Submission No 2

INQUIRY INTO THE SUPPLY AND COST OF GAS AND LIQUID FUELS IN NEW SOUTH WALES

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Submission
to the Inquiry by the
New South Wales Parliament
Legislative Council

Select Committee on the supply and cost of gas and liquid fuels in New South Wales

by

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17 December 2014

Inquiry Terms of Reference

1. That a select committee be established to inquire into and report on gas and liquid fuels supply, cost and availability in New South Wales, and in particular:
   a) the factors affecting the supply, demand and cost of natural gas and liquid fuels in New South Wales;
   b) the impact of tight supply and increasing cost of natural gas and liquid fuels on New South Wales consumers, including manufacturing, agriculture, energy production, small business, public services and household consumers;
   c) the commercial conduct of gas producers and the operation of the international and domestic gas markets;
   d) the adequacy of Commonwealth and State cooperation in gas market regulation;
   e) the possible regulatory responses to protect New South Wales gas consumers from adverse market fluctuations and failures;
   f) the impact of closures of liquid fuel refineries and storages in New South Wales; and
   g) any other related matter.
2. That the committee report by 25 February 2015.

The terms of reference were established by the house in a resolution passed 6 November 2014, Minutes No 15, Item 7 page 243.

Declaration

The author of this document, Geoffrey Miell, is a born and raised Australian citizen, residing in the state of New South Wales.

He has a Bachelor Degree in Mechanical Engineering from the University of Sydney.

Most of his professional life has been directed towards developing and designing industrial equipment, including elevated work platforms, scissor hoists, goods hoists, conveyor systems, automated stacking and de-stacking systems, steel structures and (for a few years) underground coal mining equipment. A few earlier years were engaged in the ongoing quality assurance testing and failure analysis of specific military hardware equipment for an Australian defence contractor.

Utilising various data sources (see the references at the end of this document) the observations and sole opinions of the author, as a concerned citizen, are as follows:

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Executive Summary

Currently our civilisation is critically dependent on fossil fuels (oil, natural gas, and coal) for our primary energy needs. Oil, natural gas, coal, uranium and thorium are primary energy resources that are finite, one-time use, non-renewable and depleting.

Nothing happens without energy. Without a secure, safe, reliable, affordable energy supply we all have a bleak future. It appears on available evidence probable that a post-peak fossil fuel world will arrive before 2030. If humanity continues to carry on business as usual, continuing to rely heavily on fossil fuels for our primary energy needs into the next decade and beyond, then a bleak future is assured.

All governments in Australia, including the New South Wales Government, must deploy effective policies now to reduce Australia's dependency on all fossil fuels for long-term energy security and prosperity reasons, expediting an orderly transition to alternative energy solutions as soon as possible. Any alternative energy solutions must be deployable and operational at scale within a decade timeframe to be effective at avoiding an energy crisis.

Alternative energy solutions are available and affordable now to ensure Australia's long-term energy security and prosperity can prevail. All that is missing is the will to execute the actions that must happen. Failure to act as required risks severe to catastrophic disruptions to our economy, politics and society.

It is hoped that the Select Committee membership heeds this message presented and succeeds in convincing the NSW Government to begin the actions required. The lives of millions of people in the state of New South Wales are dependent on the correct course of actions being expedited in a timely manner.

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Section 1: The fundamentals that governments ignore at our peril

1. Energy is fundamental to life and essential for our society's economic prosperity. We need energy to prepare and sow crops, harvest them and for transporting livestock and foodstuffs for processing and to markets. Our civilisation requires energy for lighting, heating, cooling, transportation, communication, building, manufacturing, mining, medical endeavours and leisure pursuits. **Nothing happens without energy**.
2. Currently our civilisation is critically dependent on fossil fuels (oil, natural gas and coal) for our primary energy needs. Around 78 per cent for global needs (Ref 1). **Australia's primary energy is currently derived from**:
    a. **39 per cent petroleum products**;
    b. **34 per cent black and brown coal**;
    c. **23 per cent natural gas**;
    d. 4 per cent renewable energy. (Ref 2 page 3)

    Whether these estimate numbers are sufficiently accurate is less important than the order of magnitude of these numbers.
3. **Oil, natural gas, coal, uranium and thorium are primary energy resources that are**:
    a. **Finite**;
    b. **One-time use** – Reversing the combustion process of oil, natural gas and coal and the nuclear fission process of uranium, plutonium and thorium is beyond our current technology and would require energy to do so if it were possible;

c. **Non-renewable** – Oil, natural gas and coal have taken tens of millions of years to form and accumulate. Uranium and thorium were formed in supernovae that occurred before our solar system formed; and

d. **Depleting** – See points 4 and 5 immediately below.

