

Delivering Air Power through the Next Great Energy Transition

by

Wing Commander Mia Clapton

An Air Power Seminar given at Canberra on 21 July 2016

In the coming decades there is a reasonable likelihood that the global supply of oil will be insufficient to meet growing worldwide demand. There is a growing consensus that the world is now embarking upon a great oil transition, which is likely to have serious implications for a civilisation fundamentally reliant on, and structured for cheap and abundant oil-based energy. Some researchers suggest that the oil transition could give rise to oil shortages, volatile oil markets, economic dislocation, international geopolitical strife and an increase in the militarisation of energy security.

Australia relies on the global economy and geopolitical stability for its continued national security. This global dependence ensures that Australia will not be immune to the effects of the oil transition, and the country's energy security may well decline as a result.

In support of national security the Royal Australian Air Force is required to deliver air power effects for Australia's interests; an energy-intensive activity almost completely reliant on oil-based liquid fuels. Air Force's ability to achieve its mission will be affected by the oil transition in a variety of ways during the period 2016-2035, but the risks are currently poorly understood.

As the Chief of Air Force Fellow, Wing Commander Mia Clapton has sought to address the current gap in understanding by reviewing the relevant literature and analysing Australian Government and Defence policy. Her study has identified that the oil transition presents a classic risk management problem, and where national security meets energy security, Australia is vulnerable. Similarly, Australian Government policy fails to address the link between economic security, energy security and national security. Importantly, the study concluded that declining energy security will challenge Air Force's ability to achieve its mission in the coming decades.

Wing Commander Mia Clapton

WGCDR Mia Clapton is an Aerospace Engineer with 21 years of service with the RAAF. She first became interested in energy security whilst posted as a RAAF F/A-18 Hornet Technical Liaison Officer with the United States Navy in San Diego, California. The Air Attaché in Washington DC sponsored her to attend the 2010 USAF Energy Forum, where the focus was on energy as an operations enabler. Her essay titled *Energy Security as a key challenge for Air Power* earned her a Highly Commended in the 2010 CAF essay competition and personal encouragement from then Air Marshal Binskin to continue her research on the subject.

In 2014, WGCDR Clapton was awarded the Chief of Air Force Fellowship and she spent the next two years undertaking research for a Masters of Philosophy on the subject of energy security and air power. Her thesis titled *Delivery Air Power Through the Next*

Great Energy Transition. Risks to the Air Force Mission from Declining Energy Security was submitted earlier this year and she is nervously awaiting the outcome.

Wing Commander Mia Clapton: Thank you, Sir. A couple of announcements: First, this is my own research. I'm certainly not representing Air Force point of view here, or Defence point of view. This is just my point of view. So I just want to say that upfront, right at the beginning. Also, I'm a little bit croaky today so I'm sorry if my voice deteriorates as we go through. I'll do my best to keep it, keep it coming.

Cheap and abundant energy has fuelled the rapid economic growth around the world since World War II. The enormous supply of energy that we have available to us has enabled civilisation to reach a level of complexity that we couldn't possibly have imagined just a couple of generations ago. It's fundamentally transformed how we've structured society, our economy, governments, our lifestyles and even our warfare.

Yet there is now mounting concern that there's insufficient resources to meet the global demand as we go forward. The growing consensus among academics is that we're embarking on a global oil transition and this has serious implications for a society that is fundamentally reliant, and structured for, cheap and abundant energy.

In the past decade, the global focus on energy issues has increased and this is mostly because of volatile oil prices, threats of terrorism and then political instability in energy-producing countries. Energy security has quietly slipped into discussions about energy and into the governmental policy around the world.

So when I talk about energy security, it's difficult to actually say what the description of it is because everybody has a different point of view about what energy security is. But if you look at the literature, most seem to go for these three components:

- Availability, meaning that energy is available to the end consumer;
- affordability is, to some degree, whether it's high or low prices, that the consumer can afford, but also we need to consider the volatility of energy prices, because highly volatile prices make it difficult to plan, and
- reliability, because energy services need to be reliable to the end consumer and they need to be free from disruption.

So that's energy security.

This declining energy security during the oil transition presents threats to national security that I don't think are particularly well understood at this stage. When I'm talking about national security in my research, I'm looking at these three different aspects here. Firstly, economic security is the growth and health of a nation's economy and that's considered paramount by governments in terms of economic security. Geopolitical security is required for the nation to thrive in the global economy and military security is the nation's military's ability to protect borders and interests abroad from physical threat. National security also depends on the ability of Air Force to deliver air power affects for Australia's national interests. Delivering air power affects is a energy-intensive activity, that is almost completely reliant on oil-based liquid fuels.

So the problem as I saw it, when I first started this research, is that the Air Force mission is completely reliant on available, affordable and reliable access to liquid fuels that are derived from oil. The risks presented by declining energy security during the oil transition are currently poorly understood. My research intended to start to bridge that

