Submission No 20

INQUIRY INTO URANIUM MINING AND NUCLEAR FACILITIES (PROHIBITIONS) REPEAL BILL 2019

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Submission to the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019 Inquiry

by Donald Higson

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I have a BSc and PhD in chemical engineering from Imperial College, London. After working on the development of nuclear submarine propulsion for Rolls-Royce & Associates, I joined the Australian Atomic Energy Commission (now the Australian Nuclear Science and Technology Organisation, ANSTO) in 1964 and specialised in nuclear reactor safety assessment. I have worked as a consultant to the International Atomic Energy Agency (IAEA) on nuclear safety and nuclear material safeguards. In the latter capacity, I created the IAEA's methodology for Probabilistic Assessment of Safeguards Effectiveness (PASE). I am:

- a Fellow, Life Member and former Secretary of the Australasian Radiation Protection Society (ARPS);
- a Fellow of the Institution of Engineers Australia and current Secretary of its (Sydney Branch) Nuclear Engineering Panel;
- a Former Vice President of the Australian Nuclear Association; and
- a Member of the International Nuclear Energy Academy.

I founded the ARPS Newsletter in 1995, after my retirement from ANSTO, and was editor for 10 years.

Summary of my Submission

The Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986 was an inappropriate response to the Chernobyl reactor accident earlier that year. Together with federal legislation that prohibits the development of a nuclear industry in Australia, it has been a significant contributor to our energy crisis. Overseas, the modern nuclear industry has proved itself to be the safest and most affordable way to generate electricity that is reliable and dispatchable; with minimal greenhouse gas emissions or other environmental impacts. There is no justification for prohibiting uranium mining or nuclear facilities in NSW and there are compelling reasons for allowing them to be developed. The Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986 should be repealed without delay to facilitate the prosperity and social benefit of NSW.

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Introduction

This submission is concerned with science, technology and public understanding of these matters, not with politics. It discusses only the generation of electricity by nuclear power. The mining of uranium is an essential part of this industry and has proved to be viable and acceptable in some other parts of Australia. Uranium mining is not discussed separately in this submission.

The NSW Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986 was enacted in response to the nuclear reactor accident that had occurred earlier that year at Chernobyl in the Ukraine, killing 31 workers at the power station (28 due to radiation exposure) and almost certainly causing some thousands of subsequent deaths and injuries due to delayed (latent) health effects, particularly cancers. The exact number of delayed health effects will never be known with certainty because they are indistinguishable from the far greater numbers of similar effects that occur normally for other reasons or for no identifiable reason. An increase in the incidence of thyroid cancer, particularly amongst children, is the only statistically significant physical public health effect that has occurred as a result of the Chernobyl accident [1]. Thyroid cancer is operable and is rarely fatal.

However, although Australia's federal and state legislative responses to this accident were understandable, they were inappropriate because it had no relevance to nuclear power plants elsewhere in the world or to reactors that might be built in Australia. The type of reactor at Chernobyl was badly designed and badly operated and would not have been licensed outside the former USSR. Most important: It did not have a containment structure.

The Chernobyl accident was a failure of soviet technology and regulation at that time, not a failure of nuclear technology in general. A vitally important lesson to be learned from that event is the paramount importance of a proper regulatory authority. Such an authority – the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) – has existed in Australia since 1998.

These mitigating aspects of Chernobyl's significance were just becoming fully realised by the public when the accident at the Fukushima Daiichi nuclear power station in Japan occurred in 2011, reinforcing the perception that nuclear power is unsafe. This was only true to the extent that the plant had not been adequately designed to withstand flooding by a large tsunami. Again, the accident resulted from regulatory failure, which has been fully recognised in Japan itself. Furthermore, although the containment was breached, it did not entirely fail to perform its function. Hence, no radiation-caused injuries were recorded although more than 150 plant workers incurred radiation doses at which there is a small risk of latent health effects.

In Japan, the regulatory infrastructure has been radically improved since the Fukushima accident, and the nation is slowly returning to the use of nuclear power. In Australia, the state and federal prohibitions remain in force.

Elsewhere in the world, particularly in the other advanced industrialised nations of the OECD, nuclear power is providing affordable, reliable, dispatchable supply of electricity without emission of

greenhouse gases, which is just what Australia needs to resolve its energy crisis. Nothing else seems to provide all these qualities in one source of power.

Why <u>not</u> nuclear?