4. According to the latest annual edition of *BP Statistical Review of World Energy June 2014*, at year 2013 rates of global consumption the world has, from the end of 2013, an estimated:

    a. **53.3 years of oil** reserves remaining (Ref 3 page 6);

    b. **54.8 years of natural gas** reserves (Ref 3 page 20); and

    c. **113 years of all grades of coal** reserves on a tonnage basis (Ref 3 page 30), and significantly less than a century on an energy content basis.

5. Various energy analysts are projecting:

    a. **Global oil production will probably begin a sustained decline before 2030, and there is a significant risk of it occurring before 2020**. Tight (shale) oil production capacity is unlikely to significantly alter this outcome (Ref 4 page 17, Ref 5 pages 7-10, Ref 6);

    b. **Global natural gas production peaking by early 2020s** (Ref 4 pages 10-11);

    c. **Global coal production peaking on or around 2020** (Ref 4 page 12);

    d. Global uranium ore reserves may be depleted within this century (Ref 4 pages 125-127).

Section 2: Global oil statistics and supply outlook

1. Empirical data shows that world oil production has not increased since about 2005. The production of 'conventional' oil is already in a slight decline since about 2008 (Ref 5 page 7).
2. The rising gap between global demand and global 'conventional' crude production is currently being filled by 'unconventional' oil (including tar sands, heavy oil, tight oil and natural gas liquids), "refinery gains" and biofuels (Ref 5 pages 25-26).
3. Experience gained in the US shows tight (shale) oil:
    a. Production has grown impressively and now makes up about 20 per cent of US oil production;
    b. Production has allowed US crude oil production to reverse years of decline and grow 24 per cent above its all-time post-1970 low in 2008;
    c. Well decline rates are steep – between 81 per cent and 90 per cent in the first 24 months;
    d. Overall field decline rates are such that 40 per cent of production must be replaced annually to maintain production; and
    e. Drilling rates currently are far higher than overall field decline rates and hence production is expected to continue to grow rapidly. If current drilling rates are maintained, tight oil production will grow to a peak in 2016 at about 2.3 million barrels per day, assuming the US Energy Information Administration (EIA) estimates of available locations are correct. Production will then collapse at overall field decline rates. This represents a US tight oil production bubble of a little over ten years duration (Ref 7, page 78). Putting these production rates in

perspective, in 2013 US total oil production was on average 10.0 million barrels per day and liquid fuel consumption was 18.8 million barrels per day oil energy equivalent (Ref 3 pages 8-9).

4. Global oil reserves estimated at the end of 2013 were at 1687.9 thousand million barrels, with reserves to production of 53.3 years (Ref 3 page 6).
5. Global oil production during 2013 on average was 86.808 million barrels per day (including crude oil, tight oil, oil sands and natural gas liquids, excluding derivatives of biomass, coal to liquids (CTL) and gas to liquids (GTL)). Global production grew 0.6 per cent from 2012 to 2013 (Ref 3 page 10).
6. Global liquid fuel consumption during 2013 on average was 91.331 million barrels per day energy equivalent (including inland demand plus international aviation and marine bunkers and refinery fuel and loss, biogasoline (such as ethanol), biodiesel and derivatives of coal (CTL) and natural gas (GTL)). Global consumption grew 1.4 per cent from 2012 to 2013 (Ref 3 page 11).
7. A special publication was produced by the *Philosophical Transactions of the Royal Society A*, the world's oldest ongoing peer-reviewed scientific journal, on the subject of the future of oil supply. The introduction paper to this special edition includes the following statement, with bold text my emphasis (Ref 4 page 17):

