Submission
No 215

SUSTAINABILITY OF ENERGY SUPPLY AND RESOURCES IN NSW

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Submission

to the

New South Wales Parliament

Legislative Assembly Standing Committee on Environment and Planning:

Inquiry into sustainability of energy supply and resources in NSW

by

Geoffrey Miell

15 September 2019

Inquiry Terms of Reference

That the Committee on Environment and Planning inquire into and report on the sustainability of energy supply and resources in NSW, including:

1. The capacity and economic opportunities of renewable energy.
2. Emerging trends in energy supply and exports, including investment and other financial arrangements.
3. The status of and forecasts for energy and resource markets.
4. Effects on regional communities, water security, the environment and public health.
5. Opportunities to support sustainable economic development in regional and other communities likely to be affected by changing energy and resource markets, including the role of government policies.
6. Any other related matters.

Declaration

The collector of information/data for and producer of this document, Geoffrey Miell, is a born and raised Australian citizen, residing in the state of New South Wales.

He has a degree of Bachelor 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.

This submission contains many elements of Submission #9 to the Australian Parliament Senate Select Committee into Fair Dinkum Power, by this author, dated 15 February 2019, with more recent data included.

More detailed information about nuclear-fission energy by this author was provided on 9 September 2019 as a Submission to the Australian Parliament House of Representatives Standing Committee on Environment and Energy Inquiry into the prerequisites for nuclear energy in Australia.

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

Key "Take Home" Messages

Energy is fundamental to life and essential for our society's economic prosperity. We need energy for food production and processing. Our civilisation requires energy for lighting, heating, cooling, transportation, communication, building, manufacturing, mining, exploration, medical endeavours and leisure pursuits. **Nothing happens without energy. Unaffordable energy means life becomes unaffordable.**

The *IPCC SR1.5°C* report warns that **human-induced climate change is now an existential risk to human civilisation.**

Current Paris Climate Agreement pledges are not on track to limit global warming to 1.5°C above pre-industrial levels.

To avoid worst outcomes, global carbon emissions must peak by 2020, then must be cut by half by 2030, and then to net-zero by 2050.

Existential Goal: Humanity must leave petroleum oil, fossil natural gas, and coal, before 2050 (preferably sooner), to mitigate dangerous climate change.

Adequate new 'firm' generating capacity must be built in a timely manner to replace the outgoing/retiring generating capacities, otherwise the risk of blackouts and higher electricity prices will increase in the 2020s and beyond. Doing nothing is not a viable, responsible, energy secure option.

Any new low-carbon energy technologies must be rapidly deployable. **Renewables can be deployed faster than new coal- and nuclear-based generation.**

As renewable energy costs continue to decline, energy storage remains key to solving the problem of intermittency but there is a clear path forward for economic viability.

CSP is an emerging technology that's demonstrating around the world that it can provide affordable, reliable, 'dispatchable' capacity supply, that can displace baseload generators like coal-fired and nuclear-fission power plants quickly.

Nuclear-fission-based energy in Australia makes no economic or timely energy security sense when there are other abundant, cheaper, more rapidly deployable, reliable, safer/lower-risk energy technology alternatives.

CCS fails technologically, economically, and as a pollution reduction measure.

The sooner Australia rapidly reduces its dependency on petroleum-based fuels by transitioning to battery-electric and hydrogen-fuel-cell vehicles powered from renewable energy, the more energy secure Australia will be.

Existential Goal: Humanity must leave petroleum oil before oil leaves us.

In November 2018, Australia surpassed Qatar to become the world's largest LNG exporter. Australia's rapidly increasing gas production over the last few years (15.3% growth in 2018) serves to deplete its limited gas reserves (1.2% global share, ranked world's 12th largest in 2018) much sooner.

Existential Goal: Humanity must leave fossil natural gas before gas leaves us.

New energy technologies must have adequate EROI to sustain our civilisation.

New energy technologies must have net-zero carbon emissions

The *IPCC SR1.5°C* report warns that **human-induced climate change is now an existential risk to human civilisation**:[1] an adverse outcome that will either annihilate intelligent life or permanently and drastically curtail its potential, unless dramatic action is taken.

Countries that accept or 'ratify' the Paris Climate Agreement submit pledges for how they intend to address climate change. **Current pledges are not on track to limit global warming to 1.5°C above pre-industrial levels.**[2]

A world that is consistent with holding warming to 1.5°C would see greenhouse gas emissions rapidly decline in the coming decade, with strong international cooperation and a scaling up of countries' combined ambition beyond current Nationally Determined Contributions (NDCs). In contrast, delayed action, limited international cooperation, and weak or fragmented policies that lead to stagnating or increasing greenhouse gas emissions would put the possibility of limiting global temperature rise to 1.5°C above pre-industrial levels out of reach.