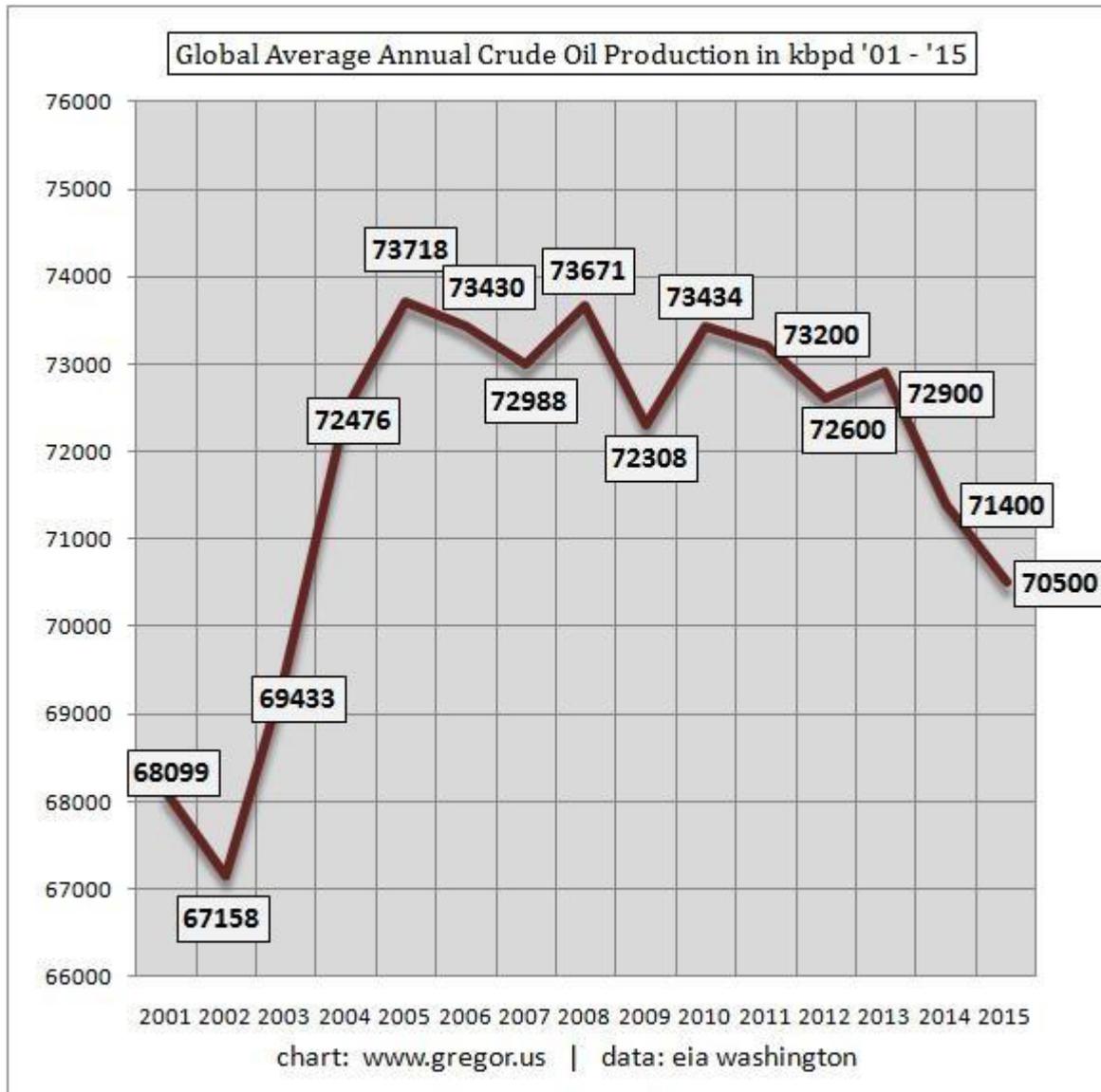
gap. When I first started researching, I thought I was going to look much more at the tactical operational level of Air Force and how fuel and energy security impacted that. But as I started researching, I realised that there's a large gap in the literature at the more strategic level, so my scope shifted accordingly.

What I've done in my research is to look at the context of the oil transition—what is the oil transition and what might be risks to Air Force as a result? I also reviewed the academic literature to see what's being said and had a look at Australian Government policy and Defence policy to see whether those risks had been identified. And today you get an hour's worth of what I managed to research for two years. It's very condensed. I'm going to skip through it quite quickly and happy to take questions at the end.

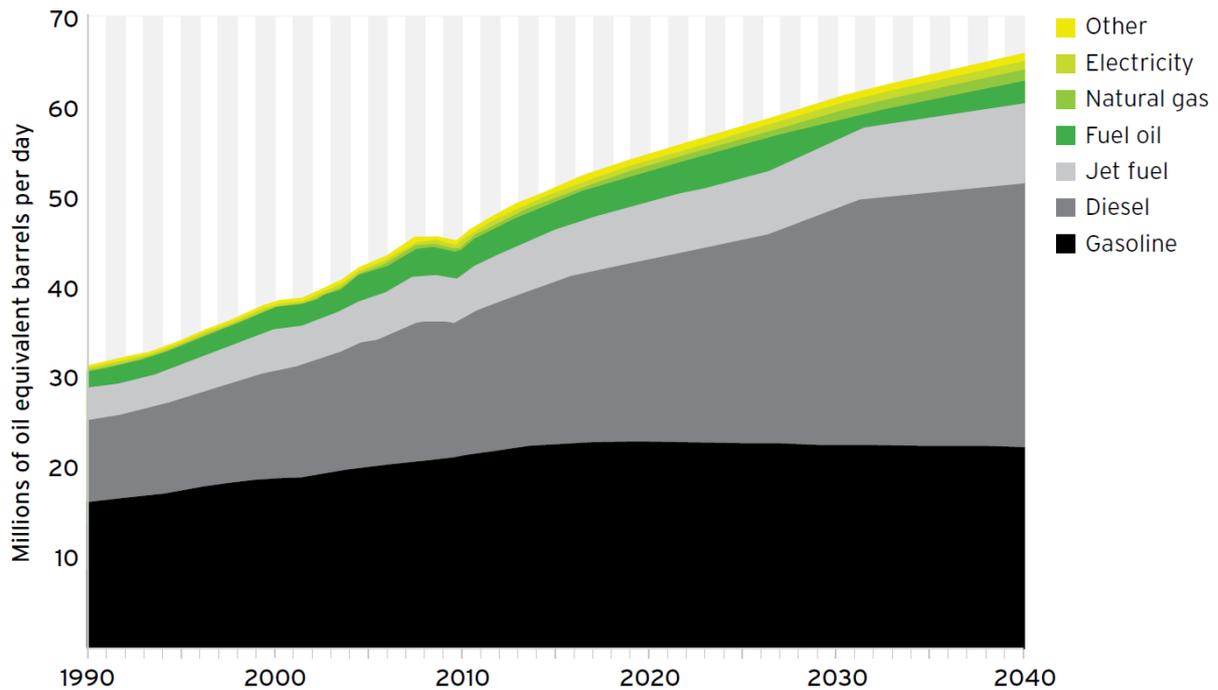
Global oil transition—what do we mean by that? Oil is a finite and non-renewable resource. As it's produced, i.e. taken out of the ground and used to power vehicles and the like, the quantity that's left in the ground is naturally depleted. In the 1950's, there was a Shell geologist, M K Hubbert, who developed this concept of peak oil to describe how conventional oil production will grow, reach a maximum—which is the peak—and then gradually decline to zero. So peak oil doesn't mean we run out of oil. It simply means that production of oil that comes out of the ground is limited and the rate at which production is growing starts to decline. So naturally, as oil is depleted from older, mature fields, new fields need to be discovered and brought onto line to ensure that the global demand is met.