    > Following an earlier literature review, we concluded that **a sustained decline in global conventional production appears probable before 2030 and there is significant risk of this beginning before 2020**. This assessment excluded tight oil resources since these were classified as unconventional. However, on current evidence **the inclusion of tight oil resources appears unlikely to significantly affect this conclusion**, partly because the resource base appears relatively modest. Despite rising proved reserves, the depletion of conventional oil resources is relatively advanced with cumulative production equal to

at least 30% of the global URR (i.e. close to the point at which production has typically been found to decline in a region). A significant portion of this resource is located in small fields in difficult locations that are unlikely to be accessed quickly. However, global supply is profoundly influenced by geopolitical factors and any supply constraints are likely to trigger much greater price increases and demand/substitution responses than would be the case at the regional level—a process that is already underway. As a consequence, a sharp peak in global conventional oil production appears unlikely.

Section 3: Australia's petroleum fuels supply & resilience outlook

1. Australia's oil production peaked in 2000. Since then the general trend has been a decline, partly offset by offshore field developments. Future projections continue this decline over the next two decades (Ref 5 page 53);
2. Australia's oil reserves at the end of 2013 were at 4.0 billion barrels, representing a 0.2 per cent share of the world's known oil reserves, with a reserves to production of 26.1 years (Ref 3 page 6);
3. Australia's liquid fuels consumption during 2013 was on average 1.026 million barrels per day oil energy equivalent, representing a 1.1 per cent share of the world's liquid fuels consumption, down slightly 0.4 per cent from the previous peak consumption year 2012 (Ref 3 page 9);
4. Australia's oil production during 2013 was on average 416 thousand barrels of oil per day, representing a 0.4 per cent share of the world's oil production, down 16.9 per cent from the previous year and continuing a decadal trend of decline (Ref 3 page 8);
5. Australia's importation of fuel products has risen from 60 per cent of total fuels consumed in 2000 to 91 per cent in 2013. An estimated 23 days of real oil and fuel stock was held in-country as at April 2012 (Ref 8 page 8);

6. Australia is moving towards a situation where by 2030 it could have:
   a. No refineries;
   b. Less than 20 days of liquid fuel stock in-country:
   c. 100 per cent imported fuel dependency (Ref 8 page 6);
7. Diesel fuel stocks held in-country are currently at around 12 days of supply (Ref 9). **Without diesel fuel Australia's current transport systems, food supply and economy would fail.**

Section 4: The false promise of biofuels

The factors that make most biofuels a poor fuel substitute are (Ref 10):

1. Crippling fossil fuel dependence;
2. Deficient Energy Return on Investment (ERoI) at scale;
3. Poor quality (energy density, power density, infrastructure and engine compatibility, need for hydrotreatment, etc.);
4. Huge environmental impact (land and water footprint, nitrate poisoning (eutrophication) and agricultural runoff, irreversible conversion of and damage to biodiverse habitat);
5. Higher lifecycle greenhouse gas (GHG) emissions (when properly counting land use change and all nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2));
6. Increased global instability (food competition, "green grabbing" land confiscation, displacement of native populations, pseudo-slave labour); and
7. Decreased energy security (higher cost, greater price volatility, annual production with no reserves, vulnerable to weather and crop failures, etc.).

Section 5: Global natural gas statistics and supply outlook

1. Global natural gas reserves estimated at the end of 2013 were at 185.7 trillion cubic metres, with reserves to production of 54.8 years (Ref 3 page 20);
2. Global natural gas production in 2013 was 3390.5 billion cubic metres (excluding gas flared or recycled). Global production grew 1.1 per cent from 2012 to 2013 (Ref 3 page 22);
3. Experienced gained in the United States of America shows (Ref 7 pages 50-77, 142-145):
   a. Coalbed methane (CBM) production is and will continue to be a small player, currently around 8 per cent, in total US gas supply;
   b. CBM production peaked in 2008 at almost 2 trillion cubic feet per year (roughly 2100 peta-joules per year) and has plateaued since then;
   c. In the 21 years since significant CBM production was initiated 27 trillion cubic feet has been produced;
   d. In 2012 CBM reserves were 17.5 trillion cubic feet, having fallen from 21.9 trillion cubic feet in 2007, meaning production had not been replaced with new reserve additions;
   e. CBM (or what is known as coal seam gas (CSG) in Australia) is an example of a resource with a very large "tank" but with a limited and closing "tap", if we consider the geological realities of what can likely be produced;
   f. Tight (shale) gas production has grown very rapidly to account for nearly 40 per cent of US natural gas production, although production has plateaued since early 2012, and is likely to decline from 2015 onwards;

