and motivational deficits that have so far limited government action must be overcome…" for a more comprehensive and practical response to be developed (Dodson and Sipe, 2010, P.300). While oil vulnerability has seen limited academic research and policy discussion in relation to urban society and planning, it has yet to be considered in the context of what this will mean for rural land use planning, social policy development or the continuance of increased production for Australian agriculture.

3.17 Summary

As with the study of climate change, oil vulnerability can be conceptualised in many ways. Vulnerability is a difficult concept to apply in relation to energy depletion. Difficulties arise in defining and measuring vulnerability. The impacts of peak oil will cross cut all aspects of our industrial society and both effect and in turn are influenced by the sequence and mix of events and impacts that it creates. Further, as with climate change, the "…existence of competing conceptualisations and terminologies of vulnerability has become problematic…"(Fussel, 2005 P.2). Issues of what could/should be measured as an effect of peak oil, what constitutes vulnerability and how is it bounded complicate understanding. Is it local, regional or global? A global impact, for example a decline in overseas markets, may have consequences locally, but also that effect may flow on to impacts regionally as individual businesses reduce costs by spending less. A decline in consumer confidence may lower oil price temporarily leading to reduced exploration and production of oil fields, further increasing risk for supply into the future. Economic and social impacts will be complex, dynamic and display both negative and positive feedbacks. Timeframes for impacts will possibly be much tighter than those of climate change, but will have to accommodate stressors that climate change itself imposes; and itself will, possibly to a lesser extent, alter those climate change impacts. Research in relation to this concept is nascent, if not nearly non-existent, and presents a significant vulnerability in itself. How do we plan for those risks if we have a limited understanding of what they are, how they will manifest and how we could best respond to them?

However the concept of oil vulnerability is valuable in that introduces the concept of risk and presents a label for the development of a conceptual framework that both research and policy can be focussed around. Peak oil labels a physical event; oil vulnerability labels an effect that the concepts of vulnerability,

sensitivity, exposure and resilience are useful sub-frameworks for research, policy and response. This research starts that process through the research approach outlined below. It identifies and examines the event that creates the risk, and considers two aspects of oil vulnerability via interrogation of our research and policy preparedness and begins the work of understanding community based on-ground vulnerability via the case study.

4.0 Methodology

4.1 Introduction

This research thesis, beyond defining the concept of peak oil, possible depletion timeframes and economic implication, as well as the role of energy in modern agriculture and the rural communities that support it, considers the concept of oil vulnerability through two lens, that of the Australian policy and research framework and via a case study of an energy dependent remote Australian community. Effects from the peaking of oil supply will be felt in all areas of society, but will particularly manifest itself in the day-to-day activities of local communities. Timely preparation will assist in mitigating or building resilience to oil vulnerability. However, without clear policy signals communities may possibly fail to respond with timely adaptive measures. Given our current risk adverse/growth focussed political culture, governments are unlikely to provide clear authorising environments for research and policy development to assist in informing those community level responses. Government is unlikely to prove that authorising environment prior to the palpable economic impacts of peak oil without clear signals from communities. In that space is the wicked problem of this matter. It is hoped that this research assists to clarify the need to engage with this problem.

4.1 Research Question

This research attempts to consider the above problem via asking the following question:

What will be the possible effects of oil vulnerability upon Australian agriculture and rural/remote communities?

4.2 Approach

The research for this thesis is made up of four approaches and sub questions:

(1) A review of the literature setting out the event of the peaking of world oil, including dates for depletion and supply issues, review of literature around the linkage of GDP and economic activity to energy, including Energy Return on Investment (EROI) that will establish the situation of “oil vulnerability” for the study area.

This assumption is draw from the available literature as set out in section 22.1-2.4. This sets the context for the key geophysical and economic event, that being diminishing supplies of the primary and most economically important drive for industrial civilization. It looks at the literature linking energy use to GDP, principally economic activity. Section 2.5 addresses briefly the ability for alternative energy sources to replace oil and finds that it has very limited capacity in terms of net energy, scale and scalability (volumes and timeframes) and flexibility (appropriateness of use or conversion issues). It finds that there is a very probable likelihood of conventional oil supply and flow on significant economic disruptions. This sets the context for the research. There is a problem that provides (a) the context for the examination of its potential impacts for agriculture and rural Australia, of whether it is reflected either in research or policy and (b) looks at the issue through the lens of a regional case study.

This would attempt to answer the sub question of: How and when would peak oil influence the global, national and local economies?

(2) A review of literature relating to energy use in modern agriculture, including Australian agricultural production and consideration of the vulnerabilities for production arising out of the peaking of global oil supply.

This would attempt to answer the sub-question: what are the implications of peak oil for Australian agriculture and rural communities?

Sections 2.5 – 2.8 look at energy examines the research, policy and planning responses to oil vulnerability currently in Australia at a national, state, regional and local levels. Analysis is made of what the current policy positions and analysis exists in likely of the vulnerabilities identified in sections 2.1 – 2.8, identifies the gaps and points to vulnerabilities resulting from this research and policy blind spot.

This would attempt to answer the sub question of: Does the Australian policy adequately address oil vulnerability?

(3) A case study undertaken in the Southern Gulf region of North West Queensland. The field research and analysis provides a real life, spatially bounded, contemporary testing of oil vulnerability in the context of peak oil event and risk management frameworks, extant or not. To my knowledge no direct research has been undertaken that looks at what peak oil vulnerability could mean to a specific community. Information gained would be valuable in terms of starting to build a picture of vulnerabilities, possible responses and adaptation measures.

This would attempt to answer the sub question of: What is the oil vulnerability of the case study area and how is this influenced by the Australian policy in relation to oil vulnerability?

4.3 Case study

The literature presents three types of case studies, being exploratory, causal and descriptive, usually within a contemporary real life situation (Yin, 1994, Baxter and Jack, 2008, Hancock and Algozzine, 2006, Stake, 1995). Yin describes case studies as empirical inquiry into contemporary phenomenon where the how or why is being asked in which the investigator has limited or no control over. Yin writes that:

> The case study allows an investigation to retain the holistic and meaningful characteristics of the real life events such as individuals, life-cycles, organisational and managerial processes, neighbourhood change, international relations and maturation of industries. (Yin, 1994, P.13)

The case study is then well suited to this research topic and study area in that it is people orientated, is contemporary in focus, holistic and beyond the direct control of the researcher and is qualitative, combining elements of the explorative, causal and to a lesser degree descriptive forms. The qualitative method of research is well suited to the investigation as carried out by this research thesis. As Creswell writes:

> One of the chief reasons for conducting a qualitative study is that the study is exploratory. This means that not much has been written about the topic or the population being studies, and the researcher seeks to listen to participants and build an understanding based on their ideas. (Creswell, 2003, P.30)

This thesis research looks at an event that is only fully beginning to emerge in the literature, has not featured significantly in the media and yet has to manifest itself fully in the region and population being studied. As Morse has identified, quantitative research is better suited to a body of knowledge that is well researched and is repeatable:

> Characteristics of qualitative research problems are: (a) the concept is immature due to the conspicuous lack of theory and previous research; (b) a notion that the available theory may be inaccurate, inappropriate, incorrect or biased; (c) a need exists to explore and describe the phenomenon may not be suited to quantitative measures. (Morse, 1991, P.120)

Miles and Huberman note that qualitative data is grounded in the events of everyday life, in "…naturally occurring, ordinary events in natural settings, so that we can have a strong handle on what real life is like"(Miles and Huberman, 1994, P.10). They feel the research is buttressed by "local groundness" because it is being collected in a specific situation or location (Miles and Huberman, 1994). This method is therefore suitable for the study of how an event that will have significant on ground implications and effects for a specific community. How peak oil/oil vulnerability may 'demonstrate' itself in a community is better understood through a research method that enables the research to become located in the topic with the subjects of that research (Family Health International, 2011). In that context it provides:

> … information about the "human" side of an issue – that is, the often contradictory behaviours, beliefs, opinions, emotions, and relationships of individuals. Qualitative methods are also effective in identifying intangible factors, such as social norms, socioeconomic status, gender roles, ethnicity, and religion, whose role in the research issue may not be readily apparent. When used along with quantitative methods, qualitative research can help us to interpret and better understand the complex reality of a given situation and the implications of quantitative data. (Family Health International, 2011, P. 1)

The qualitative method allows for a higher degree of conceptual flexibility, the ability to explore themes and reveal complexity (Miles and Huberman, 1994). Debate still continues around the use and validity of qualitative data, its use in a wide range and significant body of study has led to it being recognised as a valid form of critical inquiry (Carey, 1989). It has been accepted and used in a number of fields of study including, social work, communication studies, education, management studies, nursing, medicine, and psychology (Denzin and Lincoln, 2003, Marshall and Rossman, 1989).

4.4 Data Gathering Model

The purpose of the data analysis is to identify, interpret and describe themes, common patterns, and emergent issues among the group and communities that are subjects of this research (Ezzy, 2002). The methodological models considered were, (a) case study, (b) survey and (c) face-to-face and telephone interviews. This researcher's knowledge of the low response rate to surveys conducted in the region indicated that a survey (a) would not solicit significant responses and (b) not allow for discussions that may lead to new information and understandings. The method chosen for data collection was by face-to-face or telephone interviews. The questions asked were semi-structured and open ended to allow for the area of conversation to accommodate the interviewees interests, knowledge and belief structures. This allowed a greater flexibility for the interviewer to establish an effective relationship with the subject. As Robinson writes: "....interpretive methods are required which can give special attention to the knowledge and understanding of individuals and communities'' (Robinson, 1998, P.409). Semi-structured interviews provide both a framework for investigation but also allow for flexibility in scope, of modifying the questioning to explore threads and themes as they may arise in the interview (Dunn, 2008). Interviews followed a set format with fully worded questions. However, while the interviews allowed for investigation of other themes, topics or issues, the interviewee was brought back to the main topic when necessary (Dunn, 2008). It is believed that this method can provide useful information when working with a small sector of a larger community (Denscombe, 2007, Hay, 2008). This allowed for the collection of a quantity of information that is both relevant and specific (Thomas, 2007, Robinson, 1998, Laws, 2003). The open ended interview process allowed the interviewee, through the process of engagement with the topic, to build an understanding on the topic as the interview progressed, providing deeper and richer material for the interviewer (Rubin and Rubin, 2005).

4.5 Case study Region

The case study area was focused around the Southern Gulf Catchment area, of 214,000 square kilometers, which includes the catchments of four main rivers: the Norman, Flinders, Leichardt and Gregory/Nicholson. Many parts of the region can be isolated for long periods by rains and impassable roads during the wet season. Geographically the region is diverse with basalt and limestone ranges forming much of the headwaters, with rivers flowing out into vast grasslands and savannahs all the way to the coast of the Gulf of Carpentaria. The climate ranges from arid to tropical. The region is serviced by a rail line from Townsville on the eastern coast through to Mount Isa. Sealed roads service most of the smaller towns and Mount Isa, but beyond that all other roads are unsealed and of varying condition depending on use and seasonality.

Figure 3: Southern Gulf Region.[4]

The main industries are pastoral (cattle), mining, fishing and seasonal tourism. The region is both a major producer of beef cattle and a mineral province significant for its copper, lead, zinc and uranium resources. The population is just over 32,000. Mount Isa is the main regional centre with around 25,000 residents. Small regional service towns include Cloncurry, Julia Creek, Richmond, Hughendon, Normanton, Burketown, as well as Indigenous communities and Councils at Mornington Island and Doomagee. The nearest major administrative centre is Townsville on the eastern coast, which is a 10 hour, 906 kilometre drive away.

[4] Map courtesy of Southern Gulf Catchments Ltd

Twenty-eight percent of the regional population identifies as Indigenous, however this sector of the population was not interviewed for this research. To give a scale for comparison the area of Victoria is 237,629 square kilometers and has a population of over 5 million. This researcher lived and worked in the region for nearly 4 years, as CEO of a small not for profit natural resource management organisation which worked with the pastoral, indigenous, mining and government sectors on initiatives to foster and enable land management practices in the region. This role provided access to a wide range of landscapes, individual communities, government and industry sectors, policy and planning mechanisms and processes in a comprehensive context that has assisted in and was used in relation to this research. This experience and knowledge has assisted in the analysis of the research data.

The use of a case study was put forward by my then supervisor Dr. Jacqui Dibden, as a suitable method of inquiry that was both relevant, accessible and might provide information useful to the community. The region was chosen also because it was where I was living and working. I had access to transport and was known to many of the interviewees. To study any other region would have involved more travel than was involved in the study region itself. I have worked in a number of regional communities and brought to my research a depth of experience and knowledge that aided my analysis of the literature. I have attempted to remove any bias in the research. My selection of questions mainly focuses upon liquid fuel use, how energy is used and how and the nature of what price increases and shortages may mean for that community.

4.6 Initial Approach

I sent out 230 letters using the Southern Gulf Catchments Ltd database that included a cross section of the North West Community, but with an emphasis on the pastoral sector. The standard introductory letter as set out by the Ethics Committee was adapted and used, with only two direct responses back to me. It was later found that the recipients found the letter challenging and put it to one side; even those who knew me personally. My second approach in response to the poor result of the letter was to contact potential interviewees directly; almost all prospective interviewees agreed to be involved. I attempted, using my knowledge of the regional community, to seek a mix of participants who would bring a varying knowledge of the topic, size, scope and local geography. Twenty three face-to-face interviews took place over a period of 12 months in 2010/11. Where possible, I conducted face-to-face interviews at the home or workplace of the interviewee; although some interviewees chose to meet me in Mount Isa when they came on business or shopping. A small number were conducted via telephone hook-up. It is estimated that over 5000 kilometers were travelled to conduct the interviews, with one round trip involving 1500 kilometers. Much of this travel involved travel off main sealed roads.

I informed participants that the interview would follow a set group of questions; if they requested they were sent a copy of the questions prior to the interview. The same format of questions was followed for each interview but adapted appropriately to suit the background and interests of the interviewee. Through this I could collect consistent data across the sample group, which enabled comparison between

participants. At the commencement of each interview, I informed the interviewees of the interview conditions that I had initially set out in the letter of approach. I taped all interviews using a digital recorder and the interviews were later transcribed. Each individual was labeled with a code for both identification and anonymity. All findings in the thesis are written to protect the identity of the interviewee, especially given the small population of the community and because some descriptive content may possibly identify participants.

4.7 Selection of sectors

Groups were based around key sectors of activity in the region to provide a range of perspectives. These are not inclusive of the whole region but cover areas where peak oil effects would be significantly manifested and useful data could be collected. These also were spread across the region to incorporate any intra-regional variations such as location, access, associated industries and climate.

They are:

Sector	**Number of interviewees**
• Pastoral: Land managers producing beef cattle for the sale at market; •	**13**
• Local government: Spread across the region and represented by both Mayors and CEO's; NB: two LG representatives also were also involved in the pastoral industry.	**3 plus (2)**
• Government: Represented at both the regional and state capital level, including the then elected state representative and public servants; • Tourism: With regional tourism representative;	**4**
• Mining: Two interviews from mining company employees and one university academic with a mining research focus;	**2**
• General community: One interview from a general community member.	**1**
Total	**23**

Sectors were chosen to enable focus on areas that would specifically be subject to changes that oil vulnerability may bring, such as price volatility or shortages. Sector choice also allowed for the interviewer to follow identified themes, where the number of participants enabled cross checking of data. No one

participant could be viewed as being solely representative of their sector as there was a variation of methods, markets and geographic location, given the scale of the research region. I found that the response of the participants was open and relaxed. There was a willingness to provide information freely and honestly. I asked questions around the cost of running a business, but I felt it was not felt appropriate to ask about final income or matters of a personal nature.