To stay below the upper 2°C temperature increase limit of the Paris Climate Agreement, global carbon emissions would have to peak no later than 2020, then must be cut by half by 2030, and to zero by 2050.[3] This is an unprecedented task, requiring a reduction rate of at least 7 per cent annually. To meet the lower 1.5°C target requires even more rapid reduction. **The only possible response is emergency action to transform our social, economic and financial systems.**

Professor Hans Joachim Schellnhuber, founder of the Potsdam Institute for Climate Impact Research, advisor to German Chancellor Angela Merkel and to Pope Francis, said: "***…climate change is now reaching the end-game, where very soon humanity must choose between taking unprecedented action, or accept that it has been left too late and bear the consequences***".[4]

The urgent task now for New South Wales, Australia, and the world, is to cut carbon emissions far more rapidly than current Paris commitments, exiting the fossil fuel era and accelerating the introduction of low carbon solutions, coupled with demand reduction measures. **What's the impetus for governments, businesses and human society to take effective action? If we (i.e. humanity) don't, then we risk not having markets, sustainable businesses, or an economy, due to the escalating damaging effects of dangerous climate change around the world over the next twenty to thirty years – this is an existential threat to human civilisation.**[5, 6]

New South Wales (and Australia) need to eliminate carbon emissions, sector by sector, beginning with the less challenging and affordable sectors first. Australia's electricity generation sector represents about 35 per cent of total emissions, land transport is about 13 per cent, and low temperature heat is about 7 per cent.[7]

Existential Objective: Humanity must leave petroleum oil, fossil natural gas, and coal, before 2050 (preferably sooner), to mitigate dangerous climate change.

National Energy Market's ageing coal-fired electricity generator fleet

The information contained in the table below is sourced from the Australian Senate Environment and Communications References Committee inquiry into the Retirement of coal fired power stations, which published a *Final Report* in March 2017.[8]

Rank Number	Power station (>140 MW capacity) ranked oldest to youngest	State	Primary fuel type	Commissioning date(s)	Nameplate capacity (MW)	Announced closure year	Years to announced closure, OR on reaching 50 years old
1	Liddell	NSW	Black coal	1971-73	2,000	2023	< 4
2	Yallourn W	VIC	Brown coal	1975 & 1982	1,480	ND	< 7
3	Gladstone	QLD	Black coal	1976-82	1,680	ND	< 8
4	Vales Point B	NSW	Black coal	1978	1,320	ND	< 10
5	Eraring	NSW	Black coal	1982-84	2,880	ND	< 14
6	Bayswater	NSW	Black coal	1982-84	2,640	2035	< 17
7	Tarong	QLD	Black coal	1984-86	1,400	ND	< 16
8	Loy Yang A	VIC	Brown coal	1984-87	2,210	2048	< 30
9	Callide B	QLD	Black coal	1989	700	ND	< 21
10	Mt Piper	NSW	Black coal	1993	1,400	ND	< 25
11	Stanwell	QLD	Black coal	1993-96	1,460	ND	< 25
12	Loy Yang B	VIC	Brown coal	1993-96	1,026	ND	< 25
13	Callide C	QLD	Black coal	2001	810	ND	< 33
14	Millmerran	QLD	Black coal	2002	851	ND	< 34
15	Tarong North	QLD	Black coal	2002	443	ND	< 34
16	Kogan Creek	QLD	Black coal	2007	750	ND	< 39

Note: **ND** = Not disclosed. On 2 Aug 2019, AGL announced that the first unit at Liddell will close in April 2022 and the remaining three units will now close in Apr 2023. On 4 Sep 2019, EnergyAustralia announced that Mt Piper would be reducing operations to conserve coal due to an "acute coal shortage".

Internationally, only 1% of power stations in operation are older than 50 years.[9]

Within 10 years, it's likely that Liddell (NSW), Yallourn W (VIC), Gladstone (QLD), and Vales Point B (NSW) could all be retired, representing a loss of up to 6,480 MW of generating capacity that have been contributing to the National Energy Market (NEM).

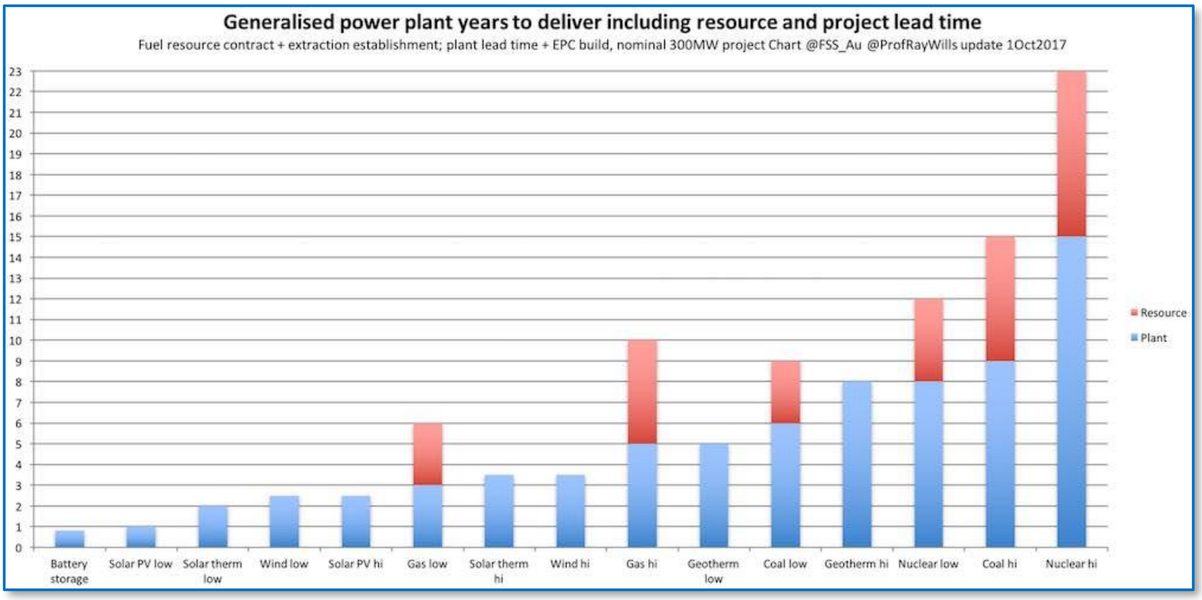
Within 20 years, it's likely that Eraring (NSW), Bayswater (NSW), and Tarong (QLD) could all be retired, representing a further loss to the NEM of up to 6,920 MW of generating capacity.