g. Individual tight (shale) gas well decline rates are high, ranging from 79 per cent to 95 per cent after 36 months;
h. Overall tight (shale) gas field declines require from 30 to 50 per cent of production to be replaced annually with more drilling. This translates to US$42 billion of annual capital investment to maintain current production. By comparison, shale gas produced in 2012 was worth about US$32.5 billion at a gas price of US$3.40 per million cubic feet;

4. The Energy Watch Group's March 2013 report *Fossil and Nuclear Fuels – The Supply Outlook*, resulting from an in depth analysis of individual oil, gas, coal and uranium producer countries (Ref 5, pages 10-11), shows:
   a. Conventional gas production is in decline in Europe and North America which together hold almost 35 per cent of world gas production;
   b. Shale gas production in the USA is unlikely to see a significant further expansion. In 2030 gas production in the US probably will be far below current production levels;
   c. Gas production in Europe has been in decline since the turn of this century and will continue to follow this trend. Shale gas production will not play a role comparable with the one in the US, since geological, geographical and industrial conditions are much less favourable;
   d. The Russian Federation, the second largest natural gas producer closely behind the US, faces a struggle between declining production from ageing fields and new expensive and time consuming developments in Northern Siberia and offshore. Russian gas production reached a first peak in 1989 when the largest fields passed peak production;

e. Domestic consumption in the Russian Federation and growing demand from Asia will put increasing pressure on volumes available for export from Eurasia to Europe in the coming years;

f. The Middle Eastern countries, Iran and Qatar, are expected to feed the rising demand for liquefied natural gas (LNG) over the next decades. Though these countries have large reserves reported, it is highly probable that they are exaggerated;

g. It is projected that global gas production will probably peak around 2020 or perhaps even before 2020.

Section 6: Australia's and NSW's natural gas supply outlook

1. Australia's natural gas reserves at the end of 2013 were at 3.7 trillion cubic metres (about 141710 peta-joules), representing a 2.0 per cent share of the world's known gas reserves, with a reserves to production of 85.8 years (Ref 3 page 20);
2. Seven Australian LNG projects are under construction and scheduled to come on line between 2014 and 2017 providing over 60 million tonnes (3264 peta-joules) of additional LNG export capacity. The outlook for LNG in the Asia-Pacific region is for continued strong demand (Ref 11 page 136);
3. Over the next two decades, Australia's gas production is projected to increase almost fourfold, driven largely by LNG exports, which are projected to reach 5663 peta-joules by 2034-35 (Ref 11 page 136);
4. Projected cumulative production volumes from present to 2034-35 set against Australia's current categories of estimated gas resources show most of the natural gas Economic Demonstrated Resource (EDR) would be consumed

within this period (Ref 11 figure 9.2). Some sub-EDR category resources are expected to be 'proved up' and available to supply the market, but the question that needs to be answered is whether these gas resources will be significant and sufficient to extend Australia's affordable gas supplies to more than three decades;

5. Australia currently has no reserves of tight gas. An estimate of recoverable shale gas resources of about 435600 peta-joules (around 396 trillion cubic feet) is based on limited data, and this initial estimate is likely to contract in light of actual well performance data (Ref 12 pages 18-19);
6. New South Wales does not have large reserves of natural gas. There are no commercially viable reserves of 'conventional' natural gas within the borders of NSW or in adjacent waters known at this time (Ref 13 paragraph 2.42);
7. New South Wales CSG reserves are estimated at 2904 peta-joules (around 2.8 trillion cubic feet), representing 8 per cent of Australia total CSG reserves (Ref 12 page 17). Note that NSW CSG reserves are **less than** the additional annual LNG export capacity becoming available by 2017;
8. New South Wales currently imports around 95 per cent of its domestic needs from Queensland and Victoria. These supplies are from mature gas fields and their production rates are in a sustained declined. There are also concerns about possible supply disruptions caused by problems with ageing infrastructure (Ref 13 paragraphs 5.40, 5.42 and 5.43 and Ref 14);
9. Expiration of NSW gas supply contracts from 2015-16 coincident with completion of export LNG capability in Queensland means adequate, affordable NSW domestic supplies are threatened in view of export contract commitments and export parity pricing (Ref 14).