In 2017, I made presentations entitled "Why not nuclear?" to several branches of Engineers Australia in NSW and Queensland, and to a joint meeting of the Australian Nuclear Association and the Australian Institute of Physics in Adelaide [2], in which I discussed reasons "why not" that had been mooted nationally on the grounds of:

- Cost;
- Safety of reactors;
- Proliferation of nuclear weapons;
- Disposal of waste;
- Environmental effects;
- Abundance of alternatives; and
- Limited resources of uranium.

I concluded that, from scientific and technical points of view, none of these issues warranted either the elimination of the nuclear option from consideration or the continuation of anti-nuclear legislation; but that safety, misunderstanding of radiological risks and cost are public issues that need to be addressed.

Disposal of radioactive waste is a political problem, which is outside the scope of this submission. Viable technology exists for safe disposal of the waste from nuclear power overseas for at least as long as it takes for levels of radioactivity to decay to less than those from naturally occurring uranium ore bodies. Australia has some of the best sites in the world for this.

Safety

No source of energy is without risk as illustrated by Table !, which shows figures that were presented at a meeting of the Nuclear Engineering Panel of Engineers Australia, Sydney Branch, on 27 March 2019 by Dr Ron Cameron (former Head of Nuclear Development at the OECD Nuclear Energy Agency), with some minor amendments by me.

The excellent safety record of nuclear power compared with other sources of energy is also illustrated by Figure 1 [3].

There can be no significant release of fission products from a reactor, to cause exposure of people to radiation, unless there is damage to the reactor core (a meltdown). During more than sixty years of civil nuclear power generation throughout the world – in nearly 500 nuclear power plants of various types – there have been only three core-melt accidents, *viz*:

- at Three Mile Island (TMI) in the USA in 1979;
- at Chernobyl in the Ukraine in 1986; and
- at Fukushima in Japan in 2011.

At TMI, the reactor had a proper containment. Hence, there was no radioactive release of any significance to the environment; therefore no significant exposures to radiation and no radiation injuries. If there were to be a core-melt accident in a modern nuclear power station, this would be

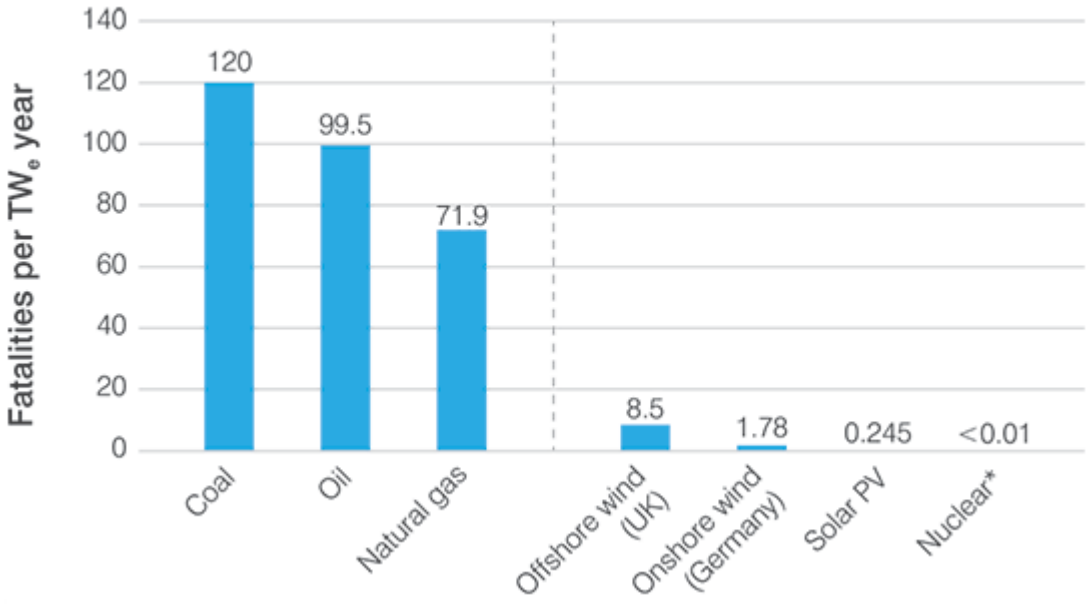
Table 1: Accidents having 5 or more fatalities in fossil, hydro and nuclear power generation* – in the period 1969-2000 unless otherwise stated

Source of Energy	OECD			Non-OECD		
	Accidents	Fatalities	Fatalities/TWy	Accidents	Fatalities	Fatalities/TWy
Coal	75	2,259	157	1044	18,017	597
Coal (China 1994-1999)				819	11,334	6,169
Coal (without China)				102	4,831	597
Oil	165	3,713	132	232	16,505	897
Natural gas	90	1,043	85	45	1,000	111
LPG	59	1,905	1,957	46	2,016	14,896
Hydro	1	14	3	10	29,924	10,285
Nuclear	No such accidents			1	31** (~4,000**)	48 (~6,200)
Total	**390**	**8,934**		**1,481**	**72,324**	

* Solar and wind power generation have also suffered numerous fatal accidents.