Coal supplies within the Lithgow Local Government Area (LGA) appear inadequate to sustain Mt Piper Power Station's operations for another quarter century.[10]

Adequate new 'firm' generating capacity must be built in a timely manner to replace the outgoing/retiring generating capacities, otherwise the risk of blackouts and higher electricity prices will increase in the 2020s and beyond. Doing nothing is not a viable, responsible, energy secure option. NSW's energy sector is ageing and apparently ill-prepared for the energy transition.[11]

New low-carbon energy technologies must be rapidly deployable

Given the necessity to rapidly reduce carbon emissions ASAP, **any new low-carbon energy technologies must be rapidly deployable.** The graph below indicates how long it takes to deliver a range of different types of electricity generation plant.



Source: https://reneweconomy.com.au/graphs-day-wind-fast-solar-faster-batteries-fastest-68311/

Battery storage is fastest to deploy, then solar-PV, then wind. Solar thermal with energy storage is quicker to deploy than coal-fired plants. Nuclear is the slowest by far and should not be considered a timely solution for rapid emissions reduction. Pumped-hydro energy storage (PHES) is absent (perhaps being site dependent?).

Solar and wind technologies are lowest-cost new-build technology

The CSIRO and AEMO collaboratively published their inaugural *GenCost 2018* report in December 2018, confirming that while existing fossil fuel power plants are competitive due to their sunk capital costs, solar and wind generation technologies are currently the lowest-cost ways to generate electricity for Australia, compared to any other new-build technology.[12]

The calculated Levelized Cost of Energy (LCOE) by technology and category for 2020 shows wind and solar-PV 'firmed' with 6 hours of PHES is competitive with high emissions gas, brown and black coal flexible 40-80% load with no carbon price.[13]

Lazard's Levelized Cost of Energy Analysis – Version 12.0, published November 2018, one of the major global industry benchmarks, infers that an inflection point has been reached where, in some cases, it is more cost effective to build and operate new alternative energy projects than to maintain existing conventional generation plants. Lazard's figures are based on US data and US conditions but provides an insight into global trends.[14]

As alternative energy costs continue to decline, energy storage remains key to solving the problem of intermittency but there is a clear path forward for economic viability.[15]

Concentrating solar power (CSP): an emerging 'dispatchable' tech

The emerging benefits provided by CSP with molten salt thermal energy storage technology for new low-carbon energy technologies are:

- **Energy and Capacity Value:** CSP with molten salt energy storage enables the transition from fossil fuel- to renewable energy-based generation, providing energy security, network strengthening and wholesale price stability. **With enough storage, CSP enables reliable capacity supply, to replace baseload generators like coal-fired and nuclear power plants and operate at high capacity factor.**
- **Ancillary Services:** CSP with storage can provide frequency regulation, "spinning reserve", non-spinning reserve, load following services, and black start capability.
- **Intrinsic Stability:** CSP with storage offers fault ride-through capability, frequency response, and voltage / Volt-Amp Reactive support, complementing high percentages of intermittent renewables.
- **Risk Management:** CSP hedges against future electricity price increases (as it has no fuel cost). CSP hedges against the future cost of integrating a high percentage of renewables into the grid – typically socialised in the cost of transmission upgrades and interconnectors and the implementation of higher reserve margins. **Weather conditions will only affect the number of operating hours – the MWh delivered per day – but will not affect the MW capacity that the system produces.** CSP can also change its behaviour mid-life, 10 or 20 years after commencing operations, to adapt to new market realities.[16]
- **Affordable, 'dispatchable' electricity:** South Australia's Aurora project's lone 150 MW capacity generator unit with 8 hours (1,100 MWh) storage, was contracted to supply electricity **capped at AU$78/MWh**,[17] but couldn't complete.[18] Multiple concurrent-built CSP generator units, with larger capacities and more storage[19] may supply wholesale 'dispatchable' electricity at significantly lower prices in future.