The geological aspects of peak oil are well understood and are not in dispute. However, there are some above ground factors, which make predicting the rate of oil production difficult. There are factors that relate to technology, to economics and to geopolitics which all can affect how oil is produced. We'll talk a bit about them a bit later.

There's two main schools of thought when it comes to talking about the timing of peak oil. Firstly, there's the early peak. The early peak is anywhere from about 2000 to 2015. There's a point of view that global peak oil will occur in that time period. It's mostly geologists, engineers, social thinkers, bankers and economists that are coming up with this argument. They base their argument upon the fact that oil discoveries reached a peak in the 1960's and have been declining ever since.



Also, the growth in conventional oil production has ceased—well the growth ceased in 2004 and we've been bumping along this plateau ever since. Also, oil production has peaked in the majority of oil producing regions around the world, so we're becoming increasingly reliant on a smaller number of oil exporters as we go forward. So the availability of oil to export is actually decreasing as countries start consuming more of their own fuel-to-fuel economic growth. So oil export availability is actually decreasing.



Global Transportation Fuel Demand

Meanwhile, oil demand continues to grow. So oil supply is flat or declining; oil demand continues to grow. The concerns are that if oil supply is declining or flat and demand continues to grow, there's going to be a point where there's some oil scarcity if that demand is not also reduced.

While conventional oil production has reached somewhat of a plateau, and demand continues to grow, what's filling the gap? Unconventional oils, is the answer. Unconventional oils are not like conventional oil. They're difficult to get out of the ground. They require an extraordinary amount of effort, investment and energy to produce them. And they also entail higher environmental costs than conventional oil. It's difficult to say that they're the same thing. Conventional oil, unconventional oil: not the same thing.

Modern economies rely on a substantial energy surplus to fuel their complexity. At this stage, predictions are that our economy, our society, relies on an energy return on energy-invested ratio of about 10:1. That means for every ten barrels of oil that we get out of the ground, we need one barrel of oil invested. And that's enough energy surplus to fuel the societal complexity that we enjoy today.

Now if you can imagine back to the days when the oil gushed out of the ground and we've struck black gold, in those days, the estimates were that the energy return on energy invested was 100:1, so huge energy surpluses, which have enabled society to grow in complexity quite rapidly. However, what is being found today, in the new heavy oil fields in California, for example, the ratio is only down to 5:1. So for every barrel of oil energy in, we get five out. So that ratio is not enough to fuel the societal complexity we've come to enjoy. At some point, there's going to come a time when too much energy has to be invested to get energy back, that it becomes unproductive to do so.

In 2005, the US Department of Energy commissioned a report into the risks that might be presented by peak oil and that report became known as the Hirsch Report. In that

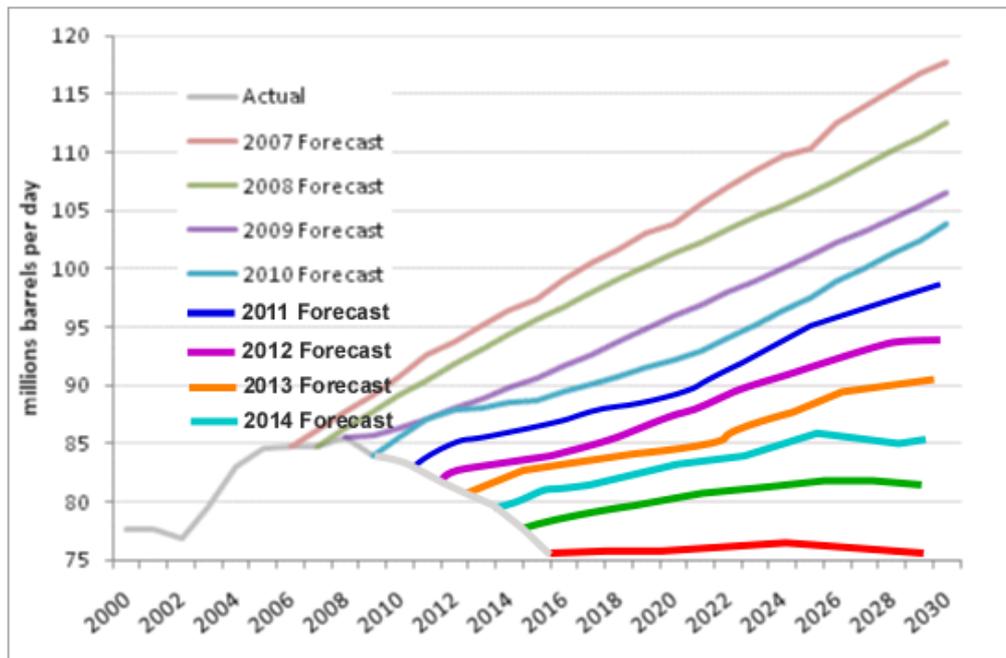
report, they predicted that peak oil would produce high oil prices which would cause economic hardship in the US and in the world. That was in 2005.

If we think back to 2007, 2008 when oil price skyrocketed up to \$147 a barrel soon after the GFC [global financial crisis] occurred. There are some analysts who look at that and say, 'Well, the high oil prices certainly had an impact on that economic crisis'. We can also see from history, that four of the last five global recessions were also preceded by an oil price spike.