**At Chernobyl in1986, there were 30 identified fatalities of workers and one missing, presumed dead. Credible(though speculative) estimates of latent/delayed deaths due to radiation exposure of workers and members of the general public range from 4,000 to 60,000, depending on assumptions about the risk from low dose radiation; but the true figure might be much lower; 4,000 is the figure agreed at the Chernobyl Forum in 1995.

Figure 1: Nuclear has the lowest energy accident fatalities for OECD countries



Source: Paul Scherrer Institut. Data for nuclear accidents modified to reflect UNSCEAR findings/recommendations 2012 and NRC SOARCA study 2015

the likely consequence. And engineers learn from experience: The design of the type of reactor used at TMI was immediately modified to ensure that a similar accident could not happen again.

The accident at Chernobyl was the worst that could happen, *viz*; a full core meltdown in a reactor that had no containment. This has been the only nuclear power plant accident in which deaths due to radiation exposure and public health effects of radiation have been recorded.

There have been no physical health effects of radiation exposure recorded at Fukushima although there was a large release of fission products.

Radiological risks

Much of the opposition to nuclear power stems from the unwarranted fear of low level radiation. By "low level", I mean levels of the same order of magnitude as natural background radiation or not much higher. These are the highest levels to which members of the public are likely to be exposed by the nuclear industry even under accident conditions. Anthropogenic alpha, beta and gamma radiations are physically the same as natural alpha, beta and gamma radiation. Only the level of exposure determines the biological effect, not the source.

The level of natural background radiation at ground level ranges around the world up to at least ten times the average level in Australia and does not correlate with any discernible increase in local incidences of adverse health conditions, such as incidences of cancer. Some of the highest natural radiation levels exist at spa resorts – e.g. Bath in England, Baden in Germany and Ramsar in Iran – where people have been visiting for thousands of years for the good of their health.

Very high levels of anthropogenic radiation exposure, as were incurred by nuclear plant workers and some members of the public at Chernobyl in 1986, are harmful and may be fatal. No physically harmful effects of radiation have been observed at Fukushima since 2011, even amongst workers exposed to radiation from the nuclear power plant at the time. The psychological impacts of both these accidents were high.

Most of the information on the long term biological effects of radiation exposure comes from the Life Span Study of Japanese atomic bomb survivors. These studies are hampered by the fact that around 25% of the population dies from cancer normally and there are no bio-markers to distinguish between cancers that are caused by radiation exposure and cancers that have other causes or are endogenous. The only way to be certain of an effect is when an increase in the incidence of the disease in a cohort correlates with its exposure to radiation. For the most highly exposed bomb survivors, there is an increase from the normal (about 25%) cancer fatality rate to around 30% or more. For minimally exposed bomb survivors, there is either no statistically significant effect or even a reduction of cancer incidence. Nevertheless, it is postulated that high level effects should be extrapolated to low levels – called the "linear no-threshold (LNT) hypothesis".

The LNT model is recommended by the International Commission on Radiological Protection (ICRP) for designing systems of radiation protection, but the ICRP specifically states that it should not be used to estimate the number of casualties from exposure to low levels of radiation caused by accidents.

Despite this *caveat*, the LNT recommendation has been misinterpreted to mean that there is no safe dose of radiation. For example, the South Australian Nuclear Fuel Cycle Royal Commission was told

that 20% of all cancers are caused by natural background radiation. There is no scientific evidence to support this contention. It has been said that “absence of evidence is not evidence of absence”. This is an argument that could be used to support a belief in ghosts, fairies and leprechauns. Anyone is entitled to his or her beliefs but this is not a scientific approach.

