

## **Submission to the Senate Standing Committees on Environment and Communications Inquiry into the Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022**

### **Personal Details of Donald Higson (author)**

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 at AERE Harwell in Britain, 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. This led me to a related specialisation in the biological effects of ionising radiation. I have worked as a consultant to the International Atomic Energy Agency (IAEA) on nuclear safety and nuclear material safeguards (non-proliferation measures). 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; a committee member and former Secretary of its (Sydney Branch) Nuclear Engineering Panel;
- 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.

At a joint conference of ARPS with the International Commission on Radiological Protection (ICRP) in Adelaide in 2019, I presented the invited keynote address "The Boyce Worthley Oration", upon which much of this submission is based.

### **Summary of my Submission**

This submission identifies fear of radiation as the reason for the prohibition of nuclear power in Australia. This fear is unnecessary. It is due mainly to the esoteric nature of radiological risk which militates against proper public understanding of the risk. If there was ever a justification for the prohibition on technical grounds, it certainly does not exist today.

### **Introduction**

The atomic bombing of Japan that ended WWII was the first public demonstration of nuclear power. Although most of the casualties were due to blast and heat, there were also many deaths caused by radiation exposure; and it was already known that ionising radiation could be a cause of delayed health effects, particularly cancer. Radiological risks became a matter of enhanced public concern, which was later reinforced by the nuclear power plant accident at Chernobyl in 1986 when radiation exposure was identified as the cause of at least 28 deaths. The fear of nuclear power was therefore understandable at the time it was prohibited in Australia but advances in the understanding of

radiation health effects, as well as advances in nuclear safety technology, have since removed the need for that fear.

Nevertheless, public opposition to nuclear power generation at that time was due largely to fear of the nuclear industry – which is essentially the fear of radiation. This tends not to be acknowledged at either extreme of opinion now because:

- Those who favour the use of nuclear power do not want to draw attention to radiological risks and prefer to concentrate on other issues of controversy.
- Those who oppose the use of nuclear power recognise the evidence that modern nuclear power plants are very safe and prefer to rely on the underlying fear that exists in the community, without any need to stress it.

Hence, arguments tend to be based instead on cost comparisons of nuclear with other power generating technologies. These arguments are inevitably inconclusive because cost can be viewed in a number of different ways, and different technologies operate in different ways. **Furthermore, cost is irrelevant when considering whether or not an activity should be prohibited.**

Other reasons that are sometimes cited as justifying the prohibition of a nuclear industry in Australia are the disposal of waste and that it would contribute to the risk of nuclear weapons proliferation.

Concern over waste disposal is a manifestation of the fear of radiation. This is a political problem, not a technical problem. 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. (It is not generally recognised that digging up uranium and putting it through a reactor actually reduces the amount of long-lived radioactive material in the world.)

Waste disposal is the safest phase of the nuclear fuel cycle and Australia has some of the best sites in the world for this purpose. Once nuclear waste is properly encapsulated and buried in a dry, stable rock formation, it will be better isolated from the environment than the original ore body from which the uranium was mined.

And there would be no risk of proliferation from a domestic nuclear industry. This is not and never has been a valid argument. Australia is a signatory of the Nuclear Non-proliferation Treaty (NPT), under the oversight of the International Atomic Energy Agency of the UN (IAEA) and the Australian Safeguards and Non-proliferation Office (ASNO).

In any case, commercial nuclear power plants do not use or produce materials that would be suitable for use in nuclear weapons. The enrichment of their fuel is far too low and the plutonium in spent fuel contains too much of the 240 isotope. Even if Australia were to embark upon the enrichment of uranium for nuclear power reactors, the facilities would not be available to rogue nations or terrorist groups to abuse for production of weapons grade material.

This leaves radiological risk as the only real issue of contention regarding the prohibition of nuclear power in Australia.

## Radiological risks

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 that there is a radiological component to the risk is when an increase in the incidence of the disease in a cohort correlates with its exposure to radiation.