So that's the early peak argument. The view is that peak oil, conventional peak oil, has already occurred; unconventional oils will find it difficult to fill the gap as we go forward if demand is not decreased, and this could lead to some challenges in society in terms of economics and societal complexity.

The other point of view is the late, or the no peak argument, so either the peak will come so late that we don't need to worry about it or there's no peak at all and it's all hogwash. These views that are primarily from the major oil companies and the International Energy Agency. There are others, but they're the primary ones.

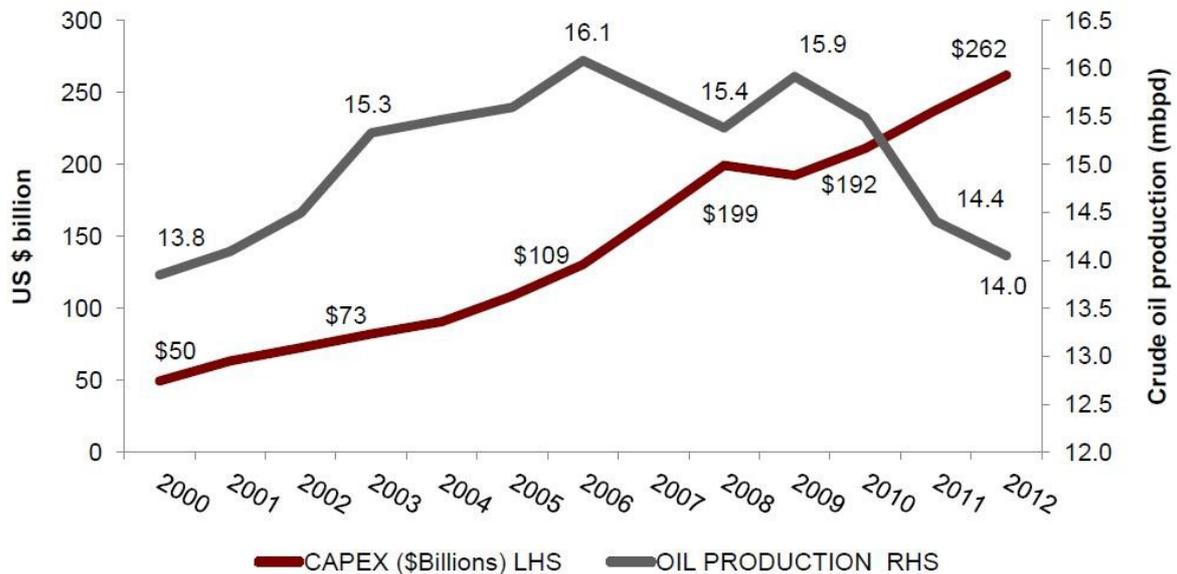
They base their argument on the fact that rising oil prices will stimulate exploration and discovery, that technology will enhance our ability to recover more of the conventional oil that exists and that alternative energies will start to be gradually adopted and phase oil out. The International Energy Agency [IEA] put out an annual World Energy Outlook Report. It assesses the geological aspects of oil, but also the aboveground factors—economics, geopolitics, technology. So it looks at all of these things and makes an assessment about what the future of oil production might be.



IEA Oil Production Estimates 2007 – 2014

A decade ago, IEA had very promising forecasts, were very optimistic. But as you can see from this chart, their reviews, or their reports, have become a lot more tempered over the, over the years. They're gradually coming down. And the Executive Summary of the 2014 World Energy Outlook warns of an energy system under stress. 'The global

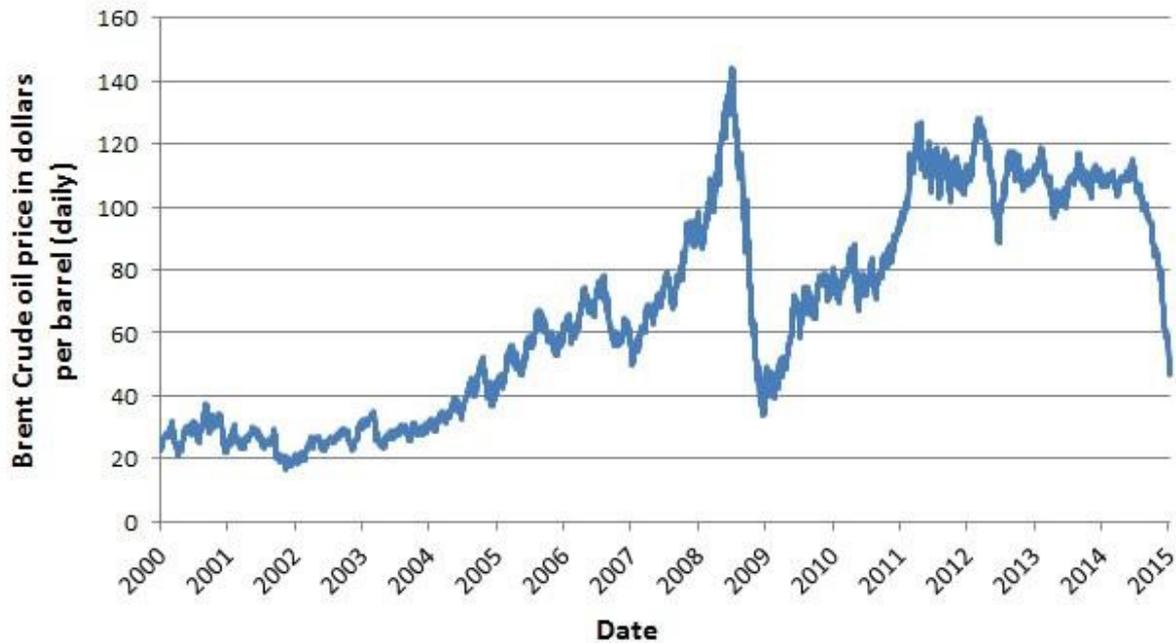
energy system is in danger of falling short of the hopes and expectations placed upon it.' Certainly when you listen to what the IEA is saying in presentations and things like that, they appear to be a lot more concerned about this than perhaps what comes through in their reports.