CSP is an emerging technology that's demonstrating around the world that it can provide affordable, reliable, 'dispatchable' capacity supply, that can displace baseload generators like coal-fired and nuclear-fission power plants quickly.[20]

Crescent Dunes Solar Energy Project, Nevada, USA. 110 MW with 10 hours (1,100 MWh) full load storage (SolarReserve)

Nuclear: mistimed, expensive and long-term unsustainable choice

Some reasons that strongly indicate that nuclear-fission energy for Australia is a mistimed, expensive, and long-term unsustainable energy choice are:

1. Nuclear power generation within Australia is currently prohibited by Federal Australian law, specifically:
   a. *Australian Radiation Protection and Nuclear Safety Agency Act 1998*; and
   b. *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*.[21]

   A completely new legal and regulatory framework would need to be established, with the acceptance of most of the Australian electorate. Much political 'argy-bargy' is required. **This will take time that Australia simply doesn't have.**
2. **Only governments, and therefore taxpayers, will underwrite a nuclear power industry; and pay dearly if dire incidents occur.** This also requires an acceptance by most of the Australian electorate.
3. There's currently minimal nuclear power generation technical and engineering expertise within Australia. An extensive recruitment programme (likely sourcing key skilled personnel primarily from overseas) would be required to establish a completely new, highly complex industry.
4. Large-scale nuclear power generators require 7.7 years on average to construct.[22] This point, together with the required planning process and the other points above, would suggest any electricity generated by **nuclear-fission within Australia would probably be closer to 15–20 years away from when the decision was made to proceed.**[23] With many ageing Australian coal-fired power stations due to retire within this timeframe (beginning with NSW's 2000 MW Liddell power station in 2022-23), deploying nuclear power would take much too long. **Australia cannot afford to wait for nuclear power to become available if it needs to keep the lights on in the 2020s, and beyond.**
5. New nuclear fission-, gas- and coal-based electricity generation technologies are now decisively more expensive than new renewables (wind and solar-PV) with 'firming'[24] – **the economics and deployment times required renders the nuclear-fission energy option unappealing for Australia.**
6. There's approximately <100 years global supply of high-grade uranium ores remaining.[25] **Nuclear fuel costs will continue to rise as finite, lower cost, easier-to-extract, higher concentration and higher quality ores are progressively depleted.** An aggressive expansion of global nuclear power plant capacity **cannot be adequately fed with the required nuclear fuel** over the expected operational lifetimes of the reactors that would need to be built.[26]
7. **The thorium nuclear fuel cycle is immature, not yet self-sustaining, and is decades away from viability, if ever.**[27] Thorium lacks a fissionable isotope – it's impossible to start any fission chain reaction solely on mined thorium.
8. Nuclear-fission energy produces nuclear waste that needs to be safely contained for tens of thousands to billions of years (for high level waste).[28] Few

people in Australia want a permanent nuclear waste repository near them.[29] Due to strong resistance by local communities to various proposals, the Federal Government is having little success to date at establishing a permanent low and intermediate level nuclear waste repository in Australia (with anticipated operations over 100 years and monitoring up to a 300-year lifespan) for dealing with waste generated from various sites including the Lucas Heights research reactor facility and nuclear medicine facilities at various hospitals around the country. **Establishing a nuclear power generation industry in Australia would likely produce much greater quantities of nuclear waste that need to be safely contained for a very long time, burdening future generations.**

Nuclear fission-based energy in Australia makes no economic or timely energy security sense when there are other abundant, cheaper, more rapidly deployable, reliable, safer/lower-risk energy technology alternatives. Establishing a nuclear power generation industry in Australia only makes sense if the objective is to source adequate quantities of key materials necessary for nuclear weapons production to perhaps mitigate a perceived strategic military threat.

CCS fails technologically, economically and for pollution reduction

There are three reasons why Carbon Capture and Sequestration (CCS) is not a viable option:

1. **It doesn't work.** Some examples that have tried and failed include:
    a. Southern Company's Kemper "clean coal" plant in Mississippi, USA – US$7.5 billion;[30]
    b. SaskPower's Boundary Dam 110 MW unit CCS plant in Saskatchewan, Canada – C$1.4 billion;[31]
    c. Queensland government's Stanwell ZeroGen CCS retrofit project abandoned – AU$96.3 million.[32]
2. **It's more expensive to produce energy with CCS than without.** Significantly more fuel is consumed, and a substantial quantity of energy diverted to operate the associated CCS equipment for a given net output, compared with a generator unit without CCS. New renewables with 'firming' are now cheaper than new gas and coal electricity generator technologies without CCS, and cheaper than existing gas and coal plants with retro-fitted CCS. There's simply no economic benefit for coal- and/or gas-fired generators to utilise CCS.
3. **CCS will not stop all CO_2 emissions entering the environment.** CCS doesn't capture 100 per cent of a plant's emissions. Any emissions that are captured need to be captured forever. Any storage site will inevitably leak (whether that's in a few years' time, decades, centuries, millennia, or more) posing ongoing toxic air pollution risks to people and the environment nearby. CCS does nothing to reduce methane and dust emissions during extraction and transportation of coal and does nothing to reduce dust from the disposal of fly ash after the coal is burnt.

CCS fails technologically, economically, and as a pollution reduction measure.

New energy solutions must compensate for global post- 'peak oil'

Evidence indicates global supplies of petroleum oil are likely to peak soon (i.e. 2020s), then begin a sustained decline. New energy solutions must take up the energy supply slack as the transition away from petroleum-based fuels progresses.