As I had to approach participants directly there could be a risk of my biasing to those I thought may have a particular point of view. In many cases the participants were selected because they were linked to a particular role or location rather than who they were. This is particularly so in a region of vast area and low population. In general the participants were not well read upon the topic, some having heard of it, some having a better understanding than other, but many had not heard of the term peak oil.

4.8 Semi-structured interviews

The interview followed a set format driven by the structure and nature of the questions, as set out below. Whist in some cases the relevance of the questions to the interviewee varied, the format was followed as much as possible to ensure consistency of approach and allow comparison on analysis. In the first part of the interview process there was an emphasis on fuel use as the interviewer saw this as: (a) an area of key vulnerability, (b) a means of having a topic that was accessible to the interviewee because it was being familiar, (c) was non-confrontational, and (d) allowed the concept of how energy is used and was applicable to their lives, which could be drawn on and expanded during the interview. As mentioned above oil supply (and via that fuel) is seen as a given necessity and exploration of fuel use allowed for the participant to contextualise areas of threat or risk through discussion of use and consumption. In this situation care was taken not to lead but to allow the space for the participant to explore their own experiences and to evaluate those phenomena in the context of the interview process (Denzin and Lincoln, 2003).

4.9 Interview format

- Context
- What do you do/is your business/employment/role in community?
- Geographical scale of operation
- Nearest town/community
- Personal understanding
- What is your understanding of the issue?
- What is your understanding of the concept of Peak Oil?
- Fuel use in your life/business?
- Fuel use in your community?
- Fuel use in your beyond your region?
- What does it mean?

- How do you see it affecting you/your family?
- How do you see it affecting your community?
- How do you see it affecting beyond your region?
- Adaptation
- How will you adapt?
- How do you see your community adapting?
- Types of skills/indicatives possible.
- Role of local/state/federal government?

4.10 Limitations of the Research

The Southern Gulf region of North West Queensland is a vast area and is subject to regional variations in climate, geography and methods of production. It is therefore difficult to gain a truly representative sample from the number of participants involved, however it is felt the cross section provided is suitable for the level that this research was undertaken. Care was taken to see a spread of participants that has drawn out interesting themes and data. For example, whilst each pastoralist may have differing business and farming models there is a consistency of basic production methods in the business of raising beef enabling comparisons and identification of patterns and themes.

Whilst oil vulnerability studies have attempted to extrapolate potential effects of peak oil, very little work has been carried out that speaks directly with people in the day to day situations that would inform understanding to assist adaptation planning. As a result it is difficult to make comparisons with one community to another across a range of issues, such as understanding, impact and responses to change. In asking what the level of understanding of peak oil was for the interviewees, a benchmark comparison against other regions is difficult because that data is not known to exist. As this research is both exploratory and addresses an issue (peak oil) that is in general not fully researched this is not surprising and does make comparisons difficult. It is only possible to draw out potential vulnerabilities and, in such, cannot take into account the myriad of interlinked and dynamic variations of response and outcome that an event of this scale would have for such a community, both internally and externally. In such it is, as an exploratory case study, still of value in beginning to directly consider what this economic and social challenge may mean.

Further, in relation to the implication of oil vulnerability for Australian agriculture the local industry is predominately that of rangelands beef production, so the study can only provide a snapshot of how oil vulnerability will manifest itself. However, as this research is exploratory it at least provides a starting point for further such research and interpretation.

4.11 Analysis off research.

5.0 Policy

5.1 Introduction

Given the possible timeframes for either mitigation or adaptation responses, early policy identification of oil vulnerability will assist the development of government policy and possible responses. Dodson and Sipe note that where oil vulnerability policy is developed, "…innovation is flowering into an arid and hostile national climate" (Dodson and Sipe, 2010, p.293). This chapter looks at whether we are in any way closer to policy recognition of oil vulnerability. It attempts to answer the research sub-question: Does the Australian policy adequately address oil vulnerability?

This chapter revisits policy development since Dodson and Sipe's paper, *Emerging Australian planning practice and oil vulnerability responses*, appeared in the special peak oil edition of the journal the Australian Planner in 2010. It first examines current energy policy, followed by agricultural policy, and then considers how policy positions on oil vulnerability influence agricultural and rural policy frameworks. I focus in particular on policies that set directions for food production and security, and consider how this will be informed by oil vulnerability research or any parallel policy development.

Dodson and Sipe identify a range of challenges facing policy development around oil vulnerability, but note that these are in no way unique to this issue. These are that oil vulnerability awareness has arisen via fringe networks, comprised of retired petroleum geologists, "citizen-analysts" and the work of academic commentators publishing in the popular press. Alongside this small but rapidly developing commentary is a body of academic energy analysis that arose out of the oil shocks of late last century and has been increasingly strengthened in the last seven years by the introduction of oil depletion studies into academic research and peer reviewed papers. Assisting this further data analysis, if not consistently in policy statements, is the work of the International Energy Agency (IEA); especially in the area of the mapping and presentation of the current plateau of world oil production (International Energy Agency, 2008, International Energy Agency, 2010, International Energy Agency, 2011b). However this has not assisted either policy development or political acceptance of an issue that poses real political challenges in messages and philosophy for a growth based industrial society that is (currently) dependent on the continuance of both cheap and readily available oil and petroleum by-products. This tension has in part led to "… a petroleum security policy stasis in which obscuration or deferment of problem acknowledgement substitutes for the formulation of a response" (Dodson and Sipe, 2010, p.294). This places policy development in a weakened position, in a complex and often misaligned or crowded planning framework where issues and policy responses compete, cancel or confuse appropriate development. While this is understandable, it is a self-replicating dilemma and until oil vulnerability becomes more palpable, or is taken up by planners and politicians proactively we will continue to see policy failure and inaction. The failure of policy development to respond to oil vulnerability's ability to cause harm or at least social dysfunction is in part a failure to locate that engagement on the sphere of duty of care. In the arena of

finance, this could be considered in relation to a fiduciary duty. For duty of care this involves the requirement of policy to recognise future needs and aspirations of people and communities, not just structures, processes and/or ideological frameworks (Steele and Gleeson, 2010). Continued avoidance of policy development to clearly engage in serious analysis of the emerging literature around oil vulnerability or at worst actively discourage or suppress open policy discussion represents, however understandable, is a clear failure of responsibility.

The status, consistency and general accuracy of the central thrust of the argument for peak and depletion, now supported by clearer IEA data and academically rigorous peer reviewed articles, has meant that avoidance has increasingly become a deliberate act of self-limiting of awareness and recognition, rather than reasonable doubt and caution in relation to government, policy development. While this comes in part from an unclear or even overt denial of an appropriate "authorising environment" for policy discussion and formulation by leadership at both state and federal levels, it also arises out of philosophical frameworks, path dependency, fear of the difficult, fear of career damage and the human predisposition to see and present our concepts and depictions of both conceptual and physical reality in positive, optimistic and often emphatic terms. Policy development at best should aim, given reasonable knowledge and allowances for unforseen changes in economic, environmental and social circumstances, for a structure and set of principles and actions for what could be defined as societal good (Adger, 2003a, Barnett and Dovers, 2001, Graham et al., 2003). Where ideology or self-interest colours or directs policy, in the light of conflicting or difficult data, then policy runs the risk of failure, either significantly or incrementally (Crowley and Coffey, 2007). Given the long timeframes of policy direction, getting it wrong can have major ramifications and take a considerable period to adjust. An example is the decision to sell off Victoria's electricity generation infrastructure into private ownership. This has meant that in the face of increasing climate change and mitigation and adaptation responses, including carbon trading and the federal government's carbon reduction program, the ability for government through what would have been a centralised authority (in this case the State Electricity Commission) to write off inefficient assets such as the Hazelwood power station and carry the loss on the accounts as a demonstrable social good has been diminished. As Steel and Gleeson note, micro-economic reform has "… reorientated planners towards infrastructure projects rather than strategic visions, sustainable policies or plans (Steele and Gleeson, 2010, p.305).

5.2 Australian situation

Federally oil vulnerability has been the subject of one senate inquiry (Commonwealth of Australia, 2007) and has been referenced in only a small number of reports (Bureau of Infrastructure Transport and Regional Economics, 2009, CSIRO Future Fuels Forum, 2008, Dunlop et al., 2004b, Graham and Poldy, 2008). While the content of the Senate inquiry was comprehensive and the analysis sound, the report's recommendations lacked strength and failed, as Dodson and Sipe note, to have importance or power as a government statement (Dodson and Sipe, 2010, p.295). However, it was important in that it reflected one

of the first official considerations of the topic at the federal level; paralleling the Queensland State Government's oil vulnerability taskforce study driven by the then Minister for the Environment, Andrew McNamara (Queensland Government, 2007).

The Queensland task force study was compiled from input from various departments and of varying quality of analysis. Its main strength was that it provided a basis that gave some legitimacy (along with the content of the Senate inquiry) for public discussion of oil vulnerability in government and non-government forums; especially through the strength and clarity of its recommendations. In 2009 McNamara lost his seat and the work of the oil vulnerability strategy was taken up by the Department of Main Roads and Transport. Prior to the 2012 state election the report was sitting with Cabinet, officially reported to be awaiting the release of the federal government White Paper on Energy. With the change in 2012 from a Labor to Liberal government it is unlikely that the oil vulnerability task force study will be published.

Despite this official recognition of oil vulnerability, federal analysis remains restricted and is invisible in the 2004 energy paper (Prime Minister and Cabinet, 2004). Subsequent energy papers and supporting documents have almost actively avoided acknowledgement of the issue, including the An Assessment of Australia's Liquid Fuel Vulnerability (ACIL Tasman, 2008), and the subsequent and mostly similar liquid fuels vulnerability assessment of 2011 (ACIL Tasman, 2011), that informs the oil vulnerability analysis for the draft Federal government's Energy White Paper, 2011 (Australian Government, 2011a). The fact sheet published for community comment for the white paper mentions that there "… are a range of challenges facing Australia's energy sector in the period ahead" (Australian Government, 2011b, p.1), but fails to reference oil vulnerability as an issue of consideration in relation to future energy supplies for either Australia or globally. Most of the recommendations in the white paper are either reporting or administrative and do not send messages to the wider community that any energy supply situation exists in the near future. This is evident in the final white paper itself where the only references to peak oil and depletion are, primarily dispensed with in one paragraph. Drawing on the ACL Tasman 2009 and 2011 reports the Energy White Paper 2012, states that:

> The IEA forecasts that global oil production will continue to grow as conventional supplies are increasingly complemented by unconventional sources to meet demand. Physical production limits (so-called 'peak oil') are unlikely to be reached before 2035. However, rising oil prices and demand-changing policies and technologies could produce a demand-induced peak in production after 2020, depending on the strength of global climate change action. Should high oil prices be sustained, substantial unconventional oil reserves, such as Canadian tar sands, are expected to enter the market, sustaining global reserves for many decades. While oil will remain the main energy source for the transport sector to 2035, there will be increasing take-up of alternative transport fuels (Treasury 2011:62). There is also likely to be increasing electrification of transport and adoption of energy-efficient technologies (IEA 2011a) (Department of Resources Energy and Tourism, 2012) .

This fails to reference a parallel study by the same department, a national energy security assessment that identified energy security issues (liquid fuel) by 2023 (Department of Resources Energy and Tourism, 2008), nor Infrastructure Australia's A report to the Council of Australian Governments, that identifies the peak and plateau of oil production around 2013-15 (Infrastructure Australia, 2008). Supporting this is the fully developed study, Transport energy futures: long-term oil supply trends and projections (Bureau of Infrastructure Transport and Regional Economics, 2009), which included an executive statement from the Bureau's Executive Director, based on extensive analysis of world oil field reserve and production figures summarised in the report, that:

> Given the growth in deep and non-conventional balancing the shallow decline in conventional production, it is predicted that we have entered about 2006 onto a slightly upward slanting plateau in potential oil production that will last only to about 2016—eight years from now (2008). For the next eight years it is likely that world crude oil production will plateau in the face of continuing economic growth. After that, the modelling is forecasting what can be termed 'the 2017 drop-off'. The outlook under a base case scenario is for a long decline in oil production to begin in 2017, which will stretch to the end of the century and beyond. Projected increases in deep water and non-conventional oil, which are 'rate-constrained' in ways that conventional oil is not, will not change this pattern (Bureau of Infrastructure Transport and Regional Economics, 2009, p.V).

This report was withdrawn from publication and replaced with another report with the same report number (Bureau of Infrastructure Transport and Regional Economics, 2010). Access to the withdrawn report in full can still be found on the internet.[5] Given the scope, provenance and conclusion of this report it is significant that its findings were not included in the development of the Energy White Paper 2012. Further, the White Paper fails to include the work by CSIRO on future transport fuel supply, Modelling of the future of transport fuels in Australia (Graham and Poldy, 2008) that points to a significant challenge in supply and pricing of liquid fuels for Australia. Inclusion of these study's findings could have meant a change (or at least a questioning) of a key premise of the white paper: that there is no immediate threat to oil supply globally.

In the event of another oil crisis, say for example a major terrorist attack or a significant climatic event that impacts supply of oil products to Australia, or even a longer term supply constraint situation, the Australian government could invoke through the office of the Energy Minister, the Liquid Fuel Emergency Act 1984 (Cth) and the National Liquid Fuel Emergency Response Plan, supported by relevant State Government acts and policies. This Act however only deals with the potential for a supply disruption through the powers of the responsible minister in relation to rationing and allocation of petroleum. Passed in response to the two earlier oil shocks, and later reviewed and amended based on a study by ACL Tasman (ACIL Tasman, 2004), it

[5] http://www.aspo-australia.org.au/general/us-pressure-distorted-iea-oil-figures-says-whistleblower.html

neither addresses any future risk nor has the capacity to effectively deal with incremental, episodic or longer term oil supply constraints, price increases and the economic and social ramifications that would result. Actions are limited to the designation of essential users and control of fuel allocations as recommended by the National Oil Supplies Emergency Committee, made up of Commonwealth and State government officials and representatives of the major Australian oil retailers. Despite being a member country of the IEA, Australia fails to meet the IEA's 90 day supply strategic reserve requirement (International Energy Agency, 2011a, p. 12), relying instead upon stocks held within the oil industry and market place, often falling below a 90 day reserve. This presents a wider nation-wide oil vulnerability situation if global shocks or constraints limit available stocks for import into the nation and sufficient capacity within the supply chains are insufficient to meet both transport and chemical stock needs. The efficacy of a 90 day reserve as a mechanism for dealing with longer term supply shortages can be questioned. While it would be unfair to criticise this Act, as it arose in response to a particular event and is not designed for much beyond abrupt and short term supply disruption, it provides little capacity to deal with oil vulnerability as it will manifest itself in the future.

The white paper seeks not to move beyond traditional market driven responses, which see energy security in relation to liquid fuels, as:

> Our lack of oil self-sufficiency and the prospect of further refinery rationalisation does not in itself compromise or reduce our energy security (see Box 4.1). Our liquid fuel security is expected to remain high because of our access to reliable, mature and highly diversified international liquid fuel supply chains (Department of Resources Energy and Tourism, 2012, P. 53).

The issue of the potential for the imminent depletion of oil would challenge this position and that of:

> … the Australian Government believes that the practical set of energy security developments considered possible in the foreseeable future can be managed effectively using existing energy security mechanisms and market responses (Department of Resources Energy and Tourism, 2012, P. 58).