Section 7: Global coal statistics and supply outlook

Although the inquiry concerns gas and liquid fuels supply, cost and availability in New South Wales, this section on global coal statistics and supply outlook has been included in this submission to show supply factors that would impact on any coal to liquids (CTL) and coal to gas (CTG) production, that may supplement liquid fuels and gas supplies.

1. Global total coal (including anthracite, bituminous, sub-bituminous and lignite) reserves estimated at the end of 2013 were at 891.531 giga-tonnes, with reserves to production of 113 years on a tonnage basis. 54.8 per cent of these reserves (488.332 giga-tonnes) were categorised as sub-bituminous and lignite which have significantly lower energy density (or energy per unit mass) compared with anthracite and bituminous coal grades (Ref 3 pages 30 and 44). Reserves to production on an energy content basis would be significantly less than a century;
2. Global coal production in 2013 was 3881.4 mega-tonnes oil energy equivalent content (one tonne of oil equals approximately 1.5 tonnes of hard coal or 3 tonnes of lignite). Global production grew 0.8 per cent from 2012 to 2013 (Ref 3 pages 32 and 44);
3. Coal is still wildly regarded to be an abundant resource. However, internationally coal is only available from few countries having large export capacities. This signals a supply risk that is actually greater than it seems at first glance (Ref 5, page 12):
    a. The USA has passed peak production of bituminous coal in 1990 (Ref 5 figure 159) and peaked in total coal production in 2008 at 1.171 billion short tons (1.062 giga-tonnes). US coal production is now trending

downwards on both a tonnage and energy content basis (Ref 15 page 5). The extent of US reported reserves is also in question (Ref 15);

b. China has switched within a few years from being one of the largest coal exporters to being the world's largest coal importer (Ref 5 page 12). China at the end of 2013 is ranked as having the world's third largest coal reserves (12.8 per cent of world's share on a tonnage basis), is ranked as both the world's largest coal producer (47.4 per cent) and consumer (50.3 per cent) but with only a reported reserves to production of 31 years (Ref 3 pages 30, 32, 33);

c. India is among the largest reserve holders, but also its coal imports are rising, due to the low quality of domestic coal reserves which contain up to 70 per cent of ash (Ref 5 page 12);

d. Only about 10-15 per cent of world coal production is sea-traded. Trade volumes more than doubled over the last decade. This rising demand was predominantly supplied by two nations:

    i. Australia, the world's largest exporter of coking coal for steel production; and

    ii. Indonesia, the world's largest exporter of steam coal for power generation.

e. Future world coal trade volumes will predominantly depend on Australia and Indonesia;

f. The quality of mined coal will gradually decrease over time;

g. Global coal production is expected to peak around 2020, greatly influenced by China's expected coal production peaking at around this time (Ref 5 page 12).

Section 8: NSW coal supply outlook

1. NSW coal reserves are estimated at 16.64 giga-tonnes, representing 44 per cent of Australia's black coal reserves (Ref 13, paragraph 2.37). The NSW Government Resources and Energy website recently stated "*NSW recoverable coal reserves total over 11.5 billion tonnes ...*"
2. NSW saleable coal production was at:
   a. In 2009-10: 145 mega-tonnes (Ref 13 paragraph 2.38);
   b. In 2013-14 196 mega-tonnes (Ref 16).
3. NSW coal export capacity is at:
   a. Newcastle coal-loaders T1+T2+T3: 202 mega-tonnes per year
      Newcastle coal-loaders T1+T2+T3+T4: 280 mega-tonnes per year
      Terminal T4 subject to planning approval (Ref 17 and 18)
      Further future upgrades proposed: 331 mega-tonnes per year
   b. Port Kembla coal-loader: 17.5 mega-tonnes per year
      Stage 1 Upgrade (in 2013) to: 22.5 mega-tonnes per year
      Stage 2 Upgrade (proposal): 25.5 mega-tonnes per year
      (Ref 18).
4. NSW coal consumption was at:
   a. For electricity generation in 2009-10: 28.66 mega-tonnes
      (Ref 13 paragraph 2.38)
   b. For electricity generation in 2013-14: ~30 mega-tonnes.
5. If New South Wales coal production plateaus at 200 mega-tonnes per year then reserves to production would be:
   a. Optimistically: 16.64 ÷ 0.2 = 83.25 years; or
   b. Less optimistically: 11.5 ÷ 0.2 = 57.5 years.