Most of the data on this effect come from the Life Span Study of Japanese atomic bomb survivors. For the most highly exposed bomb survivors (with doses more than 500 mSv)<sup>1</sup> there is an increase from the normal (about 25%) cancer fatality rate up to around 30% or more. For minimally exposed bomb survivors (with doses less than 100 mSv) 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. This is called the “linear no-threshold (LNT) hypothesis”.

The International Commission on Radiological Protection (ICRP) recommends that the LNT model **should** be assumed for the purpose of optimising radiation protection practices but that it **should not** be used to estimate the number of casualties from exposure of large numbers of people over long periods of time to low levels of radiation, as might occur in the case of accidents. The news media and the anti-nuclear activists do not seem able to cope with this distinction. Or don’t want to.

Major misconceptions about radiological safety have arisen because the LNT model is generally used for risk evaluation. In particular, this has led to the widely held but mistaken belief that there is no safe dose of radiation and to estimates that hundreds of thousands will die from delayed cancers caused by the accidental release of radioactive materials into the environment. If it were true that there is no safe dose, we would not be here because we are all exposed to similar levels of naturally occurring radiation all the time. Radiation is radiation, whether it is natural or man-made.

The level of natural background radiation at ground level ranges around the world from less than 1 mSv/y to more than 100 mSv/y but the incidences of cancer, other diseases, birth defects and genetic damage are not elevated due to the high levels that occur in some places. If anything, the reverse has been observed. Dose rates from natural background radiation at Ramsar in Iran are:

- about 100 times the global average of 2.4 mSv/yr;
- more than 200 times higher than the limit of 1 mSv/yr recommended by the ICRP for members of the public [10];
- more than 10 times higher than even the dose limit of 20 mSv/yr recommended for workers in the nuclear industry [10].

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<sup>1</sup> The sievert (Sv) is the unit of dose that is generally used in the field of radiation protection. As explained in reference [10], the dose in Sv is the absorbed dose in joules of energy per kilogram of tissue, multiplied by factors that depend on the type of radiation (for equivalent dose) and the relevant tissue (for effective dose). One Sv is a large dose; low doses are usually expressed in mSv.

Yet Ramsar is a spa resort and is only one of many such spas around the world (e.g. Bath in England, Baden in Germany) with high levels of radiation, where people have been visiting for thousands of years for the good of their health.

The human race, indeed all life on earth, has evolved in an environment that is full of potentially harmful agents, including radiation. We have adapted to them and they are necessary for normal life and health; deficiencies can be harmful and there may be health benefits if the levels are increased slightly. There is substantial evidence of such benefits from accidental and occupational exposure of humans to radiation and from animal experiments.

The extrapolation of radiation health effects – from atom bomb explosions down to natural background radiation and below – is therefore not justified scientifically. It's not just the size of the dose. The rate of exposure is also a vitally important factor.

- A dose of 5 Sv (5000 mSv) incurred in an atomic bomb explosion caused about 50% probability of death from acute radiation sickness and an estimated 50% excess cancer risk later in the lives of survivors.
- A dose of 5 Sv spread over a lifetime, as occurs in some areas of high natural background radiation, causes no discernible harm.

The LNT assumption provides us with a simple mathematical model on which to base the practice of radiation protection but it has also led to the myth that there is no safe dose of radiation. This provides a basis for propaganda against the use of nuclear power, which Australia desperately needs.

### **Risks from power generation**

No source of energy is without risk and nuclear power has an excellent safety record compared with other sources of energy. Indeed, it has proved to be one of the safest industries in which to work and possibly the safest way to generate most of the electricity the world needs. Outside the former USSR, there is no record of radiological harm to any member of the general public from any accident anywhere in the nuclear power industry.

However, there is one significant difference, viz: that the risk from nuclear plants includes a risk (no matter how small) of exposure to radiation. Members of the public are usually unable to perceive or evaluate this risk but know that it includes a risk of cancer.