Per *BP Statistical Review of World Energy 2019*, from pages 14 and 16, **the world's top ten oil producing countries in 2018** were as indicated in the table below:[33]

Rank	Country	2018 Oil Production – Annualised Average (*x10⁶ barrels / day*)	Global Share (%)	Proved Reserves-to-Production At end-2018 (*years*)
—	**World**	**94.718** (▲ +2.4%)	**100.0**	**50.0**
1	USA	**15.311** (▲ +16.6%)	16.2	**11.0**
2	Saudi Arabia	**12.287** (— +3.3%)	13.0	66.4
3	Russian Federation	**11.438** (▲ +1.6%)	12.1	**25.4**
4	Canada	**5.208** (▲ +8.5%)	5.5	88.3
5	Iran	**4.715** (▼ -6.1%)	5.0	90.4
6	Iraq	**4.614** (▲ +1.8%)	4.9	87.4
7	United Arab Emirates	**3.942** (— +0.8%)	4.2	68.0
8	China	**3.798** (▼ -1.3%)	4.0	**18.7**
9	Kuwait	**3.049** (— +1.6%)	3.2	91.2
10	Brazil	**2.683** (— -1.4%)	2.8	**13.7**

Includes crude oil, shale oil, oil sands and NGLs. Excludes liquid fuels from other sources such as biomass, CTL and GTL.

The world's top five oil producers represent more than one half (51.7%) of global share, and the top ten represent more than two-thirds (70.8%) of global share.

USA, Canada, Iraq and Russian Federation are oil producers currently at pre-peak (i.e. still increasing production year-by-year). Saudi Arabia, Kuwait, UAE and Brazil are currently at peak (i.e. production is on a bumpy plateau). Iran's production has dropped due to the oil embargo. China's oil production has declined since 2015.

Many oil producing countries are now 'post-peak', including Australia, which peaked in year-2000,[34] and has declined since then, now producing only 0.3% global share (in 2018) yet consumes 1.1% global share.[35] More than 90% of Australia's transport liquid fuels and crude oil for transport are now imported.[36]

Since about 2012, Australia has not complied with the International Energy Agency's (IEA's) 90-day petroleum fuel stockholding requirement.[37] **From 2010 to January 2019, Australia's in-country petroleum stockholding consumption covers for:**

- **Crude oil:** **from 21 to 32 days**;[38]
- **Diesel fuel:** **from 10 to 22 days**;[39]
- **Turbine (jet) fuel:** **from 13 to 25 days**;[40] and
- **Gasoline (petrol) fuel:** **from 15 to 28 days**.[41]

A balancing act is occurring between declining and growing oil producing countries. The whole system will peak when US shale oil peaks (in the Permian Basin) because of geology, lack of finances in the next credit crisis, and/or other factors, and when Iraq peaks possibly because of social unrest or military confrontation in the oil producing regions. Added risks include continuing disruptions in Nigeria and Libya, steeper declines in Venezuela, and the impact of sanctions on Iran.[42] **Global 'peak oil' supply is inevitable – exactly when is the question.**

World 'conventional' crude oil production has plateaued since about 2005.[43]

US 'unconventional' shale oil is a light oil, not easily converted to diesel, which is the most important transportation fuel, nowadays. It's also ill-suited for producing aviation turbine (jet) fuel and the higher-octane grades of gasoline fuels for high-performance vehicles, unless extensively blended with "heavy" crude oils.[44]

There are too many wrong investment decisions for petroleum-dependent infrastructure being made – NSW (and Australia) are ill-prepared for any disruptions to Australia's petroleum fuel supplies and ultimately, for when global petroleum-based fuel supplies begin an inevitable sustained decline (i.e. a post- 'peak oil' world).

The sooner NSW and Australia rapidly reduce their dependencies on petroleum-based fuels by transitioning to battery-electric and hydrogen-fuel-cell vehicles, and electrified rail, powered from renewable energy, the more energy secure NSW/Australia will be.

Existential Objective: Humanity must leave petroleum oil before oil leaves us.

New energy solutions must compensate for global post- 'peak gas'

Evidence indicates global supplies of fossil natural gas are likely to peak soon (i.e. 2020s), then begin a sustained decline. New energy solutions must take up the energy supply slack as the transition away from fossil natural gas progresses.

Per *BP Statistical Review of World Energy 2019*, from pages 30 and 32, **the world's top ten gas producing countries in 2018** were as indicated in the table below:[45]

Rank	Country	2018 Gas Production – Total Annual *(billion cubic metres)*	Global Share *(%)*	Proved Reserves-to-Production At end-2018 (*years*)
—	**World**	**3,867.9** (▲ +5.2%)	**100.0**	**50.9**
1	USA	**831.8** (▲ +11.5%)	21.5	**14.3**
2	Russian Federation	**669.5** (▲ +5.3%)	17.3	58.2
3	Iran	**239.5** (▲ +8.8%)	6.2	133.3
4	Canada	**184.7** (▲ +4.0%)	4.8	**10.0**
5	Qatar	**175.5** (▲ +1.8%)	4.5	140.7
6	China	**161.5** (▲ +8.3%)	4.2	**37.6**
7	**Australia**	**130.1** (▲ +15.3%)	**3.4**	**** 18.4 ****
8	Norway	**120.6** (— -2.1%)	3.1	**13.3**
9	Saudi Arabia	**112.1** (▲ +2.6%)	2.9	**52.6**
10	Algeria	**92.3** (— -0.7%)	2.4	**47.0**

Includes natural gas produced for GTL transformation. Excludes gas flared or recycled.