An acceptance of a possible supply crisis prior to the post-2035 date would necessitate a more active response and present a challenge to the policy position that market forces and structures would have the capacity to effectively deal with supply constraints in a timely, effective and economically positive way. However, it does set out some direction in relation to policy in setting a number of energy security actions, including:

- Undertaking a rigorous assessment of the costs and benefits associated with options to address Australia's 90-day oil stockholding compliance; and

This will include reviewing the NESA framework to provide a more quantitative assessment of energy security risks. (Department of Resources Energy and Tourism, 2012, P. 61)

This represents a move forward from the position of the draft Energy White Paper 2011 (Department of Resources Energy and Tourism, 2011) and without high-level signals for further analysis there is little incentive for other government policy to operate around this theme, or define a clearer authorising environment for public servants. State government policy development on issues of both global and national scale looks towards federal policy development both in relation to future directions/trends, but also for the national frameworks, state policy may have to reference or react to. Beyond state parliamentary responses in Queensland and South Australia (Parliament of South Australia, 2008, Queensland Government, 2007), and the yet to be released Tasmanian Oil Price Vulnerability Project, which do not form policy, no policy development has been initiated at the state level and certainly nothing that has moved beyond internal departmental documents. It should be considered that until issue engagement becomes unavoidable, policy development at both federal and state levels will be significantly constrained and reactive ((Dodson and Sipe, 2010, P. 297) note that regional/metropolitan planning has not addressed oil vulnerability. For example, in Victoria the Melbourne @ 5 Million (Department of Planning and Community Development, 2008), review of the Melbourne 2030 – planning for sustainable growth infrastructure plan (Department of Planning Community and Development, 2002) has no recognition of any potential constrains, whilst the South East Queensland Regional Plan, 2009 - 2031, does contain elements of oil vulnerability planning, including design, development and transport guidelines, its focus is growth and growth management (Department of Infrastructure and Planning, 2009). Regional plans are being developed in rural Victoria that, while recognising climate change as a driver for change, they do not contain formal recognition of oil vulnerability nor policy response. Regional plans in Queensland mostly do recognise oil vulnerability, mainly due to the past influence of the Minister for Environment, Andrew McNamara. These vary in form and content depending upon date of production and composition of the committees formed to draft them. For example the South East Queensland Regional Plan devotes a whole section*, 1.5* Responding to oil supply vulnerability (1page)(Department of Infrastructure and Planning, 2009, P.46) to oil vulnerability, the North West Queensland Regional Plan has scattered references and minor actions as do other regional strategic plans. These responses mainly refer to reducing fuel vulnerability and do not offer any form of internal planning framework for regional responses or action. With the change of government in Queensland it may be that planning reference to oil vulnerability will be further diluted.

Analysis of food supply chain resilience is similarly limited. A recent study of food chain vulnerability and resilience by the Australian government, Resilience in the Australian food supply chain,(Department of Agriculture Fisheries and Forestry, 2012), refers to shortage of fuel (diesel) for food distribution, tree times, mainly in reference to interviewee input, but does not further consider the risk of such a shock or potential causes. Whilst recognising the role of transport in moving food goods, the report offers little

analysis of fuel needs and use, nor the overall use of energy and hydrocarbon feed stocks in food production, manufacture, supply or consumption. A more recent report by the NMRA Motoring and Services organisation, Australia's Liquid Fuel Security, (Blackburn, 2013)identifies Australia's transport fuel systems fuel vulnerability (including the food supply chain), particularly in relation to vulnerability presented by Australia's failure to maintain even a ninety day strategic oil supply reserve. In both reports the issue of depletion as a future source of risk, the NMRA study does however recognise oil dependence in the transport and food chain supply systems.

Local government has led a limited but exploratory push into oil vulnerability planning (slightly less than 1% of total LGA's according to Dodson and Sipe (Dodson and Sipe, 2010, p.299), primarily in socially progressive councils, with no noticeable trend of expansion beyond this grouping and only two non-urban councils preparing such plans (Sunshine Coast Council, 2010, Hepburn Shire Council, 2011). This is consistent with oil vulnerability studies initiated by local and regional governments internationally (City of Portland, 2007, Krumdieck, 2010, Glilbert, 2006, Bloomington Peak Oil Task Force, 2009), totalling approximately 40 worldwide (2012).[6] While this provides a model for further regional oil vulnerability planning, these policies tend to sit on the sideline to mainstream policy and planning based on long term assumptions of continuing economic growth. However, they provide some analysis and activity that may inform responses for future actions and, being mainly community driven, may be categorised as bottom-up responses and initiatives.

5.3 Alternative models

Developed out of the counter culture and whole earth movements, in response to the oil shocks and the publication of Limits to Growth (Meadows et al., 1972), but without the psycadelic overlay, contemporary responses can be found presented in the transition and/or relocalisation movement, permaculture, and organics and in the writings of Trainer, Fleming and Hopkins (Fleming, 2001, Hopkins, 2008, Trainer, 2011, Odum, 2005). These writers point to a possible rural future where the need to reduce energy inputs for food production and constrained personal mobility lead to a re-localisation of communities, where a leaner, more economically constrained lifestyle is developed. These initiatives are focussed around ideas and activities aimed at locally re-sited food production and marketing, smaller and more personalised community based activities, farmers markets and a philosophy of a less consumption based lifestyle is necessary for social and environmental good.

Community interest in relocalisation and the Transition Town movements has seen growth across the United States, Europe and Australia, at a rate that is rapid, but as a percentage of the population it is still very limited (Bailey et al., 2010). While this transition, as driven by events such as oil vulnerability, for the wider community could be both difficult and disruptive, it ultimately does not mean a lower quality of life;

[6] From presentation to Grampians Regional Forum, Horsham, 2012

but rather one where values of community, connection and constraint may replace those of consumption and complexity. Indeed such a transition may lead to a revitalization of rural society in purpose, community and in the return of production and terms of trade back to the local producer and away from industrialised agriculture and markets. Communities and industries that commence planning and adaptation earlier will have greater resilience to change and will likely offer their residents and stakeholders a better quality of life. North writes in relation to the arguments of intentional localisers that, "[m]ore radical change is necessary (given climate change) and inevitable (given peak oil)" (North, 2010, p. 590); noting that models that developed out of the counter-culture responses to the oil shocks of the last century and to concerns about limits and the environment will offer responses to an energy constrained future. However North writes that, "… localisation will not happen overnight…"and that the "…stickiness of economic transformation…" means that change may be slow and difficult (North, 2010, p.590). In rural Australia the economic challenges faced through oil vulnerability may lead to a further economies of scale and reduction in farmer numbers as economic pressures, combined with debt, increasing average farmer age and climatic stresses push out smaller holdings; further reducing both rural population and social capacity beyond the larger and more stable regional centres. Whether a longer term repopulation of rural society, as if often presumed in peak oil writings (Goodstein, 2004, Greer, 2009, Heinberg, 2004, Holmgren, 2009, Kunstler, 2005), will occur is dependent ultimately upon the sustainability of industrial agriculture in a severely energy constrained future. As with past agricultural methods this may mean an increase in physical labour in agricultural production, but simply not enough research exists to identify whether this will occur.

While general oil vulnerability awareness exists in the not-for-profit community sector, in not-for-profit social and environmental policy it appears only as a footnote. For example the key 2010 policy statement for the Australian Conservation Foundation (ACF) only refers to oil vulnerability as "…future fuel, energy and water price increases"(Australian Conservation Foundation, 2010, P. 5). Inherent in many of ACF's policy directions, such as alternative energy technologies and energy efficiency, is an assumption of the need to reduce oil dependency, mainly in response to concerns around climate change, however it is in general a simplistic approach to a complex energy situation. ACF's model for a sustainable Australia, in not recognising comprehensively the issues of systemic fossil fuel (oil) use in our economy, the scale and time frames of eventual oil depletion and of EROI and linkage to GDP, misses the very point made by North, that peak oil makes more radical change inevitable. In its current form, ACF's policy response, albeit from a green perspective, is similar to government and industry policy development that may be aware of oil vulnerability, but places the policy lens to its blind eye. This is not inconsistent with policy statements from NGOs and community organisations across the board. Perhaps the only organisation in Australia that is directly presenting the issue is the Association for the Study of Peak Oil and Gas, Australia. However NGOs have their own set of factors that dictate policy framing, including value structures, path dependency, external funders and member expectations (Mautner, 2008) that make such policy shifts or developments difficult. It is likely that NGO responses will parallel those of government and industry in terms of

awareness and response till they reach a point where recognition of depletion is unavoidable due to price increases and/or supply disruptions.

5.5 Agricultural research and policy

This research found that there was minimal recognition of oil vulnerability in Australian agricultural research and policy. This was consistent with the findings of Dodson and Sipe (Dodson and Sipe, 2010) in relation to urban land use and transport policy and planning. References are scattered and infrequent. Where energy is considered it is in terms of usage, often as a carbon output, no consideration of changes to availability, cost or Energy Return on Investment are taken into account.

Key policy documents that could influence agricultural policy planning take their lead from policy directions set in the Energy White Paper, 2011. For example the National Food Plan green paper 2012 deals with future energy security via referencing the Energy White paper. The green paper states:

> On 13 December 2011, the Australian Government released its draft Energy White Paper to provide policy direction and help address future energy challenges, and provide confidence about Australia's future energy security (see www.energywhitepaper.ret.gov.au). This in turn will ensure there are adequate energy resources available for future food production and processing (DAFF, 2012 P.71).

Here potential energy risks for Australian food production are written away by a simple reference to the Energy White paper. Whilst the green paper recognises some difficulties in the future, both the limited analysis and energy understanding demonstrated points to superficial analysis of the situation:

> Remaining oil reserves are more limited but could be supplemented through new discoveries and technological advances including enhanced extraction techniques or coal-to-liquids or gas-to liquids.

and,

> However, the cost of energy is increasing, reflecting increased demand and rising production costs. The rising costs of energy will require food businesses to reduce energy consumption and move to low energy input production and processing systems (DAFF, 2012 P.70-71.).

Had the White Paper pointed to energy supply concerns in relation to Australian agriculture both researchers and funding bodies would have had clearer signals to develop research programs in response.

5.6 Implications of policy failure

Given that the exact flow on effects of this event, as described in this research, are both difficult to quantify in regards to scale, impact and timeframes as well as being little understood via direct research, assessments of vulnerability are difficult. Vulnerability can best be seen on broader scales as being in the realm of a failure to identify, consider, research, understand and formulate suitable, timely and active response measures that would enable society to better mitigate or manage risk and impact. At local levels it can be reduced to more measurable effects such as increased costs of fuel directly used in the operation of set business processes, services delivered or activities undertaken. However as none of these exists in isolation this form of analysis provides a limited basis for risk analysis. Individuals and organisations have in the study area made responses to past fuel price increases, but these were not formed upon the basis of a broader or longer timeframe based set of information, criteria or policy directions. In such they represent an often ad hoc and piecemeal response to immediate stimulus, although having the capacity to assist in future similar or increased pressures. For example, the purchase and use of more fuel efficient vehicles provides cost savings (after initial investment is factored), as it offsets possible future fuel cost increases, but only provides a very focussed response in terms of scale, timeframes and forward planning.

Policy presents to government, community and industry both analysis and direction for planning appropriate coordinated social, economic and environmental activities. For example, land use policy drives land use planning, hopefully sensible direction to state and local government in relation to land use schemes, infrastructure development and social planning. Timeframes and scales of activity are often long and large and have inbuilt inertia and are not readily responsive to change. Infrastructure developments may have high embodied energy inputs susceptible to changes in energy availability and cost which could lead to project failures and/or social perturbations (Tainter et al., 2003). Academic research and community input can inform policy settings, as is with the increasing peer reviewed papers around peak oil, however policy development can be supressed or hindered by a lack of, or even hostile, philosophical environment within government departments (Steele and Gleeson, 2010). Public servants and policy writers may have to wait for clear authorising environments to begin to even broach difficult topics. Until appropriate signals for research and policy development are available, Australia will be at increased risk of risk management failure in regards to this event and its ability to effectively implement timely mitigation and adaptation measures.

5.8 How is this manifested in case study region?

This thesis research identified within the community some awareness of peak oil and oil vulnerability but that this understanding was limited in understanding or acceptance of potential risks. Individual land managers or local governments had initiated responses to past fuel price increases but were not actively responding to any concept of future oil vulnerability. This took the form of changes to land and stock management, or vehicle type and use. On questioning in relation to government's role in relation to peak

oil/oil vulnerability nearly all interviewees saw it as a government responsibility (state and/or federal), but this appeared to be framed in the context of government's role in all such peripheral issues that were seen beyond individual or local control. Although oil vulnerability was referred to in the North West Queensland Regional Plan it was not raised in any interviews as a vehicle for furthering planning or planning development. It is unlikely in its present form that the regional plan would further oil vulnerability planning (Steele and Gleeson, 2010, Dodson and Sipe, 2010). Unless a clear policy signal is provided either at the federal or state level it is unlikely that oil vulnerability planning and action will occur prior to the time that either price signal or supply constraints of both drive increased local recognition and action. At that time local responses will possibly be more difficult due to the economic implications of this event.

5.9 How might local government respond

The potential economic disruption driven by both increased oil price and the implications of oil supply shocks will be felt particularly at the community level. This research thesis has both, through reviewed literature and the case study identified some of the possible changes and stressors. Local government itself, in being the tier of government closest to individual citizens and communities, will likely feel the most immediate impact. This will be both in the form of stress and outcomes manifested geographically and via increased demands for social services (community support) whilst at the same time facing increased operating costs (fuel, chemicals, bitumen, materials, etc.) and declining income through reduced rate revenue (via asset depreciation) and the possibility of government financial support (grants). This has been identified in the peak oil plans and strategies undertaken by a very small number of municipalities in Australia and overseas, but to my knowledge this has not be subjected to any rigorous research process.

Local government plays an active role both directly and via its various state associations in influencing and developing both state and federal policy. Given its close connection with local communities, both via its elected representatives and via its shire based programs and activities it is well positioned to receive, understand and promotes community concerns and aspirations. Local government has the capability to:

- provide 'grassroots' community engagement and activity;
- make local decisions and to deliver initiatives;
- influence both state and federal policy and planning.

Local government lacks the ability, except via agreed mutual co-operation, to make macro scale changes. There has been at the local government level the capability to develop and implement peak/oil vulnerability planning and risk management policies and documents, as identified above, which provide the basis for a more coordinated state and federal response, were this to eventuate. Those local plans and activities, if implemented and carried through, not only set a local policy direction, but add to local acquired learning that will prove very useful in practical situations as the social and economic changes that oil vulnerability will entail. However, as the level of peak/oil vulnerability risk planning (those LGA's with

specific action plans) is lower than 1% nationally and is not supported by a relevant research knowledge base, it is unlikely that will provide a significant resource at its current level of activity and possible timeframes.

5.4 Summary

The limited academic research on oil vulnerability in Australia is either primarily urban focused (Wight and Newman, 2010, Dodson and Sipe, 2005, Dodson and Sipe, 2006, Dodson and Sipe, 2010), or focused on energy and depletion (Mohr, 2010). Agricultural research and analysis is limited to referencing secondary sources that (a) do not accurately factor in the role of energy in relation to agriculture and (b) do not recognise oil vulnerability as a key driver of change (Larson et al., 2011, Dunlop et al., 2004b, Campbell, 2008, Baker, 2000, Beilin et al., 2011). Analysis may also be found in internal reports of government departments, such as the Department of Primary Industries, Victoria (Department of Primary Industries, 2007), but if and where they do exist, these are most likely to be internal documents with limited public (and likely internal) policy influence. This is not inconsistent with the state of broader policy development, however given the role of academic research in informing policy development, both sectors appear to be failing each other in terms of signalling needs and directions on this issue.