Crude Oil Production and Capital Expenditure

As conventional oil production starts to falter, the oil industry needs much higher prices in order to bring new production online. These figures illustrate the huge increase in capital expenditure. Capital expenditure is the red line. Huge increase in capital expenditure between 2000 and 2012 and the difficulty that the oil companies have had in increasing production, despite this investment. So you can see production's pretty plateaued there.

This period also represents a period of very high all prices. Those high oil prices were necessary to extract the oil, but they were still struggling to do so.



Brent Crude Oil Prices 2000–2105

The problem we have now is that lower oil prices will curtail upstream spending plans. So that means if companies can't profit from high oil prices, they may not invest in future production. That might not cause problems in the short-term, but certainly in the longer term that, that may present some challenges to the future supply.

I've talked about the two main perspectives of peak oil: early peak, late peak. Either it's going to be very challenging or don't worry about it, it will be fine. Despite the debate that's been going on, very little of this seems to have made its way into public energy policies. Policy-makers appear to be wedded to the optimistic viewpoint of future oil production being enough to carry on society as we enjoyed it. However, if these optimistic forecasts turn out to be incorrect, there are some risks.

While the timing of peak oil production is inevitable, it can't be predicted with absolute certainty and I think that that seems to be a bit of a challenge for a lot of people. If we don't know exactly when it's going to happen, then we don't really need to worry about. Or we'll wait till it happens to start planning for it.

However, there's an alternative option. Krumbieck, Page and Dantas, some academics, have taken the wide range of expert opinions about oil production and have put it into a very geeky simulation, Monte Carlo simulation, to come up with a range of probabilities about what they think will happen based on all of the expert opinions. The benefit of this approach is that you don't actually need to know exactly when peak oil is going to occur. This gives you a range of probabilities.



What this is showing here is that in 2030, there's a 90 per cent probability that globally, there's going to be less oil supply than was available in 2005. So if you have an oil-dependent organisation and you want to consider how, how you're going to be operating in 2030, this might be an opportunity for you to look at it in terms of risk management.

That was a global context in terms of the oil transition globally. What I'm going to do now is bring the context into more of an Australian view, and I'm going to look at two of those energy security components—availability and affordability—because they're more of the long-term components.

Australia is largely self-sufficient in the coal and gas that it needs to run its economy, but not oil. Australia's oil production peaked in 2000 and has been declining ever since. Whilst our oil production in this country is in decline, national consumption continues to grow. This gap between production and consumption is met by an increasing quantity of imports. This shows that about 60 per cent of our consumption is met by imports.

However, our self-sufficiency is actually far less than that number might suggest because we actually send the majority of our fuel overseas. We get better prices for it in Asia, and for a variety of technological reasons, we export the majority of our oil to Asia, so therefore we import even more. The estimates of how much of the oil that we use domestically comes from our own oil fields is between 9 and 17 per cent. So the literature varies in its figures, but between 9 and 17 per cent is what is locally produced, which is not much.

Now oil imports are currently supplied by a reasonably diverse number of countries in South East Asia, Middle East and West Africa. However, for some of Australia's long-term suppliers such as Malaysia, Indonesia and Vietnam, oil production has already peaked in those countries and is now in decline. Also, given the projected rates of

economic growth in the Asia Pacific, those oil exporters will probably find that they'll start consuming a lot more of their own oil, which makes it likely that there'll be even less available to export.

As our own domestic oil self-sufficiency declines and our traditional suppliers start to export less of their oil, we're going to become even more reliant and exposed to the risks that are inherent in the global oil market, which I've just discussed. For a modern, industrialised society like Australia, oil is absolutely essential. Almost all of our personal and commercial transport relies on oil and significant segments of the industrial and agricultural production systems also rely on oil.

But perhaps the sector that's most vulnerable to oil depletion is the aviation sector. Aviation fuel is constrained by a stricter set of safety, technological and regulatory requirements and it's going to be much more difficult to substitute into alternatives, with aviation fuel.

Noting all of these vulnerabilities I've discussed, let's have a look at what the Australian Government has to say about it. There's been a few, very few, inquiries and research reports into the issue of oil depletion at the Federal level. The first, and this one's significant because it was the first of its kind at the Australia Government level, was the 2007 Australian inquiry into Australia's future oil supply. Despite its conclusions that Australia should begin planning for a decline in global oil supplies, it carried little weight as a Government statement at the time and since. And it appears that nothing much has come of it at all.

In 2007, the CSIRO stood up a Future Fuels Forum because they could see that the transport sector would face some serious challenges from the oil transition. They concluded that there was likely to be only moderate preparation by individuals and businesses in order to mitigate or prepare for the oil transition, and as a result, they argued for greater Government intervention.

The final review, or report, that I've been able to find was a 2009 Australian Bureau of Infrastructure, Transport and Regional Economics report that was a very comprehensive report of the oil depletion issue globally. It was an Australian report but it looked at the global issue of oil depletion. They predicted that we were on a slightly upward-slanting plateau or oil production that would last to about 2016—here we are—and then it would, would start dropping off.

Some time after publication of that document, it was removed from the website and replaced with an unrelated report on aircraft movements. The Government at the time was accused of hiding the report and people were articulating that they thought that the Government was deliberately hiding the report in order to avoid public discussion of the risks highlighted by the report. So it's disappeared and there hasn't been anything to replace it since.

In terms of oil depletion in Australian Government energy policy, there are a few key documents. The first is the ASL Tasman Liquid Fuels Vulnerability Assessment, and this was commissioned by the Department of Resources, Energy and Tourism in 2008 and in 2011, so they've done two. The report argues that market responses will signal to consumers, investors and producers when and how to respond to the evolving global oil market. They have faith that peak oil will pass with little fanfare, albeit with higher oil prices and perhaps a different energy mix.