6. New South Wales export demand is forecast to increase (Ref 18):
   a. From: 123 mega-tonnes per year in 2011;
   b. To: 182 mega-tonnes per year in 2021; and
   c. To: 270 mega-tonnes per year in 2013.
7. If New South Wales coal exports continue to increase and NSW coal production reaches 330 mega-tonnes by about 2020, maximising NSW export capacity plus domestic consumption, then reserves to production would be about:
   a. Optimistically: 16.64 ÷ 0.33 = 50.4 years; or
   b. Less optimistically: 11.5 ÷ 0.33 = 34.8 years.

   Although this production rate scenario is probably at the extreme end of possibility it is an illustration of how rapidly NSW coal resources could be depleted if left unmanaged.
8. **New South Wales coal reserves include a significant proportion that reside under prime agricultural lands and other critical land uses**. If these lands are preserved and excluded from coal extraction then **uncontested coal reserves would be significantly smaller and therefore depleted sooner – perhaps within three decades**. The question that needs to be answered is whether we wish to destroy productive lands for perhaps forever in order to gain only a few decades of energy from coal underneath.
9. With perhaps only a few decades of affordable to extract coal supplies remaining in NSW, and assuming price controls could be maintained domestically with regulation in NSW, coal to liquids (CTL) and coal to gas (CTG) production options that may be considered would still seem a high risk proposition.

Section 9: Alternative energy solutions

As it can be seen in the previous sections of this submission our civilisation is currently critically dependent on fossil fuels (oil, natural gas and coal) for our primary energy needs. It appears on available evidence probable that a post-peak fossil fuel world will arrive before 2030. If humanity continues to carry on business as usual, continuing to rely heavily on fossil fuels for our primary energy needs into the next decade and beyond, then there will be probably insufficient energy supplies available to meet demand, and then a bleak future is assured. Nothing happens without energy.

Any alternative energy solutions must be safe, reliable, affordable, deployable and operational at scale to substantially reduce our dependency on fossil fuels within a decade timeframe in order to be effective at avoiding an energy crisis.

The conclusions relating to technology choices are as follows:

1. **Nuclear fission energy** – highly unlikely to be viable in Australia within a ten year period for the following reasons:
    a. Nuclear power generation is prohibited by the current *Australian Radiation Protection and Nuclear Safety Agency Act 1998*. A completely new legal and regulatory framework would need to be established, with the acceptance by the majority of the electorate;
    b. Only governments, and therefore taxpayers, will underwrite a nuclear industry, and pay dearly if dire incidents occur. This also requires an acceptance by the majority of the electorate;
    c. There is currently minimal nuclear power generation technical and engineering expertise within Australia. An extensive recruitment

programme would be required to establish a completely new, highly complex industry;

d. Nuclear power generators require ten years minimum to plan, construct and commission (Ref 19), with some requiring almost twice as long (Ref 21 Table 2.3). This point together with the previous point would suggest any electricity generated by nuclear fission within Australia would probably be close to two decades away from when the decision was made to proceed;

e. There is approximately 100 years global supply of uranium remaining at current rate of consumption, and uranium fuel prices will continue rising. Currently, global production of uranium ores is not meeting demand by existing operational nuclear power generators. Additional nuclear fuel is being sourced from the reprocessing of nuclear waste and the demobilisation of nuclear warheads (Ref 5 pages 124-127). Additional demand from Australia or other countries intending to expand their nuclear industry will necessarily reduce supply depletion times, exacerbate existing strains on providing adequate nuclear fuel for current demands and increase fuel prices further;

f. Thorium-based nuclear power generation is not proven technology to date. There are no thorium power generators currently operational and therefore at this point in time it cannot be assumed that this technology is or will be a viable, cost-competitive alternative energy source in the foreseeable future. The UK National Nuclear Laboratory's position paper (Ref 20 page 5) stated this assessment as follows:

> *"It is estimated that it is likely to take 10 to 15 years of concerted R&D effort and investment before the Thorium fuel cycle could be established in current reactors and much longer for any future reactor systems."*

2. **Wave, tidal and enhanced geothermal energy** – on the horizon but as yet have not overcome all technical hurdles nor have they been demonstrated at scale.
3. **Wind, solar photovoltaic and concentrating solar-thermal with storage** – commercially proven, scalable, safe, reliable and affordable solutions are available now for deployment. The *Zero Carbon Australia Stationary Energy Plan* (Ref 21) provides a fully costed and detailed system of concentrated solar thermal plants and large scale wind farms with an upgraded national electricity grid. It demonstrates the case that with commercially available and proven technologies renewable energy can fully provide for Australia's electricity generation needs within 10 years.
4. **Hydro** – commercially proven but limited by topographical, geological and climate conditions. Better suited to supplying backup and balancing power with wind and solar.
5. **Biomass** – limited in their scalability due to environmental considerations. Better suited to supplying backup and balancing power with wind and solar.
6. **Demand reduction measures** – by reducing energy consumption with increased energy efficiency measures and peak demand management less energy is required to be produced and transmitted. Less energy required to be produced means savings can be made in energy generation and/or transmission infrastructure. The *Zero Carbon Australia Buildings Plan* (Ref 22)

provides a detailed strategy to substantially increase the energy efficiency of Australia's building stock and reduce Australia's overall energy consumption.

7. **Alternatives to petroleum liquid fuels** – projected declining petroleum fuel availability means there are enormous challenges for transport systems, particularly aviation, and for agriculture. This appears to be the most difficult challenge for our civilisation and there are no easy solutions. Deploying technologies that avoid using petroleum fuels, such as electrified rail and battery-electric and hydrogen fuel-cell vehicles, at scale would reduce the consumption of petroleum fuels significantly. The *Zero Carbon Australia High Speed Rail* proposal (Ref 23) provides a detailed rapid rail network connecting the major capital cities and regional centres along the Australian east coast corridor between Melbourne, Sydney and Brisbane.

Section 10: Conclusion

This submission shows that total world fossil fuel supply is close to peak. Declining oil production will create a rising energy deficiency that coal and natural gas will be unable to compensate for.

The hype about huge reserves in the Caspian Sea, or the deep sea discoveries in the Gulf of Mexico, or tar sands in Alberta, or the soon to end boom in shale oil and gas in the USA, or recent news of shale gas in Australia, cannot dispel the fact that the era of cheap and abundant fossil fuels is coming to an end. These new frontiers create more problems than being solutions to problems they promise to solve.

New South Wales oil, natural gas and coal supplies are influenced by international markets and so any disturbance in global supply and demand will be felt locally.

Angus Place colliery's change from production to 'care and maintenance' status (Ref 24) has been as a consequence of declining international coal prices brought on by an over capacity in global coal production. Other Australian coal producers are also experiencing difficulties. This will be a temporary situation as US coal production will probably decline further and China's coal production peaks and then begins a steep decline. There are already indications China may peak earlier, although this seems at the moment more to do with demand than with supply (Ref 25).

New South Wales has minor natural gas reserves of its own. It is heavily dependent on importing gas from other states where production is either in decline (i.e. Victoria, South Australia) or committed to exporting large quantities to other countries (i.e. Queensland) and the outlook for global gas production is for it to probably peak on or around 2020. Perhaps the unthinkable must be thought and NSW abandons domestic gas consumption over a planned transition timeframe of a decade or two.

The rapid fall in international oil prices in recent weeks is also temporary. If relatively low oil prices are sustained for months the economic viability of many 'unconventional' oil production projects will be severely challenged as well as 'conventional' oil exploration and development (Ref 26 and 27) and may ultimately precipitate a collapse in 'unconventional' oil production. If this scenario eventuates then total liquid fuel production will fall and bring forth instability in the liquid fuel supply and demand dynamic resulting in fuel price instability. Instability in energy prices will have an adverse effect on economic activity, politics and society.

Rather than seeing this as a doom and gloom outlook, this should be taken as an extraordinary opportunity to transition to a cleaner, sustainable future. It forces us to take action by reducing consumption of fossil fuels. A similar response is required to mitigate climate change, which reinforces the need more so for prompt action.