The world's top five natural gas producers represent more than half (54.3%) of global share, and the top ten represent more than two-thirds (70.3%) of global share.

Conventional gas production is in decline in Europe (since the 2000s) excluding Norway, and North America (since the 1970s).

Shale gas production in USA is unlikely to see significant further expansion. The nature of shale play developments is that they decline quickly, such that production from individual wells falls 70–90% in the first three years, and field declines without new drilling typically range 20–40% per year. Continual investment in new drilling is required to avoid steep production declines. Shale plays also exhibit variable reservoir quality, with "sweet spots" or "core areas" containing the highest quality geology typically comprising 20% or less of overall play area. Drilling has focussed on these "sweet spots" which provide the most economically viable wells. As these "sweet spots" are exhausted then new shale developments are by necessity left with less productive and more costly areas to exploit.[46]

The Russian Federation, the world's second largest gas producer (not far behind USA), faces a struggle between declining production from ageing fields and new expensive and time-consuming developments in Northern Siberia and offshore. The delayed developments of Shtokmanskoye in the Barents Sea and of other fields in the Yamal Peninsula are unlikely to be enough in the longer-term to compensate for the decline of ageing current fields.

Domestic consumption in Russia and growing demand from Asia will put greater stresses on volumes available for export from Eurasia to Europe in the coming years.

Iran and Qatar are expected to feed the rising demand for liquefied natural gas over the next decades. Though these countries have large reserves, it's highly probable that these reported reserves are exaggerated.[47]

In November 2018, Australia surpassed Qatar to become the world's largest LNG exporter.[48] **Australia's rapidly increasing gas production over the last few years (18% growth in 2017 alone) serves to deplete its limited gas reserves (ranked world's 15th largest in 2018, at 1.2% global share, R/P 18.4 years) much sooner.**

A balancing act is occurring between declining and growing gas producing countries. The whole system will peak when US shale gas peaks (in the Marcellus and Utica plays) because of geology, lack of finances in the next credit crisis, and/or other factors, and adverse weather and geological conditions within the Russian Federation's remote production regions. Added risks include Canada's gas production declining because of geology, and the impact of sanctions on Iran. **Global 'peak gas' supply is inevitable – exactly when is the question.**

Existential Objective: Humanity must leave fossil natural gas before gas leaves us.

In an inevitable global post- 'peak oil' and 'peak gas' supply world, oil and gas will become scarcer and more expensive. Preparation for a contingency oil and gas allocation system is needed to minimize disruptions to critical infrastructure.

How much affordable domestic natural gas does NSW really have?

At a public hearing on 2 February 2015, conducted by the NSW Parliament Legislative Council Select Committee on the Supply and Cost of Gas and Liquid Fuels in NSW, The Hon. Dr. Peter Phelps MLC asked (from page 71 of the corrected transcript, highlighted text for emphasis):[49]

> The known reserves in New South Wales at the moment are extensive. You might need to take this question on notice. At current levels of production and consumption, how long will those reserves last if they are used purely for domestic purposes in New South Wales?

Mr. Paul Fennelly, Chief Operating Officer, Eastern Region for the Australian Petroleum Production & Exploration Association (APPEA) responded with:

> Based on the Australian Energy Market Operator's figures and on today's demand, which obviously will increase, we are saying that we have of the order of 500 years of supply.

Does NSW have "*500 years of supply*"? In the APPEA Submission (#21), authored by Mr. Fennelly for that inquiry, dated 23 December 2014, it states (on page 1):[50]

> NSW has considerable onshore gas potential, Australia's second largest onshore natural gas field is located within the state, yet energy pricing has become a serious and impending challenge. A report undertaken for the Australian Energy Market Operator – *Eastern & Southern Australia: Existing Gas Reserves & Resources*[1] estimated that NSW has up to 85,000 petajoules (PJ) of undeveloped gas resources. To provide context, the state's current demand is approximately 156PJ per annum.

In the Core Energy Group's *Eastern & Southern Australia: Existing Gas Reserves & Resources* document, dated April 2012, that Mr. Fennelly refers to in the APPEA Submission (#21) for that inquiry, **as at 31 December 2011**, it states in:

Table 6.6: Remaining Total Reserves and Resources (PJ) by State.[51]

Basin	Reserves			Contingent Resources (2C)	Prospective Resources
	1P	2P	3P		
NSW	24	2,885	7,130	20,159	85,951
QLD	4,721	39,005	49,689	38,169	93,005
SA	15	1,299	1,379	7,602	109,597
TAS		254	254	239	10,070
VIC	2,501	5,054	5,098	3,631	5,557
Total	**7,261**	**48,497**	**63,550**	**68,800**	**304,108**

Source: Core Energy Group; 2012.
Note: No entry does not mean no reserves / resources, rather it indicates that the company / source has not disclosed
Note: Slight differences in totals can be attributed to rounding.