The 2012 Energy White Paper was developed to provide a framework to manage Australia's energy security in the face of shifting geopolitical balances and changing global markets. However, the Energy White Paper dispenses with any notion of vulnerability to long-term oil depletion and suggests it's a very low probability of reaching global oil supply limits in the period to 2035.

Australian researchers who've spent any time looking at this issue have argued that the present energy policy from the Federal Government is in effect a *laissez faire* reliance on economic principles and the continued effective operation of world oil markets. They argue that there's a degree of policy blindness to future vulnerabilities and potential fragilities, and that this way of writing policy is inconsistent with prudent risk management.

The Senate inquiry and the CSIRO report both argue for greater Government intervention, but so far there's been no action to address the risks at the Federal level. Timely preparation by Defence and Air Force will assist in building resilience to the identified vulnerabilities, however without clear policy signals from Government, Defence and Air Force may fail to respond in a timely manner.

Australian Defence policy and oil depletion. It's very limited. I couldn't find any references, in fact, but I did find a review in the Defence Annual Report that was conducted by the Joint Standing Committee on Foreign Affairs, Trade and Defence, who argued that Defence cannot afford to wait for Australian Government policy before addressing the risks of oil depletion. Given the potentially severe impact on Australia, prudent risk management would suggest that Defence should be starting to plan for these changes today.

I've looked at the global context in terms of the oil transition and narrowed that focus to availability and affordability in the Australian context. Next, I'm just going to have a look at the geopolitical aspects that relate to the oil transition, in order to inform some of the risks that might relate to national security.

The oil that remains today is not evenly distributed around the globe. Some nations have naturally less depleted oil reserves than others. The region that's known as the strategic energy ellipse possesses the majority of easily exploitable oil reserves that remain. So over the coming decades, we're going to become evermore reliant on this region for our oil resources. As global oil depletion progresses, those oil-rich states are going to enjoy higher revenues, higher international influence and increased political leverage. The region's considered unstable now and it's likely to become even more so.

Also, by some estimates, about 85 per cent of global oil reserves are held by national oil companies. So there may be some significant consequences if those national oil companies decide that they want to use their oil for national security interests rather than for economic commercial interests.

Countries and regions that are reliant on imports are going to become increasingly vulnerable. Rapid fluctuations in supply of oil are likely to cause significant and unpredictable economic, social and political dislocations, possibly on a global scale. In the presence of such strategic anxiety, there's a heightened risk of armed conflict over those energy resources that remain. And there's a view that there'll be greater clashes over access to resources in the South China Sea and the Indian Ocean.

Additionally, tankers move about 63 per cent of global oil supplies along fixed maritime routes. There's narrow channels along these maritime routes that are known as choke points and they're a critical part of energy security because there's huge amounts of oil that are traded through these straits. These choke points make tankers vulnerable to pirates, terrorist attacks, political unrest, as well as shipping accidents. And the importance of these strategic passages has not been lost on transnational terror groups. This is an article that was in the Al Qaeda magazine, *Resurgence*, and it's urging jihadists to target the oil infrastructure, calling it the Achilles heel of western economies.

Developing nations will be particular vulnerable to declining energy security because they lack the funds to compete for expensive and scarce oil. The result could be serious humanitarian or economic hardship, and perhaps even political instability. This might lead to situations that change the national security situation in our region. There's likely to be spill-over effects, such as refugee flows and the emergence of havens for terrorism and organised crime.

There are a few different potential outcomes from declining energy security that could influence geopolitics in ways that are not currently evident under current stable market conditions.

At present, the use of military force to access foreign oil or to protect its flow through those maritime straits would be considered an unnecessary impediment to the efficient operation of the market, and obviously would be widely discouraged by the international community. However, at some point in the future, if the global supply of oil is insufficient to meet the demands of all oil importers, and the global oil flow is increasingly at risk of interdiction, it's within the context of strategic anxiety that countries might decide that militarisation of energy security might be in order. This has implications for Australia's national strategic interests and the strategic objectives of Defence that are not currently well understood.

Since 2009, the Defence White Paper has started to consider new security risks that might arise from resource scarcity, including future tensions over the supply of energy. Although recent Australian Defence policy briefly touches on some of the risks that relate to energy security, the references are fragmented and non-specific and there's no explicit actions highlighted to address the risks. In the coming decades, there's a reasonable probability that energy security will become ever more militarised and this will present risks to Air Force and Australia's strategic interests more broadly. Likely, Air Force will see an increase in operational tempo as a result.

We've looked at how Australia is becoming less self-sufficient in oil and more reliant on the global energy market. We've looked at how the availability and affordability of oil in Australia may be declining in the future. It's now time to look at the third component of energy security, and that is the reliability of the supply.

Most of Australia's refining capacity is located close to the major cities on the east coast. Due to competitive pressures, mostly from large Asian oil refineries, Australia's refineries are slowly being converted to import terminals. Once the slated closures are completed, there'll only actually be four refineries left in Australia, which is equivalent to a reduction in refining capacity of 42 per cent since 2011. Obviously with less ability to refine fuel in this country, the gap's going to be met by an increase in quantity of liquid fuel imports from overseas. Our imports of liquid fuel—those are those refined petroleum products coming from overseas—are actually not as diversified as they are for oil. As of 2013, most of our imports came from Asia.

Oil and refined petroleum products are shipped to Australia through a complex network of maritime shipping routes. A large amount of that oil transits through the territorial waters of other nation states and it puts Australia at the end of a very long supply chain that could be vulnerable to changes in the regional security environment. The majority of those imports are coming through the Indonesian archipelago and so if any conflict were to break out in this region, Australia could see a large percentage of its imports affected.

Despite the Government's rather sanguine views about the country's high liquid fuel security, there's been a number of groups and individuals who are starting to raise concerns about Australia becoming vulnerable to disruption to liquid fuel supplies, especially during times of crisis. In light of the concerns, let's look at some of the mechanisms that are in place to deal with any disruptions that occur.