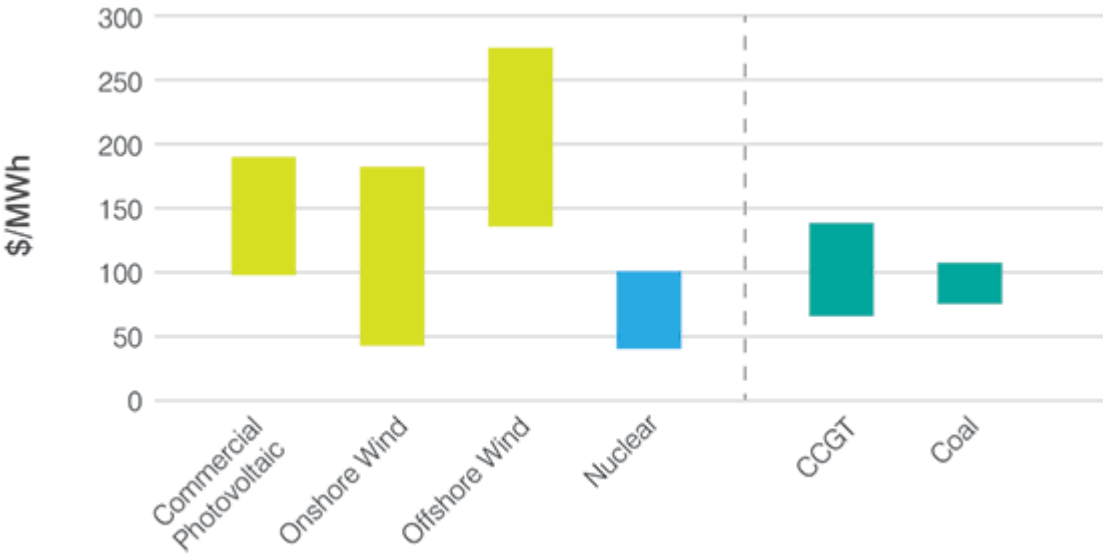
Cost

Cost was not a deciding factor in the prohibition of nuclear related activities in NSW in 1986, but the expectation of high cost might be a disincentive to the repeal of that prohibition. However, high cost would not be a credible expectation: From experience oversea, the cost of nuclear generated power should be expected to be competitive with alternatives, *viz*:

- France, with about 75% of its electricity nuclear-generated, has amongst the cheapest electricity in Europe and is the world’s largest exporter of electricity;
- Germany, which is shutting down its nuclear power plants in response to the Fukushima accident, now has the highest cost of electricity (and the highest carbon emissions) in Europe;
- Japan, faced with the same problems, is slowly returning to nuclear power despite the lingering impact of Fukushima;
- Cheap nuclear power underpins the remarkable industrial success of South Korea; and the Korean KEPCO corporation is building four 1.4GW reactors at Barakah in the gas-rich UAE.