The *Australian Gas Resource Assessment 2012* definitions for 1P, 2P and 3P Reserves and Contingent and Prospective Resources (on pages 50 to 52) were:

- **1P (or P90):** at least a 90% probability that the quantities actually recovered will equal or exceed the low estimate.
- **2P (or P50):** at least a 50% probability that the quantities actually recovered will equal or exceed the best estimate.
- **3P (or P10):** at least a 10% probability that the quantities actually recovered will equal or exceed the high estimate.
- **Contingent resources** are those quantities of petroleum estimated to be potentially recoverable from known accumulations, but the applied project(s) are not yet considered mature enough for commercial development due to one or more contingencies. Contingent Resources may include, for example, projects for which there are currently no viable markets, or where commercial recovery is dependent on technology under development, or where evaluation of the accumulation is insufficient to clearly assess commerciality.
- **Prospective resources** are those quantities of petroleum estimated to be potentially recoverable from undiscovered accumulations by application of future development projects. Prospective Resources have both an associated chance of discovery and a chance of development. Prospective Resources are further subdivided in accordance with the level of certainty associated with recoverable estimates assuming their discovery and development and may be sub-classified based on project maturity.

At a previous public hearing on 28 January 2015, the then NSW Minister for Resources and Energy, The Hon. Anthony Roberts MP included in his opening statement:[52]

> In 2014 New South Wales consumed some 150.4 petajoules of gas, the average household consumes 18.3 gigajoules per year, approximately 39 per cent of households are connected to mains gas and 12½ per cent are connected to bottle gas. This is a vital energy resource, particularly for eating and cooking for many individuals and families across this great State.

Utilising the information above, and assuming NSW domestic gas production could ramp up quickly to supply all of NSW's 2014 gas demand, then there was potentially:

- **A 90% probability** that NSW had at least: (**24** ÷ 150.4) x 365 = **58.2 days**;
- **A 50% probability** that NSW had at least: (**2,885** ÷ 150.4) = **19.2 years**;
- **A 10% probability** that NSW had at least: (**7,130** ÷ 150.4) = **47.4 years**;
- **Contingent resources** (i.e. not yet commercial)**:** (**20,159**÷ 150.4) = **134 years**;
- **Prospective resources** (i.e. undiscovered)**:** (**85,951**÷ 150.4) = **571 years**.

Was Mr. Fennelly being a supreme optimist when he said (under oath) at that public hearing that NSW had "*of the order of 500 years of supply*" of gas? **Was he describing affordable gas for NSW, or gas at any price?** Mr. Fennelly did not explain his rationale at how he arrived at the figure of "*500 years*", and the Select Committee on the Supply and Cost of Gas and Liquid Fuels in NSW did not seek further clarification on this matter. The Committee's *Report*, tabled on 25 February 2015, noted:[53]

> 3.24 According to Mr Fennelly, based on the AEMO figures and future demand projections, New South Wales has something approaching 'the order of 500 years of supply'.[74]

On 11 September 2019, in an on-air broadcast on Radio 2GB's *Ray Hadley Morning Show*, NSW Minister for Energy and Environment, Matt Kean MP told Ray Hadley:

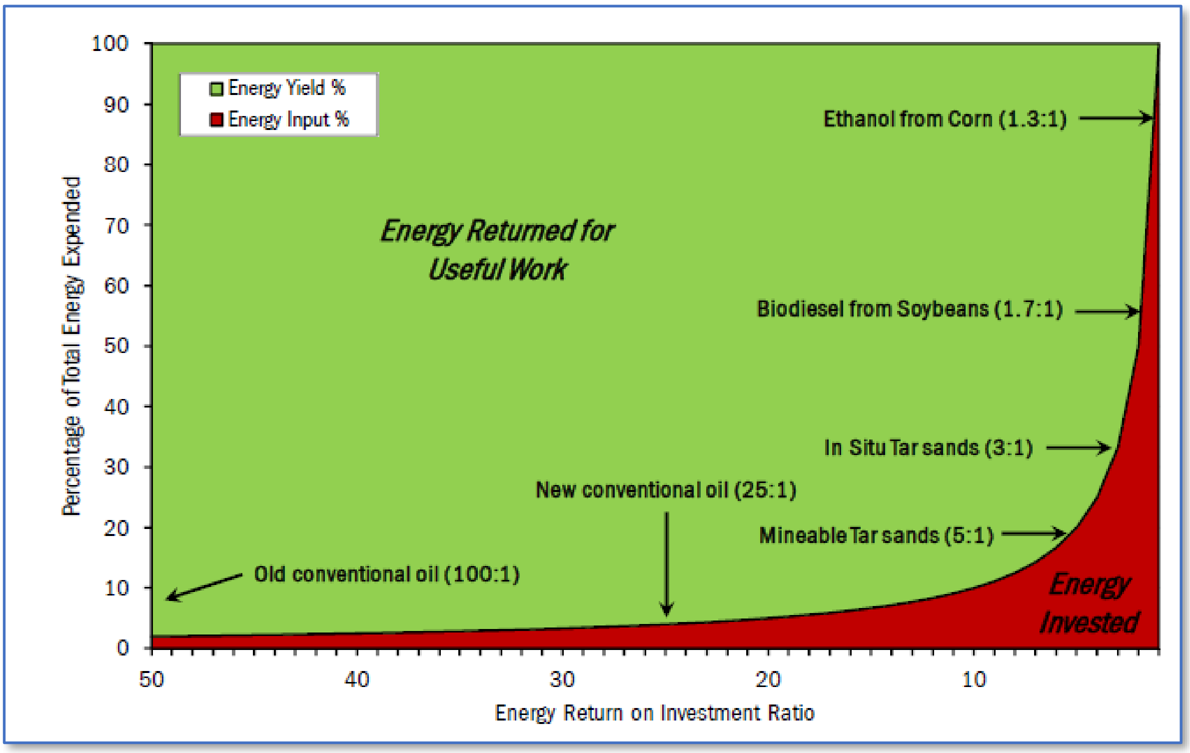
> **"***Well, because we have refused to invest in new gas generation or exploration in New South Wales. We've plenty of gas in this state – about two hundred years' worth of supply – but we are not able to access that, largely because we lost the social licence around things like coal seam gas.***"**[54]