6.0 Findings of oil vulnerability from the case study region

6.1 Introduction

Very little work has been untaken directly within communities to assess vulnerabilities and attempt to gain both an assessment of peak oil vulnerability, community understanding and thinking upon adaptation at the individual level. This research through direct interviews with a (limited) cross-section of the community of the North West Queensland region and seek to build an understanding of what that future may bring for them.

It is difficult to categorically assess the regional understanding of this issue from a small sample, however given the cross section attained and from this researcher's knowledge of the community it is possible to draw conclusions that could be applied to the wider North West Queensland community. Care was taken not to skew participant selection to favour any particular understanding of the issue.

6.2 Understanding of peak/oil vulnerability

Each interviewee was asked whether they had heard of peak oil. This informed me whether it was known of as an issue and the level of understanding being dealt with. The responses were mixed and varied from absolutely no knowledge of the term or issue through to both knowledge of the term and its implications. Fourteen out of the twenty-three interviewed had heard of peak oil, mainly via the media or mentioned in reading they had done, such as National Geographic or the Times. Of those who were aware of the term,

understanding varied from simple awareness of the term, through to a good general understanding of the concept in terms of depletion.

Comments were however general in content, such as:

> *Peak oil is the point where the world's consumption surpasses the world's production.* (P6),
>
> *I've heard about the term talked about, but that's all. But I guess my understanding of what it actually means is limited. (*LG5),
>
> *I know that oil means a lot more to me than what peak oil means.* (LG3)

Responses in those who knew of peak oil ranged from concern (but with limited personal or community focussed response) through to awareness but with no actions in response indicated. One responded indicted their understanding as,

> *Oh completely limited and until, you know, it impacts either me in some personal sense or in a work environment, I couldn't see that changing, so.* (LG2)

This was an universal theme that ran through those interviewed that were aware of peak oil, that it was something of possible concern but was not yet having a significant impact to warrant significant risk management planning or changes to the way they went about their businesses or daily life, although in some cases (P6 and P7) it was informing part of planning and operation in relation to property management measures. However, it was generally expressed as an issue that was not well understood in the community, industry or the tiers of government. This appeared consistent across the sectors interviewed but the number of interviewees is not sufficient to make a valid assessment of this trend. It was generally felt that peak oil awareness out in the wider community was very small and was not influencing either personal or wider community decisions or processes beyond to general or direct fuel price increases responses.

> *Well my understanding is we don't seem to be too much, or too aware of it, of course producers and then I don't see too much awareness of peak oil as an issue at all. We seem more concerned about fuel prices than the availability of fuel…it's still about your fuel truck arriving, how much you pay per cents per litre and top up your tanks before Christmas, I mean it's still the basic level there.* (LG4)

None that had heard of peak oil indicated that they were actively increasing their knowledge and understanding of the issue or were likely to do so in the near future. However those who had made changes to reduce fuel use through changes in their business models were doing so in response to awareness of the costs of past higher fuel prices, regardless of whether they had heard of peak oil or not. Increased fuel prices and the associated inflationary costs were well understood by all the interviewees as presenting difficulties for their business and for remote communities. This was indicated as experience via

previous increases in fuel costs and increases in freight charges and goods purchased, such as cattle feed supplements (licks). For interviewees not residing in the North West Queensland region it was through observation, communication or an intellectual awareness of the issue.

All those interviewed in the government sector had heard of it mentioned, but not through any official government response or information process. This awareness may reflect both educational backgrounds and also access to wider information sources and networks. One government employee (G2) interviewed indicated he had heard of peak oil and had been reading about it. When asked how he would rate his knowledge indicated that *"On a scale of one to ten, maybe six, maybe seven; sort of aware of it but not an authority on the subject."* No formal policy recognition or process was identified that could assist regional responses, although regionally oil vulnerability is referred in the North West Queensland Regional Plan, with direct reference to peak oil in the draft plan that was removed from the final plan released.

6.3.0 How are oil based products used in their lives, both directly and indirectly?

6.3.1Pastoral sector

6.3.1.1 Properties

All but one pastoralists interviewed (nine) operated more than one property (between two and three) and the size, electricity availability, land type, location, distance between properties, climate, access to water and distance from population centres and distance from markets and rail loading points influenced production models and costs. Three indicated that they had borrowed funds to purchase second properties. Land type was identified as a significant factor in the operating model and cost of operating the property. Rough terrain, lower fertility (and fertility rates in breeding cattle), lower stocking rates, isolation and access to electrical supply increased production costs, especially at mustering times. Stock levels were reasonably consistent, the lowest 2600 and the highest 9500 head, while the rest ran from 7000 to 8000 head. This mix is consistent with the researcher's knowledge of the region, some property owners may have significantly more properties (six to nine) but the average is consistent with two to three. I did not approach large pastoral companies operating in the region to be interviewed. This decision was based upon my understanding of the difficulty of securing any authority to interview via the complex approval structures of those companies. I chose to focus on a cross section of family based businesses. All identified labour as their most significant operating cost, averaging around 20%, followed by fuel.

Pastoralist	Peak oil awareness	Property size (hectares)	No's of Cattle	Fuel use (litres)	% of business cost	No's of properties	Adaptive measures
P1	*Nil*	59,000	7000	25,00O	NA	2	Stock management
P2	*Nil*	20,000	6000	20,000	NA	3	Fencing to reduce cost of mustering
P3	*Had heard of it*	20,000	8000	36,000	15-20	3	None
P4	*Nil*	*7000 plus leased land*	7000	44,000	15-20	3	Fencing and water supply radial to assist bringing in cattle for mustering
P5	*Nil*	158, 000	11,500	100,000	20	2	Fencing, water
P6	*Yes, informed*	53,000		120- 150,000 (includes earthmoving business)	15-30	7	Fencing, telemetry, fuel efficient equipment
P7	*Yes, had read about it*	2600	38,000	9000	20	2	Fencing, water traps
P8	*No*	4000	125,000	10,000	20	1	Uses dams instead of pumping, sells stock regionally
P9	*Yes*	*9500*	98,000	30,000 Plus goats	20	2	Stock management, fencing, goat to control weeds

Table 2 Pastoral sector

6.3.1.2 Fleet types

Liquid fuel use in terms of types of activities that related to usage was consistent across the activities of the pastoral interviewees. Primary fuel use was diesel, followed by Av Gas (aviation fuel), and then unleaded standard fuel. Volumes varied depending on a range of factors, including property size, number and location of properties, landscape type and location, stock numbers, and methods of production. Nearly all properties ran a mix of 4 wheel drive vehicles both Tray and Cabin, light and heavy trucks, graders (or hired in a contractor), loaders, body trucks (carting cattle), and two and four wheel bikes. One interviewee operated earthmoving equipment on a commercial basis, but not consistently every year. Some operated larger articulated vehicles for carting stock and contract work. Some contracted out equipment ranging from a casual to commercial basis. Beyond a core fleet of four wheel drive vehicles and body trucks the vehicle mix depended on both location and land type. In more open grassland properties, which contain flat terrain with clear line of site and allow for easier mustering, two and four wheel bikes could be used; in rougher terrain, wooded terrain or hill country necessitated the use of helicopters. Country of poorer carrying capacity tended to be larger, increasing the cost of vehicle use.

6.3.1.3 Fuel use as a business cost

Fuels usage for properties varied between 9000 and 150,000 litres of fuel types combined. There was no average amount and depended upon property factors identified above. Each landholder interviewed was very aware of their fuel use and could comfortably state the percentage of fuel use against the total cost of operating their business. Although this could change seasonally the figures given were an average. The lowest indicated was 5-6% rising to 15-20% per annum. While interviewees were not asked of fuel use as a percentage of total profit, all identified noticing increased fuel costs as impacting upon the operating cost of the operation of the business both directly via fuel, but also in haulage costs/charges for stock and in consumables such as cattle supplements (Licks) or chemicals.

Most identified that increases in the price of oil increased fuel prices and this had ramifications for the viability of their operations.

One participant observed:

> *Yeah, when the price went right up, I tried to average it out, when the price went up, it went up to about 15…precent, it wasn't double.* (P1)

This was up from an average of 7 to 10% operating cost.

Others identified fuel cost as having ramifications for the ongoing viability of their businesses.

> *… if it (fuel price) were to double again, and say in our industry we were receiving approximately the same for our product, then it would even, it would wipe out our marginal profitability to the really efficient producers, let alone the marginal ones.* (P4)

Others identified that increased fuel costs would make some country less viable than other areas, especially the marginal producers. One pastoralist identified in relation to the historically low lease purchase price of that area that:

> *Everything, all your costs associated, fuels associated, 'cause you've got freight and everything, another 10% or 15% is going to make this country up here unviable I reckon. It's not…you know, this was traditionally cheap country but the running costs were always high compared to the better country, and yeah, the running costs just kept jumping and jumping 'cause of fuel; so it's made this country pretty damn expensive sort of country."* (P7)

Comments of this sort were common across those interviewed and while reflecting what could be defined as a risk aware culture of the agricultural production community they also reflect an understanding of the costs of inputs of their businesses and the essential role that fuel has become in the delivery of their operations, both before and after the property gate. Nearly all saw that the doubling of fuel price (with associated flow on costs) would make their businesses marginal to unviable. Comments were given in the context of the current price being attained per head in markets.

Understanding scale is crucial to analysing energy use in relation to remote Australia, in terms of both site and relational scale. Trips are measured mostly in hours, property size in tens of thousands of hectares, cattle numbers in thousands, stocking ratios are at levels that would see southern farmer's quickly bankrupt and social interactions often of increased importance due to infrequency, direct cost and a sense of place, purpose and isolation. Roads are often rough, at times (and for extended periods) impassable, travel costs more (vehicle and running costs) and getting things, to and from you, takes longer and costs more. It is a part of life in the outback and I did not hear any interviewees complain, but rather express it as a component of daily life. High fuel use is both a business cost and a factor of location. Transitions that may be possible in populations of higher density and economic and social distances may not be transferable to life in remote Australia.

Given the scale and diversity of the properties of those interviewed, variances in business models and methods of production, location from markets and population centres, availability of electricity supply, climate variation, levels of liquidity or debt or existing responses to higher fuel prices presented challenges in analysis. However there was a consistency in the general form of beef production in regards to vehicle use, transport of goods and stock, isolation and community as well as having an overall consistency of production type and methods that makes analysis possible and useful. The subjects are all beef producers, operating free range grazing models, in the same geographic region, selling a very similar product into a range of markets. Comparison of a beef producer in Victoria to a beef producer in northern Australia would find some similarities but also considerable variations in terms of energy use, markets and social and community geographies.

While similarities do exist, comparison between differing agricultural production types, the models, methods and markets vary significantly in terms of energy use both before and after the farm gate (Fleay, 1995, Kingwell, 2003). Direct research into farm fuel-use related energy costs is limited, especially in relation to constraints to energy supply (Proust, 2007, Land and Water Australia, 2008).

6.3.1.4 Mustering

Mustering was identified as a significant cost of production for most producers, however the amount was dependent on land type, property size and if stock cartage was included, location from rail head or point of sale, with significant fuel costs both in the operation of land vehicles, helicopters and in the transport of stock was incurred. A number of property managers identified differing techniques for reducing both vehicle and helicopter use as a means of reducing cost in mustering. These included using fencing to bring cattle closer to central points (yards), as well as cattle traps (fenced yards where cattle can enter but not egress) on water sources as a method of increasing efficiency of mustering and also in response to increased fuel costs. Those that used helicopters identified them as an expensive cost of mustering, using them to bring in cattle in country too rough for vehicles or to shorten the mustering time, thereby reducing labour costs. One interviewee identified that helicopter use had reduced his mustering time by half, and reduced his staff component to one quarter (P5). Changes in timing of *"bringing them in"* were identified, as was progressively turning off water supply to bring stock to a collection point. Interviewees identified that it would be possible to go back to using horses, but that this would increase the labour cost *"four to five"* times (P7). Most participants still had horses on their properties, but these were now used to supplement stock work, particularly in the rough country where vehicle use was limited and was often used to supplement helicopter mustering. While participants felt it would be possible to go back to horse based mustering, it was felt, both in interviews and general conversations, as difficult, mainly due to changed business models, loss of skills, willingness of vehicle accustomed generations to adapt and the need for more labour to replace mechanical efficiencies.

The shift to multiple properties, accessed via high speed vehicles, light planes or helicopters, as well as the on farm use of two and four wheel bikes, four wheel drive and tray trucks as well as the use of helicopter mustering, will prove more difficult in terms of access and availability of staff. An economic downturn caused by higher fuel prices may force employees out of mining and back to work on properties. However economic flow-on may also reduce markets as consumers overseas and at home respond to the inflationary costs as fuel price increases flow through the economy.

6.3.1.5 Haulage

No participant interviewed drove stock to markets, all using vehicular transport either via their own vehicles or by contracted commercial haulage. Haulage of both stock (to market and between properties) as well as delivery of goods was seen as a major cost and an area where an increase in the cost of fuel prices had had implications for the viability of their businesses. Distance was identified as a key factor, both for freighting stock to markets and

between properties and for the delivery of goods and food to the properties; although personal, educational and community orientated travel was identified as also being fuel use intensive, depending on distance from local and major community centres. As one interviewee identified any fuel price increase:

> *Hits us doubly, because everything that comes in here comes in by fuel-driven machine, you know, road trains and trains and whatever else, but mostly road trains now. The (rail) train system doesn't seem to be working well for our industry. And everything that goes out, goes out on high use fuel. So, we're sort of hitting on both sides of the line. (P1)*

Usage of cattle haulage was identified to be influenced by a wide range of factors, including seasons, drought, price of cattle per head, markets being sold to, number and location of properties, land type, family involvement in business (children working on property or properties) and the general manner in which they raised cattle and ran their business. Therefore it was difficult to specifically identify trends in freight costs except that all identified it as a significant cost of production and that they saw a direct correlation between the increase in fuel cost and the cost of carting stock, both directly themselves or via services offered by contractors.

Use of rail to cart stock was mostly influenced by each properties location from point of loading and markets (including point of slaughter) that they were selling to or through. Only one small producer sold completely locally, the rest sending to ports for shipping to live markets or to markets for slaughter in Townsville, Roma or outside Brisbane. All identified the rail as a preferred transport option (price) but also a range of issues or difficulties in using rail were identified. These included cattle loading difficulties and the perceived running down of the cattle train services (loading locations and frequency of trains, lack of interest in railway management in providing cattle freight services). Interviewees preferred rail as it was more of cost efficient and had less negative affect and upon stock as well as a general sense that cattle trains provided a very useful industry asset and service and should be supported. Cost savings were also listed as a benefit with one interviewee citing a saving of $20 per head in moving stock by rail (P4). However, generally rail is thought of being difficult to use (loading), slow and that the reduction in rail head loading points was a disincentive to use rail, pushing producers to increase their use of road transport. It was felt this increased road wear and usability.

Interviewees also universally identified that past fuel price increases had increased both the cost of stock haulage, via a fuel levy, but had also increased their costs in terms of haulage that they undertook using their own vehicles. Both formal and informal interviews with freight transport representatives identified that they had held off passing on increased fuel costs for a time, but eventually passed on diesel fuel increases as a surcharge to the customer.