The Australian Government, as per the Energy White Paper, relies on the commercial stockholdings of the industry in order to maintain supply during short-term global and domestic supply disruptions. Let's have a look at the commercial stockholding practices. This figure here is from the Australian Institute of Petroleum and it shows that there's roughly five days of oil stocks at refineries, three weeks of petroleum products in the distribution chain and three days in the hands of consumers. So that's only about 11 days within the supply chain in the country, and the Australian Institute of Petroleum has made it quite clear that there's no real excess for supply disruptions.

The oil industry has optimised their supply chains to have effective just-in-time delivery of oil and petroleum products. And whilst this just-in-time approach works very well under normal circumstances, the resilience of the supply chain under a broader range of liquid fuel emergency scenarios hasn't yet been tested.

By its own admission, the Australian Government does not hold Government-controlled or regulated industry stocks for drawdown in an emergency. To manage any deeper disruptions that might occur, there's really only two options that the Government has. The first is a combination of market and industry mechanisms and voluntary demand restraint, so essentially, 'Let's let the price rise and people will automatically reduce the amount of fuel they use'. The second option is to take part in an International Energy Agency coordinated emergency response.

As an International Energy Agency member country, and a net importer of oil, Australia has an obligation to hold the equivalent of 90 days net imports of oil imports. Australia is one of the few IEA member countries that has chosen not to hold any public stockholdings for emergency purposes, and as of yesterday, Australia's reported level of net import stockholdings is equal to 52 days. So we are not meeting our obligations to the IEA. And as our refineries continue to close and our imports continue to grow, our deficit against this target will increase even more. As some academics have pointed out, it would not be reasonable for any IEA country to come to our assistance if we ourselves have decided that we don't need to comply with the requirements of its membership.

The Australian Government has made it clear that it believes in the extensive international energy market as the best mechanism for managing energy security for Australia. In the event of liquid fuel supply disruptions, fuel price increases will be allowed to flow through to consumers. The Australian Institute of Petroleum, which represents Australia's oil industry, has long argued that energy and economic security issues should be kept distinct from national security issues. They assert that energy

security should be assessed by the Energy White Paper process, but national security scenarios should be considered separately by Defence in the planning processes. This position fails to consider that national security and energy security may well be intrinsically linked.

However, there is a growing chorus of people who recognise that the ability for Australia to obtain continuous supplies of fuel is of strategic importance from an economic and national security perspective, and that this requirement takes on particular significance at times of international energy crisis or fuel shortages. Submissions to the 2015 Senate inquiry suggested that while markets and industry can address many of the issues in the energy supply chain, the issue of supply security is a Government responsibility. The Senate inquiry made a recommendation for the Australian Government to produce a comprehensive and multi-faceted approach to transport energy security, and this presents Defence and Air Force with an opportunity to engage with Government on this activity.

For now, until the nexus between energy security, economic security and national security is recognised in this country and appropriately addressed, there are potential risks to Air Force that remain unmitigated at the national level. Additionally, Defence has also been recommended to adopt a more assertive strategy in terms of mitigating risks due to oil-based fuels.

So far, we've looked at how declining energy security from the oil transition might present threats to national security in terms of economic security and geopolitical security. Now it's time to look at how it might affect military security. It's essential to understand how our military security relates to the energy that we use for military operations.

Oil is an energy source that is quite unique. It is naturally liquid and it's extremely energy-dense, so it offers superior performance when it comes to military mobility and is clearly a fundamental enabler to military capability. The US Department of Defense defines operational energy as the energy required to train, move and sustain military forces and weapons platforms for military operations. And there's quite a few logistical and financial burdens of operational energy, which those in the military here will probably attest to.

In terms of delivering air power effects, an aircraft is only useful if it has the fuel it needs to get airborne and achieve its designated mission. Fuel logistics, therefore, is a key component to Air Force capability.

Modern deployments create heavy logistical requirements, such as fuel convoys. And you can see just here the sort of fuel convoys that might occur in operations. Moving huge amounts of fuel into operations is a challenge, and potentially vulnerable to disruption. In 2009, a Deloitte's study identified that fuel convoys accounted for nearly half of American deaths in Iraq and Afghanistan. The huge quantity of fuel that's needed at a frontline of a conflict also drives higher quantities of fuel in the supply chain, which therefore requires even more fuel for the conduct of force protection.

In the US, many experts recognise that the official energy budget is actually only a fraction of all of the energy that's used to deliver that fuel. And this is called the fully burdened cost of fuel. At the point of the battlefield, the cost of fuel is actually far higher than just the price per gallon, when you take into consideration the supply chain, the logistics, the casualties and the security that are required to deliver that fuel.

Defence policy acknowledges that fuel is essential to conduct all Defence activities and we need fuel in the right time and the right place in order to conduct operations. That's quite obvious. Defence is the Australian Government's largest energy consumer. Seventy-one per cent of total Government energy use is used by Defence. And of Defence energy consumption, the liquid fuels—the petroleum products—account for nearly 80 per cent of our use. And you can see here that fuel is used in numerous locations around Australia and the near region.

Air Force itself is the largest user of fuels in Defence, accounting for 59 per cent of total Defence use. And we know that air power is a very energy-intensive activity. Ninety-seven per cent of the fuel that we use in Air Force is for aviation. Also, as military capabilities become more technologically advanced, the rate of fuel consumption is expected to increase. Defence's liquid fuel consumption is already the second biggest sustainment element in the budget, and by 2020, our liquid fuel supply costs could reach an estimated \$1.1 billion because of greater demands.

Noting that fuel is critical to our operational activities, let's have a look at some of the vulnerabilities that currently exist. For Air Force, fuel logistics support is provided through a complex network of organic capabilities, Defence service providers, industry organisations and international agreements. In general, fuel storage is expensive, complex and potentially hazardous. For Defence, fuel has the potential to be the greatest supply chain risk in the medium to longer term, and in the shorter term, demand spikes and supply dips make it difficult for Defence to sustain operational activities.