In 2015, Mr. Fennelly stated NSW had "*of the order of 500 years of supply*" of gas. A few days ago, Minister Matt Kean MP publicly stated NSW has "*about two hundred years' worth of supply*" of gas. *BP Statistical Review of World Energy 2019* indicated that the whole of Australia has an estimated proved gas reserves-to-production (R/P) of only 18.4 years (from the end of 2018) and the entire world has only 50.9 years. **Which figures are the most realistic ones? The current Committee inquiry would do well to recognise and highlight the difference between hype and reality.**

Anyway, should NSW be developing new natural gas resources and infrastructure, when human-induced greenhouse gas emissions need to be dramatically reduced? Should the NSW Government be encouraging a rapid transition away from gas developments and gas consumption, particularly when alternative energy solutions are now cheaper?[55]

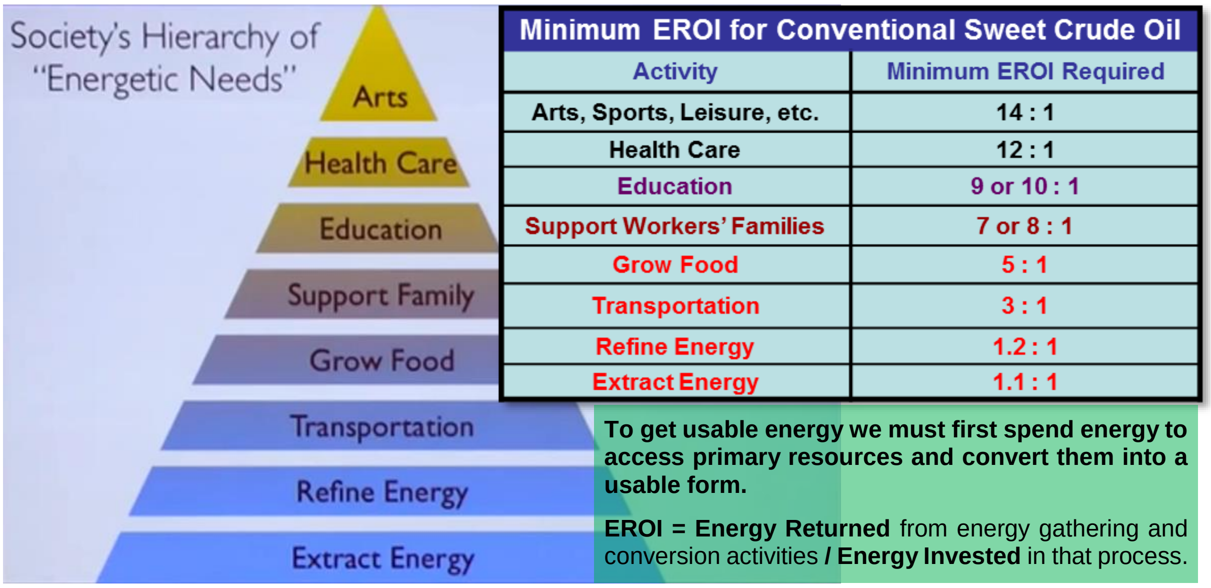
New energy solutions must have adequate EROI

The economy of a modern developed nation slips into recession if its net fuel Energy Return on Investment (EROI) drops below 6:1[56] and starves if EROI drops below 3:1.[57] The inevitable consequence if such low EROIs persist is industrial collapse and regression of civilization to agrarian-age economics (see below). Purposely displacing high-EROI energy sources with anything that returns less than 6:1 is to foolishly and harmfully push economies toward recession and civilization toward regression.[58]



Source: *Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance?* by J. David Hughes, Post Carbon Institute, Feb 2013, p45

The figure below shows the estimated minimum EROIs to sustain various activities:



Minimum EROI for Conventional Sweet Crude Oil	
Activity	**Minimum EROI Required**
Arts, Sports, Leisure, etc.	14 : 1
Health Care	12 : 1
Education	9 or 10 : 1
Support Workers' Families	7 or 8 : 1
Grow Food	5 : 1
Transportation	3 : 1
Refine Energy	1.2 : 1
Extract Energy	1.1 : 1

To get usable energy we must first spend energy to access primary resources and convert them into a usable form.

EROI = Energy Returned from energy gathering and conversion activities **/ Energy Invested** in that process.

Source: https://www.youtube.com/watch?v=teDqDyvnTxc, time interval 0:52:17 to 0:55:37

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