One transport industry interviewee indicated that they added a fuel surcharge:

Yeah, when the fuel gets to I think it's $1.10 a litre we'd next to no surcharge but when it's up to $1.20, $1.30, $1.40 where the surcharge went up I think it went up to about 20 percent on the freight cost…we was upping the price we've sort of just keep handing it on but eventually, you know like I say they can't sell their cattle and put on a 20 percent for fuel to their buyers because their buyers will say stick your cattle up your jumper, we don't want them. (T1)

Pastoral interviewees felt they were price takers and had little opportunity to pass on cost of freight directly, their only options being to reduce inputs or via operating efficiencies. One pastoralist identified that the cost in the past 4 years per deck[7] per kilometre had risen from $1 to $1.60, which he felt was directly attributable to rising fuel costs (P4).

In light of increased fuel prices, participants (and expressed wider in the community) were concerned about the closure of stock routes. A number felt that if fuel became too expensive they could consider return to driving cattle along stock routes (as a last measure), with some expressing that it was better for the cattle (P4, P7, P9). As pastoralists mostly now ran more than one property, breeding cattle at one end of the catchment and fattening them up for market on a property usually at the other (land type and rainfall patterns be the predominant factor) restrictions cause by cost or availability of stock transport would present difficulties for this model, given the usual distances separating properties, over 500 kilometres not being uncommon.

6.3.1.6 Fattening up and local slaughter

Establishing a local meat industry was identified by some interviewees as a means of reducing haulage costs. If fodder could be grown locally then it would be possible to "value-add" to the local industry to enable the establishment of an abattoir for meat to be sold regionally and to be packaged and sold frozen to national and international markets. The region was cited as good for breeding cattle but not for "growing them up", for fattening. Sending cattle to fatten at another property (backgrounding) or sending to a feed-lot to increase condition and live weight were options for most interviewees, either on properties they owned elsewhere in the region, to other properties for agistment or to feed-lots to fatten before slaughter. Feedlots were identified as being well out of the region involving freight costs (P5, P7).

Whilst cattle prices were good, they felt they could manage the increase in freight costs. However, were cattle prices to fall and fuel costs to remain higher for an extended period of time, then this would present difficulties for all of the participants interviewed.

6.3.1.7 Water

Access to water is crucial to agriculture, especially for stock in hot climates. Fuel use varied depending upon the availability of electrical supply to properties and the depth of the water pumped. Two properties had no access to

[7] A deck is a level in a semi-trailer in which cattle are transported.

the Single Wire Earth Return (SWER) electricity supply line so were reliant on diesel fuels for electricity production via generators and for the pumping of water. This significantly increased their daily fuel use. Producers interviewed had where possible shifted water pumping across to solar pumps (where away from SWER lines) but all responded that solar pumping was not yet possible for anything but shallow wells or river pumping. Unless pumps using alternative fuel sources were developed with the capacity for deep pumping properties without SWER line supply were seen as vulnerable. Although a return to windmills could be possible it was identified as an expensive re-establishment cost (P5) and would mean a reduction in the ability to draw up the same volumes of water. One participant estimated that to use only windmills would mean a 30% reduction in stock numbers, stating that: *"…today our whole figures are run on numbers, you know, it costs a little more to muster 8,000 cattle than it does for us to muster four, very little, very, very little."* (P9) Clearly increased capacity to pump water and to drive to check and service pumps and troughs, has enabled both an increase in and a greater geographical spread of watering points in addition to increasing the volume of flow. Producers would have to factor in their capacity to weather increased stock watering capacity as climate change increases annual days of weather temperature over 35 degrees and related evaporation rates and changes rainfall patterns and amounts (Department of Climate Change and Energy Efficiency, 2012, Queensland Climate Change Centre of Excellence, 2010b, Queensland Climate Change Centre of Excellence, 2010a, Preston and Jones, 2006). Adaption measures may include increasing the numbers of bores (or deeper pumping), watercourse pumps or dams, but this will come at an increased energy consumption, both in terms of infrastructure and energy cost. Improved technology has increased the ability to provide and locate more watering points across the landscape, meaning an increased spread of stock (but not necessarily in increased numbers), with associated land use and environmental effects. Increased fuel costs will not necessarily reduce this where solar is viable, but will have impacts in areas where deeper pumping (beyond SWER lines) is involved.

6.3.1.7 Social

Interviewees noted that while the on property populations had been reduced, it was possible to access more events socially due to better roads and vehicles. Whereas in the past a number of community/social events may have been organised as one key event as to reduce travel, now people were inclined to drive to a range of single events. In the past events were often organised to maximise social contact around a key event. One participant (P3) spoke of:

> *… the major social event around when once a year you had a rodeo. Rodeo, camp, that sort of thing. And they would have been the major community activities, yeah. And normally the associated events that wrapped around the race meeting wasn't just the race meeting, there were ball before, balls after and blah, blah, blah.*

The camp drafts and rodeos form a key part of remote social life, more so than team sporting events that would require higher population densities and regular travel to site based venues. These activities were seen as

important in keeping the craft of the cattle industry alive and active and of use to help maintain skills that would be of greater use again if there was a move back to increased horse use in property cattle work. However, participants saw the cost of fuel as a potential hindrance to such social events with the number of events being reduced or limited in scope due to constraints of travel, given horse floats and large towing vehicles were involved.

> *I guess there's big fuel use in remote areas because you've got to go so far and you don't have public transport and you don't have options of, you know, people all sort of travel separately from every different area and it's hard for them all to travel together; you've got long distances to travel where you want to go, to the service centre. You've got long distances to cover to get to go on holidays, for schooling, to produce, to sell your product, so it's real, it's yeah, I don't think we've got much choice…. If we are going to live and work in these regions, fuels one of the biggest things we have got. (LG3)*

Generally it was seen that they would simply adjust their activities to compensate, given the rate of change was not too great. Most spoke of the increased capacity for electronic communication, either via telecommunications or internet and how that had reduced the sense of isolation, both in social connection and with family and neighbours; but also in the running of the business, in assessing market information, business improvement knowledge or the ordering in of materials, parts or equipment. Most were conversant with internet usage and all expressed frustration at the connection speeds available in remote Australia. Participants saw electronic communications playing an increased role if increased fuel costs were to curtail mobility. However, one participant felt that without travellers dropping in as they passed through his property the isolation would become intolerable. He said:"

> *…well it is, 'cause it's very hard to bloody get, you know if you've got a girlfriend or whatever, very hard to get them to move out here I'll tell….I think they like that shopping thing…I'd probably go mad here if someone didn't turn up every now and then and have a yarn to you… (P7)*

Intergenerational continuity and educational options for children were seen as an issue and often expressed regionally. Children were mostly schooled at home through School of the Air until secondary education was required, when children were mostly sent to boarding schools, usually in Charleville and Townsville. Tertiary education, depending upon course availability was either on the coast in Townsville and Cairns or south in a range of capital cities. The challenge of employment options for youth returning to the region, although a universal rural situation (Barr, 2005; Cocklin et al., 2001; Dunlop, Poldy, & Turner, 2004), is further exacerbated by isolation and employment options in smaller communities; although mining has enabled some wider employment opportunities for university educated returning residents it is limited to specific fields and skill bases with career paths often graduates to other locations nationally. One participant stated that of those children sent away for higher education, only around 3% returned back to the region. (LG2) Those who stayed on were likely to be those

to whom the pastoral industry was the primary driver and further education not providing the training required for the pastoral industry:

> *Yeah, depending on the passion of the younger generation. I think a lot of the younger generation that are out here, once they get past probably 23, 24, and they've been here and they've been trained in this lifestyle, they've usually got them, you know. They may, if their property's not going too good they may go and get a job in a mine, but within themselves they want to go back to that life. If you, and a lot of families have done it, they've sent their kids away to get a trade or you know, go to Uni or something, they don't come back those kids. Because they see a different life you know, and they've gone too early because it's crucial that they learn the bush, all the things they need to do in the bush, when they're learning at Uni. If you're not teaching them here now, by the time they're 24 they know everything and they don't... they don't know anything you know. (P9)*

This presents challenges to communities of exacerbating isolation and exposure to new ideas, and although it should not be viewed in a pejorative sense, it does limit the community's ability to integrate new concepts, learning and approaches that the outside education, exposure and capacity returning university graduates would bring.

6.3.1.8 Environmental management

The environmental improvement management model for northern Australia and the Southern Gulf region is mainly through better on-ground activities undertaken by land managers, pastoralists, mine lease holders and Indigenous peoples, via a model of cooperative engagement with government and non-government agencies. This can take the form of partnerships in which state and federal environmental funding is allocated to on-ground based activities in which the land holder/manager partners with the funding agency in a one dollar or two dollar for one environmental works contract. Woody weed control forms a significant part of on-ground management practices, along with fencing to land type, riparian fencing and education and adoption of sustainable grazing practices. Delivery is based in part around the land manager's capacity to match the financial contribution, usually the contribution of diesel fuel and labour. Whilst weeds control action is small compared to the scale of the problem without active on-ground control of weed and animal pests the environmental damage would be significantly greater than it is now and tip over to the point where much of the landscape becomes irreparably degraded. All of the pastoral sector participants identified any reduction in environmental activity on their part as having negative impacts.

As diesel is used as an extender and wetting agent for the application of weed control herbicide (often at rates of 60 litres of diesel to 1 litre of herbicide) as well as fuel use for site access and spraying vehicles. This was seen as a challenge in the future and an area of their budget that would be reduced or ceased if the cost of diesel became too expensive, and was expressed as a desired action but one that would be forced by business needs. Opinion

was divided on the amount of pressure oil vulnerability would palace on stocking rates and land degradation, some believing that costs would force higher stocking rates*:*

> *That's a big one if you get your interests, mortgages up too high and interest too high, instead of running 4,000 breeders you need to run 6,000 breeders to pay for those costs.* (P8, P9)

Although an alternative view was expressed that past experience with drought had taught land managers that pushing the land beyond its capacity in the longer term did not make sense.

> *I think the answer to that is we've been there with the property if it gets run hard, many years ago, through drought, through overstocking, and just through bad management, and to go back to that would be a mistake ….I think probably you'd have 80 percent of your land producers would be that way, because they've been through the tough times and they know that, …But the management is so finely tuned, and because the economics of it, if you run your place down you don't run any stock, you can't run any stock on it for two or three years, well you're in a bigger problem. (P9)*

One Queensland government participant, working in the arena of natural resource management commented that:

> *…people are going to be concerned about many many more things than NRM…like health and transport and farming…they will probably overwhelm concerns about NRM…So the question is to what extent can you afford the input when it comes to controlling weeds or to sort of managing fire or to supporting through extension and so forth landholders that are already struggling with people or oil constraint for the economic part of their business? So it will have very significant impacts I expect for NRM but you couldn't call them first-order impacts. (G2)*

It is likely that environmental management will be caught between pressures on government funding budget reductions and reduced land manger budget allocations for environmental work. While in some areas of Australia reduced economic activity may reduce environmental pressures, in the north where environmental work centres on controlling environmental pests, reduced environmental control will lead to increased degradation of land quality, which will in part mean reduced overall carrying capacity, leading to increased economic stress for property managers.

6.3.2.0 Local government and local government fuel use vulnerability

6.3.2.1 Location

Within the region there are six main Local Government Authorities (LGA), plus one Aboriginal Council at Doomagee. Distances within each shire are significant, each with one main township, with very limited population densities out on the pastoral properties except for mining sites. Five LGA's are located along the main east/west

road/rail line from Townsville to the Northern Territory boundary (Hughenden, Flinders, McKinlay, Cloncurry and Mount Isa), whilst Burketown and Doomagee are to the north in the Lower Gulf region. While all derive local employment and income from mining in some way, with some it is peripheral in form, with servicing the pastoral industry and tourism as the main economic activities, beyond road contracts.

Two of the local government participants had heard of peak oil/oil vulnerability but none were undertaking any active planning in relation to it, beyond the ongoing purchase of more fuel efficient plant as it came available in the schedule of equipment replacement. Responses varied between surprise and a belief that it would not present a major problem.

6.3.2.2 Fuel use

All councils ran a vehicle fleet mix of standard passenger vehicles, 4wd vehicles, various trucks (including rubbish collection) and various road making and repair plant. Fuel use was stated as being around 360,000 to 400,000 litres per annum where it was known, with half this being for road works councils were contracted to undertake. One participant indicated they used helicopter and light plane for road inspections during flood and the wet season and as well to transport isolated Councillors to meetings. All use air travel for staff meetings in Mount Isa, Cairns, Townsville, Brisbane and other capital cities, including Canberra. Vehicles were used to drive to intra-regional meetings, including Townsville.

Regionally all local government authorities tendered for and secured a mix of state and federal funding contracts for road work mainly within their shires. This provided a significant income stream for each, estimated to provide around half the annual income for the council and similarly offer around half the employment available within the councils. A participant with the Department of Main Roads indicted the annual budget regionally was $100 million with local councils securing around 60 to 70% of that amount. Locally Main Roads employed 140 staff, mainly in Cloncurry. All local government participants stated that their councils would be unviable, including the local townships, if the roads funding became unavailable. As one participant put it*, "It would be last person out…turn off the lights"* (LG5).) All were concerned about fuel price increases, noting that while previous fuel cost spikes had eaten into budgets, a longer-term price increase would cause difficulties, "*…if it had continued it would have had major impact*"(LG5). Fuel use was estimated to be around 20% of road contract costs and price increases post contract had to be borne by the contractor, reducing operating profit that is mainly used to maintain capital investments in plant and equipment.

One council was dependent upon diesel fuel for all electricity production in its two townships. Local travel (township) was mainly very short trips and fuel price was not seen as having a major impact on daily life; however it was felt it could increase the isolation, with outside travel around every two to four months. One participant felt that any increased fuel cost would be something that would be accepted, but that the frequency of travel and nature of that social activity would change and stated that:

I honestly think that wouldn't stop people driving. Even at five dollars a litre I still think people will still drive because they want their independence. (LG5).

Another interviewee identified that any decrease in travel would create significant social issues in the community, with most of the population on low incomes:

Costs went up. It would be significant; it would mean that people would get out less often, they wouldn't you know, be as comfortable going down to Mount Isa for their specialist appointments and those kinds of things. I mean I actually think we already see kind of like a little microcosm of it happening in the wet, and it's not about fuel cost or availability, it's just the fact you can't use it…. And we're so small and we're very susceptible to, and partly it's to do with the 70 percent indigenous and the way their family relationships work and the way one family won't speak to another, the hostilities that erupt over that; and then alcohol plays its part. But yeah, I think it would be incredibly detrimental because the sanity breaks you need.... (LG1)

6.3.3 Risk management

A small number of Local Government Authorities have developed some form of risk management planning nationally, no planning for councils has taken place in remote regions either locally or regionally (Dodson and Sipe, 2010). Whilst this may be due to a range of factors, including education levels, isolation from information sources and networks, it is also in part due to each LGA's focus upon employment and growth. Most oil vulnerability/peak oil planning and documentation has taken place in inner urban or rural areas with a "counter-culture" or progressive focus, where citizens and staff are more likely to research and consider challenging topics and responses. My conversations with regional leaders and planners found that they were not hostile to the concept of undertaking oil vulnerability planning, but rather that they had not had the appropriate signals or authorising environment, either from the community or from state or federal government to begin development. No local government authority in the region had undertaken or had plans to initiate any form of risk management or specific planning in relation to oil vulnerability.