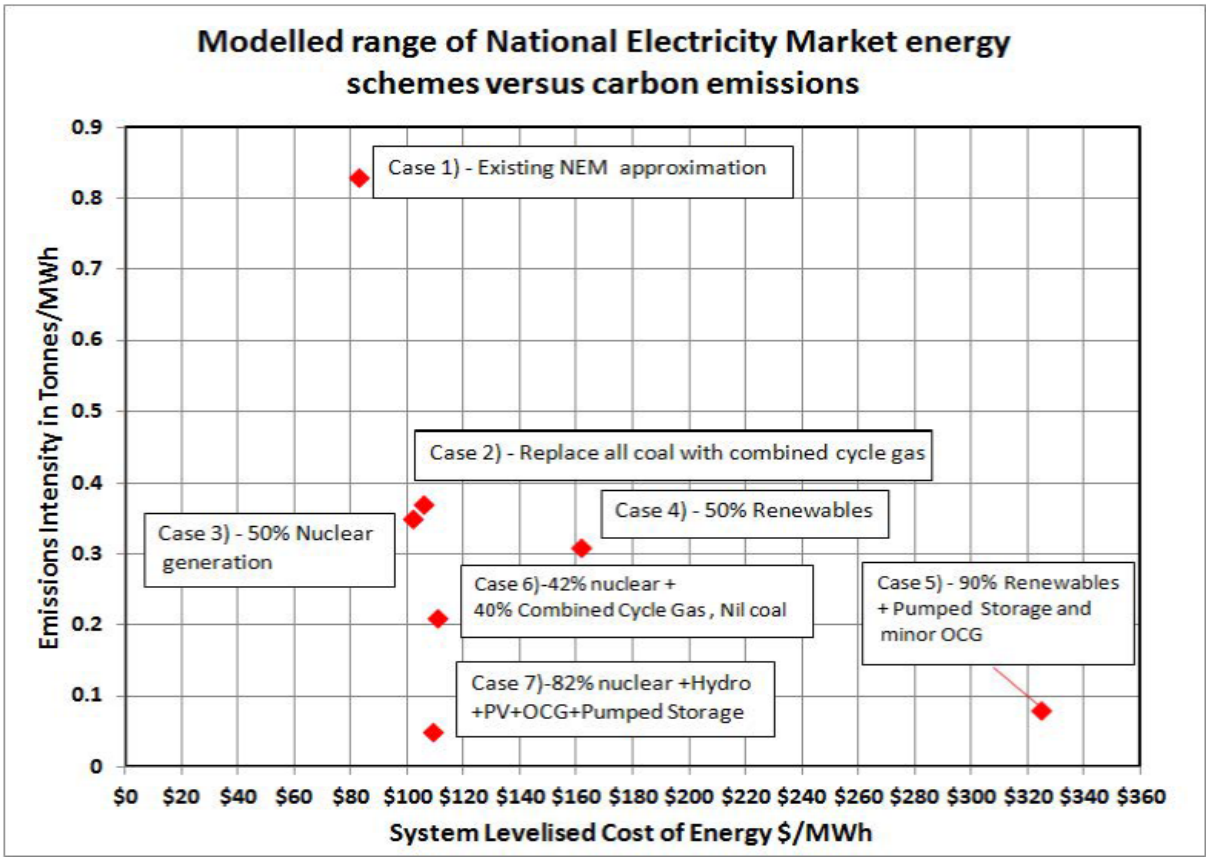
According to the IEA’s World Energy Outlook 2018, the costs of electricity in China from onshore wind, solar PV and offshore wind are respectively 16%, 50% and 140% higher than that from nuclear power, even without including the additional costs of adapting the grid and providing back-up generation to compensate for intermittent supply [3]. And, according to the OECD Nuclear Energy Agency “a mix relying primarily on nuclear is the most cost-effective option to achieve the decarbonization target of 50 g CO_2 per kWh” [3].

Figure 2: Levelized cost of electricity ranges (at 7% discount rate)



Source: Projected Costs of Generating Electricity - 2015 Edition, International Energy Agency and OECD Nuclear Energy Agency

For the comparison of costs for different sources of energy, it is essential to include the entire system of generation and its associated industries, back-up and other implications. Unfortunately, the nuclear option is often perceived as expensive because of the high capital cost of construction, without reference to its reliability and low operating costs. Furthermore, comparisons of costs in Australia (and possible overseas also) is obscured by the various subsidies applied to them. The following estimates of the true position were made in 2018 by Dr Robert Barr, then National President of the Electric Energy Society of Australia:



Conclusions

If there was any justification for the Uranium Mining and Nuclear Facilities (Prohibitions) Act in 1986, the need for this legislation certainly does not exist in 2019. The Chernobyl accident in 1986 and the Fukushima accident in 2011 were both the consequences of regulatory failure. Australia now has an effective regulatory infrastructure that could readily be extended to cover any part of a nuclear industry, and the technology of nuclear power generation itself has moved on. A Chernobyl-type accident simply could not occur in anything but a Chernobyl-type reactor, which will never be built again, and modern reactors are designed to accommodate a Fukushima-type flooding where this is a credible risk. Small modular reactors are becoming available that are inherently safe so that there is essentially no risk of accidental exposure to radiation outside the reactor site boundary.

Nuclear power has the potential to provide affordable, reliable, dispatchable supply of electricity without emission of greenhouse gases and should therefore be considered as an option in resolving

NSW's energy crisis. Repeal of the Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986 is an essential step on the way to achieving this objective.

References

[1] Higson, D. J. "The significance of thyroid cancer in reactor safety assessment". Presented at the 8th International LOWRAD Conference, held in Rio de Janeiro, Brazil, 28-30 September 2009; published in *Int. J. Low Radiation, Vol. 7, No. 3, 2010, p.* 217 (A copy is forwarded separately).

[2] Higson, D. J. "Why not nuclear?" Presentation to the Australian Nuclear Association and the Australian Institute of Physics in Adelaide in 2017 (A copy is forwarded separately).

[3] World Nuclear Association. "The Harmony Programme" (12 March 2019), https://www.world-nuclear.org/harmony