Therefore it is imperative that we face these challenges without equivocation and start in earnest to transition towards a sustainable energy supply. The longer we try to delay the transition required, by pursuing dead end solutions (and consuming limited resources) which are aimed at protecting and prolonging vested interests, the more we face the risk of falling off the 'energy cliff' with severe to potentially catastrophic disruptions to our economy, politics and society.

It is hoped that the Select Committee membership heeds this message presented and succeeds in convincing the NSW Government to begin the actions required. Failure by governments, industry and the community to respond competently, effectively and in a timely manner to these challenges will inevitably have a negative effect on the lives of millions of people in the state of New South Wales and the larger Australian population in the coming decade. **We must not fail.**

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Note: All references listed above were accessed using the respective web address Uniform Resource Locators (URLs) on 17 Dec 2014. If any of the links fail please try using an appropriate web search engine together with the respective bold text reference title.

Numbering system and conversion factors

Numbering System

Multiples of energy measurements in Australia are expressed in Le **S**ystème **I**nternational d'Unités (SI) multiplier classification terms:

Multiple	Scientific Expression	SI Term	SI Abbreviation
Thousand	10^3	kilo	k
Million	10^6	mega	M
Billion	10^9	giga	G
Trillion	10^{12}	tera	T
Quadrillion	10^{15}	peta	P

Fuel-specific to standard unit conversion factors (Ref 12 page 54)

Oil and condensate	1 barrel	=	158.987 litres
	1 giga-litre	=	6.2898 mega-barrels
	1 tonne	=	1250 litres (local)
		=	1160 litres (imported)
Ethanol	1 tonne	=	1266 litres
Methanol	1 tonne	=	1866 litres
LPG – average	1 tonne	=	1760 – 1960 litres
LPG – naturally occurring	1 tonne	=	1886 litres
Natural gas	1 cubic metre	=	35.315 cubic feet
Liquefied natural gas	1 tonne	=	2174 litres

Energy content conversion factors (Ref 12 pages 54-55)

a) Gaseous fuels	Peta-joules / billion cubic feet	Mega-joules / cubic metre
Natural gas		
- Victoria	1.0987	38.8
- Queensland	1.1185	39.5
- Western Australia	1.1751	41.5
- South Australia / NSW	1.0845	38.3
- Northern Territory	1.1468	40.5
- Average (Australia)	1.1000 (54 GJ/t)	38.8
Ethane (average)	1.6282	57.5
Town gas		
- synthetic natural gas	1.1043	39.0
- other town gas	0.7079	25.0
- Coke oven gas	0.5125	18.1
- Blast furnace gas	0.1133	4.0

b) Liquid fuels	Peta-joules / million barrels	**By volume** Mega-joules / litre	**By weight** Giga-joules / tonne
Crude oil and condensate			
- indigenous (average)	5.88	37.0	46.3
- imports (average)	6.15	38.7	44.9
LPG			
- propane	4.05	25.5	49.6
- butane	4.47	28.1	49.1
- mixture	4.09	25.7	49.6
- naturally occurring (average)	4.21	26.5	49.4
Other			
- LNG (North West Shelf)	3.97	25.0	54.4
Naphtha	4.99	31.4	48.1
Ethanol	3.72	23.4	29.6
Methanol	2.48	15.6	19.7

c) Solid fuels	Giga-joules / tonne
Black coal	
- New South Wales	
Exports – metallurgical coal	29.0
Exports – thermal coal	27.0
Electricity generation	23.4
Other	23.9 – 30.0
- Queensland	
Exports – metallurgical coal	30.0
Exports – thermal coal	27.0
Electricity generation	23.4
Other	23.0
- Western Australia	
Thermal coal	19.7
- Tasmania	
Thermal coal	22.8
Lignite (Brown coal)	
- Victoria	9.8
Briquettes	22.1
- South Australia	15.2
Uranium*	
Metal (U)	560 000
Uranium Oxide (U_3O_8)	470 000
Other	
Coke	27.0
Wood (dry)	16.2
Bagasse	9.6

Note: *Usable energy content. Oxide contains 84.8 per cent of the metal by weight.