Local Government Authority	Peak oil Awareness	Risk M'gt Planning	Population	Fuel use (Litres)	Main fuel use	Number of Employees	Adaptive measures (Current response)
LG1/LG3	*No*	No oil risk planning	827	300-400,000	Council vehicles, Road making plant	87	More fuel efficient heavy plant
LG2	*Had heard of it*	No oil risk planning	554	400,000	Council vehicles, Road making plant	51	More fuel efficient heavy plant
PG4	*Yes*	No oil risk planning	944	Not known	Council vehicles, Road making plant	80	More fuel efficient heavy plant
LG5	*Yes*	No oil risk planning	1 821	350-400,00	Council vehicles, Road making plant	92	More fuel efficient heavy plant

Table 3: Local government

6.3.4 Tourism

Despite the tourism industry's relative dependence upon transport and therefore significant potential oil vulnerability there is very little reference to it in strategic plans, research documents or web-based literature. The Queensland Oil Vulnerability Task Force report, considers both road and air transport, but does not specifically deal with tourism impacts. The Queensland Tourism Strategy: A 10-year Strategic plan (2006) vision for sustainable tourism in Queensland references oil vulnerability, specifically peak oil, noting that:

> As a transport intensive business, tourism is highly sensitive to changes in fuel prices. This is particularly evident in aviation, where rising fuel costs contributed to the recent increase in fuel surcharges to cover operating costs. Rising fuel prices are of great concern for Queensland destinations that rely on the drive tourism market. Drive tourism constitutes 75 per cent of all domestic travel in Queensland and is especially important to regional Queensland where up to 70 per cent of visitors arrive by car (Tourism Queensland, 2006 , p.20).

But it represents a lone reference within general publications and policy for tourism in Australia. Literature in relation to oil vulnerability's impacts on tourism is limited but important (Becken and Lennox, 2011, Yeoman et al., 2007, Becken, 2010, Becken, 2008). Study of the impacts of oil vulnerability on this region has not been undertaken and the main source of tourism research can be drawn from a recent study of visitor profile and satisfaction by Tourism Research Australia and Tourism Queensland (Tourism Research Australia, 2011), which did not cover the whole of the research area, covered five of the key towns in the Southern Gulf Region and is applicable to the geographic region as a whole. This found that domestic road touring was significantly the most prevalent form of tourism, eight in ten visitors were over the age of 54 years; seven in ten were travelling as couples; most tourists were retired. This combination was much higher in the region than in other tourism areas of Australia. Locally they were universally referred to as 'Grey Nomads' and were a very visible part of the key transport routes over a six month period each year. Over half the visitors reported an income of less than $52,000 per annum. While there was a limited amount of international visitors this was mainly formed by the backpacker adventure category, although some fly-in specific destination travel would occur but has not been identified. International traveller's often undertook local work when travelling in the region and tended to stay around 4 weeks. Nine in ten of Australia origin were self-drive, with a range of vehicles ranging from very expensive motor home type accommodation, a significant proportion of caravans through to single vehicles with camping gear. The international and predominantly younger market used use a range of vehicles from old cars, camper vans and bus travel. The increase in the use of badged campers such as the Wicked and Juicy companies has made the international traveller more visible. A number stop in Mount Isa and seek work prior to visiting mainly via the internet[8]. Of domestic travellers 6 in 10 were from interstate, mainly from New South Wales and Victoria and mostly from regional areas. Most visits were over seven days with the median trip length of 35 nights. This is consistent with the peak season of dry season, although a proportion (not identified) over-seasoned the wet along the coast, mainly for fishing at Karumba. The highest average daily spend was $90 per night and the lowest average $60 per night, but longer stays made it equivalent. Fuel consumed 27% of the budget, accommodation 17%, take-away food 13%, groceries11%, tours and entrance fees 10% and gifts 8%. Accommodation was mainly in caravan parks and roadside accommodation, with 64% staying at commercial parks and 30% using free caravan or camping next to the road and 23% using crown land or national parks for part of their stay;, although 25% also used a below 4 star hotel/motel with only 2% using 4 or 5 star accommodation in the region which is not surprising given the limited luxury accommodation options regionally.

Communities, especially the small towns in the region that do not have the economic input that mining brings, have improved local infrastructure in an attempt to attract overnight stays, or pass-through shopping. This has

[8] Based on conversations with staff at local venues, such as the Mount Isa Hotel. Work is secured prior to travelling, is usually short term, often with accommodation provided. Pastoralists will employ travellers for periods to deal with the shortage of local staff or for peak period. Some stay and marry into the community. One participant described it as "…good for the gene pool."(Personal communication, LG4)

involved the development of themed tourism projects (fossil discovery, outback experiences), street and town beautification, public art, water features, signage, undercover parking and the allocation of free van and camper parking (usually on an "overflow" basis when commercial caravan parks are full. This has created local employment and employment of travellers to each community, usually for limited periods as a form of income development for the next stage of travel. While regionally this income was seen as non-core, it was universally noted as beneficial, providing income mainly for the towns that would not otherwise be present. Local government has been adopting measures to attract regional visitors and encourage overnight stays, such as town beautification and free camping, but most planning is responsive and could benefit from research that better targets planning for future oil vulnerability.

A range of interview participants noted the benefit of tourism on the local economy, stating mainly that although they tended not to spend significant amounts regionally (beyond fuel), some take-away food and grocery shopping it was income and employment that would not otherwise be available. As one local government interviewee put it:

> *Tourism is important to our services and to creating a percentage of our jobs, but it's not…, we would get by without it. But the community wouldn't be as nice without it, you wouldn't have a lot of parks and gardens, nice caravan park, because caravan parks and nice motels are built for travellers; and I remember when we built that motel in x (town) that (Motel name), a fellow in x said to me this is too good for x; I said it's not for x, I said people in x don't need this motel, it's for travellers. So they're the ones that we would lose and...Creates a lot of jobs. Too right it does. And I think the community; all these communities are getting more and more reliant on it, and on the tourism trade, because it does bring a fair bit of money to the town. So yeah, you know I would say probably, if fuel was to double we would lose 60, 70 percent of our tourists….Yeah, but we saw it happen when fuel prices did go up a few years ago, it dropped off substantially straight away.*
>
> *Donald: … Do they spend much in town the tourists or is that mainly...?*
>
> *Participant: Not a lot. Not a lot of money. But what they do spend is money that we would never have had. So that's important. We need to weigh that up. (LG3)*[9]

Any cost pressures upon road based regional tourism will reduce this cash inflow into the region, decrease social contact beyond the immediate region and possibly lead to a move away from the investment in tourism related public infrastructure.

Little research exists upon the effects of fuel costs in influencing tourism activity and travel patterns. Becken et al note that:

[9] Town and business name removed.

> However, the results show that tourism is relatively more affected by high oil prices than most other economic sectors in New Zealand. There are two main reasons for this. One is that tourism is a discretionary activity (our model used an income elasticity of 2) and at times of lower incomes consumers are likely to reduce travel or substitute to destinations closer to home (Becken and Lennox, 2011 p.140).

Given the main percentage of tourism regionally is elder couples with an income below $54,000, composed of either pension, investments or a combination, they would have a greater inelasticity to rises in fuel costs (Becken and Lennox, 2011, Nicolau, 2008, Becken, 2010, Becken, 2008). The value of the experience will influence the decision to travel, but given it is generally a long-planned major lifestyle event of which location, distance and geographical conditions are a key factor in choice of destination, it may be that travel decisions will be based around managing fuel price, time frames of travel, travel patterns and discretionary spending. To date no work has been undertaken in relation to this, something that may assist both travellers and local communities best adapt to changes.

Long haul international (and possibly domestic) air travel was identified as vulnerable, depending upon the point of origin and income level (Becken and Lennox, 2011, Nicolau, 2008, Ringbeck et al., 2011). The Southern Gulf Catchments region sees very limited international fly-in tourism, as compared to the main remote destinations (Cairns, Broome, Alice Springs and Darwin) and will not feel the impact of the drop-off that oil vulnerability will bring to fly-in tourism based models (Moriarty and Honnery, 2008, Nygren et al., 2009, Tourism Queensland, 2006, Dwyer et al., 2009).

6.3.5 Emergency Management

Oil vulnerability was not identified as an actively defined issue for state or regional emergency planning, beyond the cost of fuel price increases for annual fuel allocations and costs. (G3) Budgets were determined upon known fuel prices but were hurt by subsequent price increases. This applied both to larger scale emergencies such as cyclones and floods, but also in the daily cost of administration and co-ordination of emergency responses. Past increases in fuel have had impacts on daily operations, leading to reductions in the frequency of travel to remote regions:

> *…one of my biggest expenses is fuel given the area that I cover so I have to weigh up the amount of times I can go to certain shires and certain distances based on what my travel budget is.* (G3)

This will alter the levels of communication and trust that is built through regular and sufficient one-to-one interactions, and while government officials may be able to conduct an increased level of meetings and communications via internet based technology, such as video conferencing, Facetime or emails, the transferability of this technology to the wider community space was seen as limited as the human interaction aspect of stakeholder engagement is built around face-to-face contact, the commitment shown through the act of visiting and the learning gained through travelling to, and expiring a location or situation. As one participant stated:

> *There's some things you can do by phone and some things you can do by video conference but there's nothing, nothing will replace face to face meetings; and particularly showing the communities that you are prepared to travel to them as opposed to asking them to come to you all the time. You really have to get out and about to understand the issues.* (G3)

Fuel increases also caused difficulties with operating costs for equipment, given its high fuel inputs (helicopters, heavy duty 4 WD vehicles, trucks, barges). These are estimated annually but are subject to fuel price increases that then, beyond specific large-scale emergencies have to be accommodated within the annual allocation,

> *… it was quite noted when the price did go up, the cost of running our helicopters nearly doubled; so, and then again our budget's only put out once a year so during that financial year if there is a large spike in fuel then that's going to eat out another part of the budget, we can't just find the money… We're not going to shut down our helicopters and say we couldn't afford to run them, but we do have to sacrifice in other areas to maintain the essential services. (G3)*

Most local government interviewees identified that the cost of emergencies were sent back to the state government, so increased fuel costs were not identified as a risk to their operational viability. However, the capacity for government to fund emergency recovery in a situation of oil vulnerability may be constrained as overall budgets shrink and climate change increases the frequency and/or intensity of climate events. Triage style prioritisation may not be considered an option at present, but may eventually become a matter of choice between conflicting priorities and political perceptions; and Burketown is a long way from Brisbane. In terms of the Liquid Fuel Emergency Act and associated processes fuel supply to emergency vehicles is a first order category. But emergency response extends much further beyond purely emergency vehicle use, although it is likely that once within a supply crisis situation an enhanced evaluation of needs would be initiated.

The capacity of sectors to respond to fuel price increases was identified regionally when higher fuel costs (2009) meant that local fuel suppliers and local government were not able to afford, or reluctant to hold, full capacity. This meant that in periods of extended (emergency related isolation) fuel supplies become close to running out.

> *The shire got isolated for three months at that stage and it became very very close to shutting down a multi-million dollar business (prawn fishing) because the supplier didn't have the assets there to buy a million litres of diesel at the going price. (G3)*

Whilst this research did not interview representatives from indigenous communities it was identified as a significant issue by some interviewees that communities may not have the income to meet the cost of buying in bulk fuel if prices were to rise significantly.

Increased fuel prices will impact upon the running costs of businesses and to some degree, government and the larger mining companies will have the capacity to meet those, but in a time of economic changes some smaller

operations may become unviable with temporary or permanent closure, as was seen with a number of junior mining companies regionally during the first part of the Global Financial Crisis. This could come along with changes in overseas markets (beef, seafood and mining commodities), and financial disadvantage to the self-funded retiree 'grey nomad' tourist sector, that will place further financial economic stresses on remote communities. Each community's capacity to adjust to emergencies will depend upon a wide range of factors, including the scale, nature and timeframe of that emergency, location, internal community cultural values and capacity, infrastructure and prior planning. However, as with long-term drought, the capacity of individuals to afford to maintain expenditure beyond the daily necessities as well as the positive focus necessary to actively plan and initiate (often expensive) preparedness may be increasingly challenged; perhaps at the economic and social margins first. An extended period of oil vulnerability related stress could see this moving further mainstream, especially if levels of community debt to equity are high and the value of assets fall. What the longer term impacts of price stresses may be is unknown, as no direct research in relation to direct ramification has been undertaken, and there is only limited comparative analysis for urban communities to draw upon (Dodson and Sipe, 2005, Dodson and Sipe, 2006). How communities will respond to such pressures is virtually unknown, but some assumptions can be drawn from other similar situations.

> *And any of those external stressors will have an effect; it's just another stressor on the community. If we throw an even on top of that, things will reach a breaking point before they would if everything was fairly harmonious. (G3)*

6.3.6 Mining

Mining is a high user of oil based products, mainly diesel for mining and transport. Regionally, depending on the size and the type of the mining operation (open cut as to underground) fuel use can be around 40 to 50 million litres per annum. (M3) Open cut mining is the most fuel intensive given the massive amounts of materials that have to be extracted and carted from an increasingly deepening pit. The trend is, especially as technology allows lower grades to be produced economically, towards super pits, larger in scale than previous pit mining. The viability of these developments may be challenged by oil vulnerability, at least in some locations. One participant working in mining research academia saw that:

> *People have for years talked about trying to move to an open or super-pit kind of thing like Kalgoorlie. The economics around that under a peak situation are surely constrained. The future of mineral development in Mount Isa I guess is fundamentally challenged by this issue.* (M3)

A different view was held by an energy specialist for one of the regional mining companies, in terms of fuel cost and availability, believing that mining's vehicle fleet could be readily converted to Compressed Natural Gas (CNG) in a crash program taking around 5 years. Mount Isa has a gas pipeline available that could have a CNG plant connected that could service the region. (M3) Higher energy costs both with oil vulnerability and via any carbon

pricing regime could make lower grades uneconomic, making areas considered for development no longer viable.(Giurco, 2010) Participants M2 and M3 both thought that energy cost had the potential to sterilise less economic mining provinces or individual fields. One participant stated,

> *Well, I guess, you know, as those costs go up, basically the costs of production go up and the cut-off grade goes up, and so the economics of mining starts to change, and so you take a higher grade cut on the ore…you leave behind a lot more ore. So you change the cut-off grades there, we're only going to mine down to one percent and anything below that just gets left in the ground. So if you can bring your cost structure down, you might drop your cut-off grade down to 0.75 or 0.8, and so what you're going to do is you sterilise resources…* (M3)

Mining operations in remote locations used a significant amount of Fly-in, Fly-out (FIFO) labour, although this was not always the case as Xstrata previously had a policy for its Mount Isa operation that the majority of the workforce was domiciled locally. However this did not apply to its Ernest Henry mine at Cloncurry, which is mostly FIFO. Participant M2 saw the cost of fuel for FIFO as an issue, but that Mount Isa's resident population making it less vulnerable. M3 saw fuel price less as a threat to mining, as labour was a necessary business input and that they would include into their operating models, it would simply mean that "*…it will change the economics approaches in terms of what gets mined*." This could have implications for regions and communities that are seeking to attract new mining ventures as part of potential economic development and while improvements in technologies may offset increased costs there will come a point where lower grade deposits simply become economically unviable forever.