The Australian Defence Force Posture Review of 2012 raised concerns about Defence's ability to sustain high tempo operations in support of Australia's strategic interests beyond a couple of months. The remote northern bases depend on fuel supply by road, which could make resupply very challenging in periods of high operational tempo, and additionally in the wet season when road closures might occur.

In 2013, the Wraith Report identified that poorly maintained fuel facilities and unsafe operating practices exposed Defence to extreme work, health and safety risks and environmental risks. So in parallel, Defence has commenced a fuel remediation program to assist with remediation of those fuel installations.

Most of Defence's operating activities depend on a single energy source: petroleum-based liquid fuels. And the increasing strategic threats to this energy source means that Defence needs to diversify its energy sources and consider adopting a strategy for alternative fuels. Air Force relies heavily on host nation support or coalition partners for deployed fuel support and as Australia's allies increasingly pursue alternative fuel options, there's a need for us to consider how we will ensure interoperability with our coalition partners.

To ensure that Defence can accept alternative fuels when they're offered, we must commence certification of alternative fuel pathways and work with OEMs [original equipment manufacturers] to certify equipment.

The objective stated by Joint Logistics Command of being a fast follower for alternative fuels is sound, as long as we actually start making progress and act in a timely manner.

The ability of new capabilities to meet performance parameters frequently assumes an assured supply of energy. Increased burdens on the logistics systems, as well as increased threats to fuel supply lines, could result into a situation where some logistically

intensive future concepts may not be supportable. Joint Logistics Command has recommended, in 2010, that fuel efficiency and ability should be emphasised as a key enabler of future capability. However, it's unclear how this objective has been implemented.

Additionally, the Defence approach to fuel management is fragmented and this is a key vulnerability for Defence's energy security. This table illustrates the groups and services that are involved in fuel management for Defence. And you can see that a variety of different people are required to do different things, and there's no overarching guidance on that.

So to drive improvements in the strategic management of fuel within Defence, the Directorate of Strategic Fuel was established in Joint Logistics Command. And in 2014 Defence appointed Commander Joint Logistics [Command] as the head of the Defence fuel supply chain, and the single accountable authority for its operation. Whilst that's a welcome move in terms of fuel supply, what's missing is the broader capability perspective of energy security. There's no coherent governance structure, no mechanism for influencing energy demand through capability development or management.

The unconstrained growth in energy demand, coupled with notable gaps in energy modelling, analysis and monitoring, energy research, energy education and training have all introduced risks and vulnerabilities into Defence's overall energy system.

Delivering air power is an energy-intensive activity that relies on regular access to large quantities of liquid fuels. Air Force is reliant on a broad range of stakeholders, both inside and outside of Defence. Air Force's growing fuel demands for new capabilities and increased operational tempo in an era of militarised energy security, as well as contemporary and emergent risks to the fuel supply chain, all present risk to Air Force. If there continues to be no comprehensive energy strategy or oversight of energy issues across Defence, it's unlikely that these risks will be appropriately mitigated.

Let's look at the key findings of my research. After all of that research, which was very broad—there's quite a lot to sift through, I found four main findings. First, that the oil transition presents a classic risk mitigation problem. We don't need to know for certain when peak oil will occur. However, what we can do is assess whether the risks of peak oil occurring are things we need to look at. The modelling that's been undertaken here shows that by 2030, there's a 90 per cent chance that there'll be less oil supply than in 2005. Defence and Air Force are going to have to look at that and decide whether that's a risk that needs to be looked at.

As the oil transition progresses, declining energy security may well contribute to economic recession, reshape geopolitical relationships, cause domestic political upheaval and drive military engagements. In these ways, it may impact on our national security. Australia, with limited oil reserves, will be highly dependent on the global market for oil, and therefore Australia's energy, or national security, may be disproportionately affected by declining energy security during the oil transition.

Also, the nexus between national security and energy security has not been made explicit in Australian Government energy policy or in Defence policy, and this has resulted in policy that's fragmented and incongruent in its approach. Australian Government energy policy assumes away national security risks and Defence policy assumes the continued availability, affordability and reliability of the energy it needs to

achieve its objectives. Because this nexus between economic security, national security and energy security has not been recognised in official policy, it's highly unlikely that the risks are going to be adequately addressed on a national scale. Whilst this presents risk to Air Force, it is also creating vulnerabilities for the nation more broadly.

Finally, [as well as] the strategic risks that I've been through, there's also further risk to Air Force at the operational and tactical level. In an era of increased militarisation of energy security, Air Force's operational tempo is likely to increase, further driving demands for fuel. And as that fuel demand grows, so too does the budget that needs to be spent on that fuel. As a result, the sustainment of operations is going to be more costly and may divert funds from capability development.

Air Force is reliant on the fuel supply chain for the delivery of fuel, where and when it's needed. And in the event of a liquid fuel supply disruption, Australia relies on the normal commercial stockholding practices. There's no guarantee that these market-based mechanisms will work under all conditions, especially during times of conflict. In Australia, specific concerns have already been raised about the ability of the logistics system to deliver fuel in high-tempo operations, and an increased operational tempo in the future may see fuel logistics capabilities stretched beyond their ability to sustain operations.

Expeditionary operations have a reliance on the military mechanisms of our coalition partners or local commercial arrangements, and this raises questions about our fuel interoperability with those organisations. Additionally, the management of fuel in Defence is fragmented and there appears to be no strategy to ensure energy security for services for Air Force or other Services. Whilst these vulnerabilities already exist, they may prove to become unacceptable risks to Air Force in the years to come.

My recommendations for future work. My research has just skimmed the surface. Each of these subjects could be addressed in much greater depth for Air Force, Defence or even for Australia. I think one of the key pieces of research [that] needs to be undertaken [is] into understanding better the national security and energy security nexus in Australia. I also think that Air Force has a great opportunity now to go and further analyse, assess and start to treat the risks that have been identified in this research. This will require access to classified information, so it will have to be done internally to Air Force.

Note: Words in square brackets [] were added during editing for clarity.