All participants identified that there was little strategic thinking in the industry in relation to oil vulnerability. M2 felt that individuals might be aware of it, but that:

> *I don't think that it's part of strategic thinking of the mining industry. It's certainly part of technology development, so the various players that do technology research and development in the mining space, it's a part of their thinking so…I think it's a response to energy costs and great implications and the other I guess, inputs and outputs of mining. So it's not so much that they're thinking peak oil, they're thinking what are the costs of diesel; and how are we using energy onsite…So certainly in technology development and research institutions that those, the consequences I guess you call it of peak, the exacters but that's not being driven by really the industry saying 'oh peak's an issue', I would imagine a mine manager on a site wouldn't necessarily be thinking about it in those terms.* (M2)

M3 identified that oil vulnerability (beyond fuel efficiency) was not an issue his company was looking at, that *"… it's not on our risk register",* nor that it was a topic of discussion in the forums he was engaged with professionally.

Given the lack of engagement with the issue of oil vulnerability by mining companies, industry and research bodies there exists a reasonable chance that, given adaptation timeframes, mining will face significant stresses. Mining is subject to global commodity prices and any impact that oil vulnerability will have upon economic activity will potentially impact prices and production volumes. Mining and its communities could become squeezed between declining sales and increasing production costs. The Mount Isa minerals province, with its standard of infrastructure (rail, electricity, gas, townships and airlines) may be better suited to adapt and survive than mining communities in more isolated and lower grade resource regions. Shifts to reduce fossil fuel dependency may mean a move to increased copper demand both nationally and globally for alternative power generation and electric vehicles that could increase. This combined with the Mount Isa's well-developed infrastructure and resident populations could see it fair better than other mining regions.

6.4.0 How do they see it affecting their community and the wider region?

6.4.1 Adaptation

Ability to adjust will depend upon a range of factors, in part determined both by the rate and impact of change and adaptation measures taken in and by the regional community itself. One participant believed most would find it hard to go back to less mobile, lower energy use lifestyle and felt that the next generation would find it difficult to cope:

> *I think to go back to you know the access we had, even you know 20, 30 years ago, I don't think it would be acceptable to 90 percent of people in the bush, even of, even of older generations.* (P4)

However, it was generally not seen as an option to sell up and move out of the industry, living in the region and working in the cattle industry were seen as key attributes of their lifestyle and form of employment. Although this view was expressed from the position of the current standard of living, and is in part, framed from an incomplete understanding of what changes a transition into an oil vulnerability/peak oil event may entail. It was a strong sense of wishing to live in the bush, the lifestyle and business model and the sense of community that was felt would be stronger than any challenges that may come. Participants expressed that they would try and adapt rather than seek a less isolated lifestyle elsewhere. As one participant expressed it:

> *… people live out here because they love doing it; they don't live out here because they are close to Disneyland or something you know…. I think most people in the bush would survive….I think they would adapt. I think the, most people can adapt to a situation, but it'll be hard. It'll be very hard on them to do that, and I don't know if it will be better in the bigger centres though either … (*P9)

Past experience and a sense of practicality living in the bush were seen as both skills and attributes that would assist in adaptation and would be drawn on in response to oil vulnerability induced economic and social pressures.

*Well a lot of the skills you've got in the bush would you get you through are survival; you can survive because you've really got, well you don't, you know you can grow things, you produce a product you can eat, you've got water and soil, you can grow a garden, you know, you've just got to show a bit of initiative. You can go and bulk-buy food, usually because you've got bigger cold rooms and those sort of things, so you can go away and be very frugal. And sometimes it's hard for the people in the city to do that because they might only have a small house with small fridges and that sort of thing, even though it's there for them and if they've got to pay rent, that sort of thing, it, you know it can be very hard. (*P9)

Attitudes that would assist adaption to a crisis are common in remote communities, being reinforced through isolation and the ability to cope with large scale natural events, such as cyclones, floods and drought. Smaller population levels and the permanency (at least in non-mining communities) of local communities allows for localised and manageable scales of human interaction. People in general know each other or have a sense of being part of a general concept of the region, its community and a shared sense of outback living. While debt incurred to purchase further properties could present financial difficulties, property ownership was invested in families that had apparent solid equity in at least one property and in the smaller non-mining town house prices were low and home ownership equity is high. This may be different from the communities of Mount Isa and possibly Cloncurry that have sections of the community with significantly higher incomes because of mining which has enabled house prices to rise above the usual level for remote communities.

6.4.2 How do they see themselves, their community and region adapting?

The capacity for adaptation in the region is influenced by a number of factors, including the extent of (if any) pre-preparedness of communities to have in place planning and mechanisms to respond to oil vulnerability. While individuals can make personal/business decisions that reduce fuel use or increase adaptability, they are still to a greater extent vulnerable to wider global, national and regional levels of preparedness. A pastoralist may, as many have, change their business models to reduce fuel use but will still be vulnerable to any increased freight charges, market changes or collapses or simply their inability to reduce sufficiently their fuel usage (or other business costs to offset) to maintain the viability of a beef production business. Factors such as debt and repayments and any decrease in the valuation of properties will become increasing issues if the ability to service debt taken on to purchase second farming properties cannot be met.

This will be an issue for all rural Australia, not just Northern Australia (Cocklin et al., 2001, Lawrence and Gray, 2000, Lindsay, 1997, Lockie and Bourke, 2001, Lockie and Higgins, 2007). As farming populations continue to age and the number of farms reduces, rural communities may see initially a consolidation of properties into larger holdings, as those who cannot weather oil vulnerability stresses sell to those who can. This could lead to a further reduction in rural populations and the overall viability of those communities. This may occur if fuel supplies

become significantly depleted and no suitable form of replacement supply or technology is developed, forcing primary production models to change to lower mechanisation and more labour intensive forms.

The capacity to initiate measures on a community basis, beyond the on property management measures as previously identified, is limited by the level of recognition by the general community of oil vulnerability as an issue of significance and immediacy of concern. As identified both through the interviews and my four years spent in the region, oil vulnerability as an issue sits as a low level of concern with no active planning at a strategic level. Focus is on the promotion of economic activity that will lead to increased jobs and income in the community. Attitudes and planning was not therefore positioned regionally to encompass consideration, except peripherally, of an issue that fundamentally had its basis in changes in energy availability and cost. Consideration of the need for any response measures as a result was virtually non-existent beyond individual private or organisation responses to increased fuel costs, such as the purchase of more fuel-efficient vehicles or mustering methods.

Many of the participants felt that state and federal government had a role in providing some form of leadership, but it was unfocussed and most interviewees did not raise it themselves but only in response to related interview questions. No specific activity by local government was identified, either in relation to oil vulnerability planning or active oil use initiatives, beyond generally replacing vehicle technology with more fuel-efficient forms available in the market place. This level of active awareness and planning development is consistent with the observed level of oil vulnerability preparedness at the local government level nationwide (Dodson and Sipe, 2010). However the lack of clarity, combined with contradictory policy signals federally, makes it more difficult for state planners, government officials and local government representatives to initiate responses. Local government participants indicated that there had been no guidance offered by their representative body, the Local Government Association of Queensland. The release of the Oil Vulnerability Mitigation Strategy and Action Plan, which was being prepared by the Queensland Department of Transport, should provide direction for communities to begin planning responses to oil vulnerability; however it is unlikely that this will be published given the change of government in Queensland.[10] Recognition at either a state or federal level through the development and publication of high quality analysis and planning development is a key tool for local government and communities to gain traction on this issue.

[10] At the date of writing I have been unable to find any current reference to the status of the Queensland Government the Oil Vulnerability Mitigation Strategy and Action Plan. Given it was a priority of the previous Labor government it is unlikely that it will be given any priority by the current Liberal/National party government.

Sector	Ability to adapt	Vulnerabilities	Fuel use	Economic vulnerability	Isolation	Environmental factors	Adaptive measures
Pastoralist	Flexible, self-reliant	Increase in fuel cost and flow on implications, decline in beef markets	15 -20% of business cost, essential to operation of business	Susceptible if have debt from purchase of other properties	Roads, cyclones	Drought or floods reducing income	Fencing and traps to reduce mustering costs, could go back to droving cattle to market
Local Government	Good community linkages, ability to lead local adaptation	Decline in income, increased social cost, no risk planning in place	15-20%, Main consumption roads contracts	Income loss via reduced road funding, lower rateable income, increased fuel costs	Cost of provision of services, community less mobile	Climate change leading to increased costs due to intensity of cyclones, flooding and heat	Ability to implement community wide planning and response Linkages to state and federal government
Emergency Management	Essential service, government support	Reduced ability for travel, increased community vulnerability to deal with, increased costs of service	Not identified, increased price leading to reduced community travel and direct liaison	Government funding, budgets may be reduced but will still be seen as essential	Cost of provision of services	Climate change increasing severity of events	Telecommunications, building community self-reliance and resilience
Mining	Deep pockets, engineering capability	Willingness to face economics of issue, path dependency, reduced price of resources	Not identified, possible increased cost which make some resources unviable	Economic impacts reduce capacity for change	Often mining in remote locations	Has capacity to manage most environmental costs	Conversion to CNG in a 5 year crash program
Community	Smaller communities have ability to work together	Failure to recognise event, economic implications	Lower fuel use in smaller towns, distance travel costly, cost of freight of goods in increases	Loss of local income, changes to 'Grey Nomad 'tourism	Freight costs, reduced travel between communities	Cost of managing events such as cyclones increases, capability to maintain fuel stocks	Local food production, ability to foster local purpose and social cohesion

Table 4: Vulnerabilities

6.4.4 Summary

The communities covered by this research thesis have the capacity to respond to oil vulnerability impacts perhaps more effectively than larger more resourced communities. Given the small scale and interconnectedness of the communities, a good level of inbuilt physical capacity (equipment, housing, electricity and rail), experience with periods of disruption because of drought, flood and cyclones and a sense of self-reliance combined with a skills base built up from daily life in a remote and at times difficult environment; they should be able to respond in a comprehensive and cooperative fashion. Further research, knowledge development, information transfer, strategic risk management planning and community development ahead of oil vulnerability impacts would significantly assist community adaptation.

7.0 Conclusion

The case study of the Southern Gulf region, an isolated and diesel fuel dependent region in northern Australia, has revealed some potential social transformations that the event of peak oil will have on other similar oil dependent communities in the near future. The imminent peaking of global oil supply presents a clear challenge to the availability of energy dense liquid fossil fuels that provide inputs for industrial society, agriculture and transport (Murray and King, 2012). Globally we will need to adapt to these changes in energy stocks and flows in both timeframes and ramifications that are current, significant and mostly unavoidable. One of society's challenges is the recognition that we need to significantly improve the understanding of the energy future we are entering (Poldy, 2003). Through a better understanding of the differing energy characteristics of hydrocarbon fuels that assist in the economic activity of our industrial society, how they are related to the ongoing functioning of that economy, and the timeframes for the eventual depleting of those fuels stocks, we can better build pathways to adaptions to change and disruption. This is true of the small community of my research thesis and to the wider Australian society.

A body of research and analysis has developed around this event and is drawn upon in this research thesis. It looked at the role and use of energy in our industrial society, analyses the physical characteristics of energy resources and use in relation to available net energy (or Energy Return on Investment) and its relationship to economic activity. It presents a challenge to classical economics in identifying a direct linkage of net energy to economic activity as measured as Gross Domestic Product, the concept that technological development will always meet increasing energy needs and that continued resource and economic growth will be possible into a resource and environmentally constrained future. Contemporaneous limitations to the availability of fossil fuels present a further challenge to the notion that economic and physical growth will continue beyond a period of decades. This raises the question of what that energy constrained future may involve and what pathways for response may be considered and developed. Emerging studies into the peaking of global oil supply and the possible dates for the eventual trend over the current production plateau have brought increased clarity, if not recognition, of the event by assessing available data and presenting scenarios that will inform policy and community awareness; although this may not happen until the effects of such a change become palpable and tangible.

However, research and policy development globally into the onset of peak oil and its effects upon our society and its economic systems are very limited. This research has assessed the state of existing research and literature, identified research and policy gaps through a review of the current literature relating to the peaking of oil supply, the literature around net energy and its linkage to economic activity, energy use in agriculture and then looked at how that may affect rural Australia. It also reviewed the state of peak oil, oil vulnerability policy and policy development in Australia. In part it explored this through a case study located in North West Queensland. A qualitative methodology was employed through a series of interviews within a range of sectors that revolved around questions about peak oil awareness, fossil fuel use (mainly

diesel), their own and their communities oil vulnerability and how they saw themselves and their community responding, including how the perceived government's role in any adaptive measures. Participants were open and responsive to the issues raised, even if they were previously unaware, and were generous with their time and information.

The results of this research have identified that the literature points to the potential for significant and continuous decline in the reserves of both available conventional and non-conventional oil sometime in the second half of this decade. Further, the results indicate that the peaking of oil supplies will have significant economic and social ramifications, and the potential for mitigation responses through fossil fuel or alternative non-fossil fuel replacements are significantly limited by their timeframes, scalability and availability. This will have economic ramifications that are complex, economically negative and very poorly understood. Both academic research and policy development are barely responsive to this challenge, because of a poor or negative authorising environment established by all levels of government (in Australia) to assist in policy response. This suggests a significant governance failure (Steele and Gleeson, 2010).

That the peaking of oil supply will occur, either because of above ground constraints such as infrastructure or geopolitics or the below ground constraints of geology, is mostly now no longer contested; there is general oil industry acceptance that we are now somewhere at the peak point or plateau of production (International Energy Agency, 2008, International Energy Agency, 2010, International Energy Agency, 2011b, Fantazzini et al., 2011). However, there exists variance in acceptance of a timeframe for the point and rate of decline once production moves off that plateau period (Maugeri, 2012). Initial analysis in relation to peak oil, although by experienced industry analysts, was constrained to grey literature and reflected a partial but developing approach and interrogation of the issue (Campbell, 1997, Campbell, 2004, Deffeyes, 2001, Duncan, 2003). Research has increased and now points to a depletion roll-over from plateau into terminal decline in production volumes occurring within an estimated date range later this decade. This thesis research identified that this literature points to a date in the timeframe of 2012 to 2020, with a depletion rate of approximately 4-6% per annum. While this event will not be verifiable until the data is assessed after the event it is believed that further analysis will both tighten and confirm this depletion roll-over phase. Further, this research analysis identified literature pointing to the poor likelihood of replacement sources of non-conventional oil significantly mitigating that decline rate due to limitations in available field size, recovery rates or timeframe, scalability or the economics embodied in the EROI of these resources.

Modern agriculture is fossil fuel use intensive, both in on farm use for fertilizers, pesticides and locomotion, but also in post-gate usage via a myriad of related support industries, long chain production and supply chain systems as well as a range of domestic and international markets. Review of the literature identified that internationally, and especially in Australia, there is very limited analysis of the role of energy in agriculture; it is viewed as a given, being available, affordable and substitutable into the future. Academic

and policy consideration of constraints in relation to fuel supply availability, to fertilisers and chemicals, on delivery and food manufacturing (including vulnerabilities inherent in the just-in-time, long chain systems), as well as economic disruptions to existing, developing and potential markets, is consistently absent. Further, there is virtually no research in relation to the implications for rural communities if fuel supplies, for example, become constrained. Existing literature around rurality encompasses a range of perspectives that interrogate structural changes in rural society, including globalisation, population reductions in smaller towns, increased farm size leading to less individual farmers, the aging of the farming population, and the reduced services through centralisation of delivery; but in this analysis the role, cost and availability of energy is invisible and given. Rural communities have some measure of mitigation and adaptation responses available; however the limited level of energy related analysis will hinder adaption and responses as the effects of depletion begin to be felt in agricultural production and the rural community.

Policy analysis is similarly limited, perhaps because of the absence of a clear authorising environment from both federal and state governments. While there has been past enquiries into peak oil, these have failed to provide the necessary policy frameworks and landscape to provide a clear mandate for further interrogation of this topic. Despite a limited period of focus upon oil vulnerability in Queensland, any willingness to respond appears now to have dissipated with the change of government in 2010, and with no indication of the fate or publication date for the oil vulnerability strategy work previously initiated. Federally, the policy environment is dominated by the dismissive approach taken, via the ACL Tasman oil vulnerability studies (ACIL Tasman, 2008, ACIL Tasman, 2011), that although acknowledging the possibility of peak oil, place it comfortably beyond 2030 allowing its avoidance in the development of the draft Energy White paper (Australian Government, 2011a). The development and removal of the study of the global oil supply projections that found a likely roll-over depletion date of 2017, raises questions about the willingness of either bureaucracy or politics to address the situation (Bureau of Infrastructure Transport and Regional Economics, 2009). That leaves policy development mainly active in the area of local government, through council specific vulnerability responses, involving less than one per cent of Australia's local government authorities and very limited application by rural and remote councils (Dodson and Sipe, 2010).

Academic research of oil vulnerability is also limited globally and nationally and only involves individual researchers, a scattering of studies and a number of individual papers, mainly focussed around urban planning. This represents a significant gap in our understanding of the nature and complexity of the event that will make strategic planning and adaptation initiatives much harder as society begins to feel the effects of constrained supply. Research that interrogates the topic and builds rigorous analysis will, as is happening with climate change research and policy development, build a body of work that can assist measures for mitigation and adaptation. It is very likely that this will not occur until the supply constraints focus attention

on the topic, weakening the ability and benefit that prior research could bring to understanding how oil vulnerability will manifest itself.

In the case study area of the Southern Gulf of Queensland the research found that individuals were making business adaptations to prior or anticipated oil price increases, notably diesel. This was limited to individual property based initiatives and was not expressed as an adaptation response in the wider community collectively. The situation of effective leadership and appropriate signalling from all levels of government was seen as a hindrance to the development of risk management responses. The understanding of the issue by participants, beyond specific fuel use in their particular businesses or organisations, presented a limitation to the methodology in relation to the perception of future risks and adaption responses beyond that of their immediate control. This limited the scope of discussion around this topic, but also pointed to a potential level of vulnerability and strategic planning risk. In itself it highlighted further areas for further research and adaptation activity.

This research identified some awareness of, but limited understanding of, oil vulnerability. This was balanced in the pastoral sector with primary producers' good understanding of the energy use in their own businesses. This was reflected in a detailed understanding of their own energy usage, from the practical perspective of its use in the operation of their businesses of rangeland cattle grazing. Here their primary vulnerability was identified in the amount and cost of diesel fuel. Given the nature of their agricultural activity, the size and remote location, fuel represented a significant energy input and business cost. This was identified both on the farm property and post-gate in significant relation to stock and materials costs. Participants identified that they had begun to initiate measures for reducing, where possible, fuel use, mainly through changed land management practices, including stock management and mustering, water pumping and helicopter and vehicle use. However they felt that they were price takers and were vulnerable to price increases as they had limited options to pass on costs. All noted that recent increases in the price of oil had meant both higher fuel prices per litre of diesel and other fuels purchased, but also increased costs in relation to goods and services, such as stock nutrient supplements, chemicals and stock transport. Participants identified that they saw that a prolonged doubling in fuel price would see many of them go out of business, whilst prolonged higher prices would make some country regions unviable, at least for the smaller operator. Many identified that they had purchased second properties to expand and introduce flexibility into their business model, but that had meant a higher level of debt to service and increased operating costs as the properties were usually distantly located from each other to make use of climatic and land type variations.

Participants identified that reduced levels of energy consumption were possible but that this may mean a reversion to a more isolated lifestyle, where travel was not frequent and stock transport in part reverted to the use of stock routes and greater reliance on the now under resourced rail system. Whilst it was identified that this may not be acceptable to some in the industry, it was mostly felt that they would stay in

the industry for the lifestyle and the sense of self-reliance. Few felt that the industry would fold, but that it would face significant challenges adapting to energy costs. However this capacity to adapt is based around current energy use and a limited experience in what a transition to a constrained energy situation might entail.

Principle vulnerabilities for local government directly were seen to be in relation to fuel costs for operations, especially around the provision of road construction and repair services, a key source of government income for local councils. Beyond this issues of isolation, cost of living (transport costs for food and goods), and the potential for changes in and possible reduction of loss of 'grey nomad' tourism income were identified. A key vulnerability for local government, given its central role in both local and regional planning, is the lack of key signals from both federal and state government that oil vulnerability is a matter of both concern and immediacy. Participants felt this was unlikely but also were constrained by levels of awareness, understanding and acceptance of any potential oil vulnerability, especially given the growth based focus and thinking inherent in government at all levels. While state based local government associations could play a role, this was noted as absent.

Fuel vulnerability of communities in periods of crisis, such as cyclones, was identified as a key emergency service risk. Higher fuel prices had already created actual situations where local businesses could not afford to purchase and hold the reserves in storage for the period of local isolation. This meant that state government emergency services had to provide extra fuel supplies into those communities at those times. Increases in fuel costs were also seen as a vulnerability to regional emergency budgets, especially in relation to the day to-day-stakeholder engagement and management requirements of staff. Reduction in travel to communities, while teleconferencing could in part facilitate communication, was seen as lowering levels of engagement, trust and communication that could be detrimental to effective responses. It was felt by participants from both local government and emergency services that key emergencies would be funded as required by government, however in a globally oil vulnerable situation it may be possible that income for emergency services may be restricted, especially at the lower population peripheries.

The number of participants in the mining sector was limited, but for one key mining player in the region, oil vulnerability was identified as not being a risk management planning concern. It was felt that in relation to direct fuel use vehicle and plant conversion to CNG was possible over a five year crash conversion process, especially as the region had a supply of gas via the east to west pipeline servicing Mount Isa. Despite air transport's reliance on oil based fuel, this was not seen as a risk to the fly-in fly-out model as mining would simply meet the cost as part of its general operating costs. Participants however noted that oil vulnerability would mean that marginal grades of minerals would become uneconomic to produce and that oil vulnerability had the potential to "sterilise" prospective mineral regions. However the Mount Isa region was seen as having advantages in relation to its local residential populations, strong infrastructure, communications and gas and rail infrastructure.

Universally participants were responsive to the possibility of peak oil and oil vulnerability because diesel fuel use factored predominantly in their daily lives and they had felt the economic impacts of price increases. Overall however, it did not register as a key risk to them mainly because their knowledge and understanding of it was generally limited, reflecting a general and wider community situation. Resonating through the interviews was a strong sense of both individual and community self-reliance and capacity, in part a product of the regions isolation, climate and local industries.

Absence, if not active denial, of any near term oil vulnerability recognition and response from our national policy frameworks and documents creates a vacuum in which the authorising environment to legitimise constructive dialogue, research and planning is absent. As Dodson and Sipe acknowledge federal policy is "….captive to a view that there is either little of concern in global energy markets or that concerns can be allayed by the bounteous energy resources held by Australia" (Dodson and Sipe, 2010 P. 300). In part, as identified in this thesis, this reflects a strong neo-classical economic concept that (a) energy is a smaller component of the economic structures of society then in reality is and (b) that price and technology will lead to new adaptive responses that will enable continued energy use and growth. That the nature of depletion and EROI is not taken into account is reflective of the failure of both economics and policy development to link into and understand the disciplines of geology, environmental science and resource based physical engineering. A clear recognition of Australia's oil vulnerability (both in the rapid depletion of our indigenous reserves and in the economic ramifications that peak oil will bring) would enable a more open discussion of what that means to our society and how we may progress towards adapting in whatever form.

As this appears to be politically a too difficult task for both federal and state governments it may rest with local government initiatives. Here there exists this opportunity given this tier of government's closer proximity to community and their concerns. However, so far both nationally and globally the development of local peak oil/oil vulnerability plans has been very limited and located mainly within councils that are urban or have populations with a higher socio-economic and educational demographic. A non-inner urban response to this issue are virtually non-existent and while scattered mentions to peak/oil vulnerability may be contained in some rural council sustainability and climate change plans this is very limited. That they exist however is the basis for building an overall framework for response. Here local government associations could play a role in coordinating both research and planning as well as presenting the issue further in the policy and political discussion at the state and federal level. Politics often waits for clear signals from community before taking active stances on social issues. In matters of the scale of peak oil/oil vulnerability local communities lack the skills and resources to definitively analyse both the emerging depletion situation and may see it as a global problem that is suitably the domain of the federal government and will await a strong high level response and directional framework. In this we are caught in a classical Catch 22 situation that will likely see no resolution until higher oil prices focus and drive

attention and politicians are forced to pay due attention. By this time it is very possible that global society will be at a point in the global depletion curve where the inescapable laws of physics and oil field depletion ensure that response measures become increasingly difficult.

It would be sensible to have in place a suite of research findings that can better inform society and planners on how best to respond to both the energetic and economic world that those response measures will need to respond to. Given the almost complete absence of research and analysis into oil vulnerability the development of a comprehensive research framework that first investigates and analyses what oil vulnerability will entail and engender would be crucial. This would involve analysis of the:

- global oil supply and depletion situation, including Australia's own supply scenario. This would include volumes available, timeframes and possible supply constraints. This should involve a comprehensive analysis of global oil depletion trends along the lines of the withdrawn BITRE study (Bureau of Infrastructure Transport and Regional Economics, 2009). Supporting this should be an assessment both of Australia's indigenous oil supply and strategic risks, especially in a time of global depletion
- what this would mean for society economically, looking at the direct linkages between energy use, energy return on investment and the possible impacts for our global and local economy
- what adaptive measures (taking into account environmental considerations and impacts) may exist to mitigate energy supply shortfalls (significantly liquid fuels, chemicals, fertilisers, pharmaceutical and plastics) as a transition measure to a lower net energy use society.

Beyond that it would be crucial to initiate research the impacts of what a rapid transition down the back of the oil supply (and subsequently other fossil fuels) production curve will mean for our society. This could entail in key areas analysis of:

- energy inputs to industrial agriculture, what depletion would mean for agricultural production and how agriculture could adapt
- transport and communication options and alternatives. How could society keep connected, active and engaged in an energy constrained future built around a liquid fuels rich transport structure and system
- methods for building community resilience and social cohesion. Elements of this in a nascent form can be found in the transition movement, permaculture, elements of the counter culture movement and in some local government peak/oil vulnerability planning

The above points are included only to set a general framework for research development. Any research should ideally flow out of a risk management analysis that identifies key areas of focus to identify significant vulnerabilities and emerging trends that would assist policy development and possible and appropriate action. Cascading from that would be analysis of energy vulnerabilities across key sectors, with

emphasis on principle areas of economic activity and vulnerability. That research could then provide the basis for more targeted and specific areas of research around energetic, economic, environmental and social factors.

For example, in relation to the case study area for this research thesis, a fuller understanding of the effect oil vulnerability will have on the 'grey nomad' self-drive tourist base, is in itself a fascinating social science study, that could inform planning regionally about possible changes to visitor numbers and their travel and spending patterns. This could assist local communities in developing local measures that build community capacity; both to plan for any changes and provide for timely responses where possible. Similarly, the pastoral industry, given its high diesel fuel use, both pre and post-gate, as well as its significant long term economic inputs to the local community, could benefit from a comprehensive study of energy use and vulnerability as well as possible adaptation measures. This should be a matter of primary concern for the beef industries sector organisations, such as Meat and Livestock Australia. Local government should play a front line role in relation to community planning and responses, but is poorly serviced by information that could assist both local and regional planning from an oil vulnerability perspective. Whilst some mainly urban oil vulnerability studies exist, both nationally and internationally, local government would benefit from comprehensive research that both tests and informs many of the assumptions contained and provide a better knowledge base to assist adaptive responses in times of change. This could come from local government associations. Although there has been some limited recognition and awareness of the effects of oil vulnerability on remote communities, it has been inadequate given the likely significant effects and short time-frames involved.

In general any further research will add in some form to further understanding of what will be, and how we can attempt to manage, the energy constrained and oil vulnerable future of which we will be a part. Academia has to date played an undeveloped role in this task with limited work by a range of scattered and committed academics. It is not recognised in any tertiary curriculum as a key discipline, theme or serious area for both research funding allocation and actual research. The one exception is the work of the Global Energy Systems Programme of the Department of Earth Sciences, Uppsala University, Sweden[11]. This program has its emphasis around global energy supply, primarily fossil fuels and depletion but does not extend beyond this primary focus. Compared to other key societal challenges, for example climate change, an event of this impact is barely acknowledged and understood. The value of this research is not diminished whether the depletion period or roll-over commences towards the end of this decade or two decades hence; just the immediacy of our response measures. Universities, agencies and research funding bodies that initiate this research will not only be providing an extremely valuable societal good, but also will have information, understandings, skills, tools and product that will be globally needed, sought and valued.

[11] http://www.geo.uu.se/research/global-energy-systems/?languageId=1

Greatly increased and targeted research will provide valuable information for the development of policy at all tiers of government. At the community level it could assist local governments in the formulation of effective adaptation strategies and plans. This may then increase the ability for local government to influence policy development at the state and federal levels, possibly through coordinated action via the state based local government associations, such as the Municipal Association of Victoria and the Local Government Association of Queensland. Given the timeframes identified in this research it is possible, if not very likely, that neither research or policy response will be conducted in time to make any significant contribution. However, as depletion drives price and supply changes focus upon this issue may drive activity.

To conclude, it is fair to say that my time and research in this region leads me to believe that the Southern Gulf community will adapt to oil vulnerability, but given its high dependence on diesel fuels, local preparedness planning and adaptive approaches will better build resilience and reduce localised hardships. Given the almost complete absence of research, especially in relation to rural communities, it seems unlikely that any significant resources will be available for communities to draw upon. Adaptive planning may develop at the local government or regional levels, as is happening with individual council peak oil/oil vulnerability plans; however this will likely be piecemeal and will lack connection to state and federal government policy positions. Further research around oil vulnerability would assist understanding and the validation of oil vulnerability discussion, and in the development of a wider authorising environment for government policy discussion. Government recognition and action in relation to peak oil and vulnerability would send signals to, and in cases provide the necessary authorising environment for, communities and local government to begin the discussion and planning for change and stress. However, this is unlikely prior to stronger price signals globally and further into the peak oil event itself. Therefore local and regional communities may have to begin this process in earnest prior to any significant federal or state political response. Further research, however fragmented, will greatly assist understanding and inform planning actions. Or we can continue to say everything will be alight …won't it?

It is hoped that the findings and recommendations of this research may in some small way assist.

Appendix 1

Research aims, research questions and interview questions.

Research Aims	Research Questions	Interview Questions
What is the community understanding of oil vulnerability? That is how they view energy security and how it relates to their lives, especially given the remoteness of their daily lives.	How does the North West Queensland community both use energy in their business, community and daily life?	Personal understanding Your understanding of the issue Fuel use in your life/business Fuel use in your community Fuel use in your beyond your region
What changes do they see this will bring to their lives and community? What is their level of understanding of energy and how it relates to their lives?	What they think it will mean for them and their community?	What does it mean? How do you see it affecting you/your family? How do you see it affecting your community? How do you see it affecting beyond your region?
What capacity has the North West Queensland community to respond and adapt to changes brought about by Peak Oil?	How do they think they could/should respond?	Adaptation How will you adapt? How do you see your community adapt? Types of skills/indicatives possible. Role of local/state/federal government?

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