Decision makers need to be aware that radiation levels in normal operation of nuclear plants are far below levels known to be harmful. Nuclear plants are engineered and constructed to the highest quality standards, subject to the oversight of independent regulatory authorities (in Australia, this authority would be the Australian Radiation Protection Nuclear Safety Agency, ARPANSA). The possibility of accidents is not ignored; designs are subject to the most rigorous safety analysis – at least as rigorous as that given to aircraft. All foreseeable failures of plant and operation and possible external threats are taken into account. Designs incorporate multiple layers of defence in depth against potential plant failures, including engineered safety features such as a leak tight containment building as a last line of protection against the release of radioactive material in a core-melt accident.

Unforeseen faults and events do occur, but engineers learn from experience and take such failures into account for the future. There are simple engineering measures that could have been taken to protect the emergency power supplies of the Fukushima Daiichi nuclear power station from flooding by one of the largest tsunamis in recorded history – more than twice the size of the tsunami assumed for the design of the power station. These measures have now been, or are being, applied to existing nuclear plants where the risk of flooding exists.

The design of many future plants, particularly small modular reactors (SMRs), will incorporate passive safety features such as cooling by natural circulation when shut down, thus obviating the need for emergency power supplies which failed due to flooding by the tsunami at Fukushima.

The Fukushima event did confirm the adequacy of seismic design practice. Although the six BWR plants were of outdated design, they shut down safely following the fourth largest earthquake ever recorded. The only reason for the reactor accident was the tsunami, which was the common cause of terminal damage to four of the reactors. Containments were breached and the three reactors that were operating appear to have suffered full core meltdown. There were large releases of radioactive materials into the environment but, despite media reports suggesting otherwise, no health effects have been observed that can be attributed to radiation exposure, either among workers at the nuclear power station or the general public.

During the 70-year history of nuclear power generation throughout the world, in nearly 500 nuclear power plants of various types, there has been only one accident (at Chernobyl in 1986) which has had fatal consequences due to radiation exposure. Twenty eight workers died from acute radiation syndrome (ARS) and up to 20 others have since died from illnesses that are considered to have been associated with acute exposure. This has also been the only reactor accident in which radiation has caused a discernible effect on public health, viz: a statistically significant increase in the incidence of thyroid cancer, which is typically 5% fatal.

The Chernobyl accident was the worst that could happen: a full core meltdown in a reactor that had no containment. It was a badly designed and badly operated reactor, of a type (water cooled and graphite moderated) that will never be built again. This accident was uniquely a failure of soviet technology at that time. It was an accident that simply could not occur in any of the reactor types that are being built today anywhere in the world.

The only other core-melt accident in the history of nuclear power generation<sup>2</sup> was in the US at Three Mile Island (TMI) in 1979, which clearly demonstrated the value of a proper containment. There were no radiation injuries and no radioactive release of any significance. And the PWR design used at TMI has since been modified to ensure that such an accident could not happen again.

Very high levels of anthropogenic radiation exposure, as were incurred by nuclear plant workers and some members of the public at Chernobyl, 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.

Even after the Chernobyl accident, no member of the general public was exposed to anything remotely approaching the radiological conditions of an atomic bomb explosion. During the Fukushima disaster, not even the workers at the nuclear power station incurred such exposures. At Chernobyl, public exposures were mainly within the range of naturally occurring radiation. At Fukushima, probably all public exposures were within this range. A realistic estimate of the number

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<sup>2</sup> According to the World Nuclear Association (WNA), there is now more than 16,000 reactor-years of experience with civil nuclear power plants.

of delayed cancer deaths at Chernobyl is about 4000; for Fukushima, less than 10 – probably all nuclear plant workers.

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, prohibitions remain in force.

Elsewhere in the world, particularly in the other advanced industrialised nations of the OECD but also (now) in Russia, China and South Korea, 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.

## **Conclusion**

Fear of radiation as the only reason for the prohibition of nuclear power in Australia. This fear is unnecessary. It is due mainly to the esoteric nature of radiological risk which militates against proper public understanding of the risk.

## **Historical perspective**

In 2006, the Uranium Mining, Processing and Nuclear Energy Review (UMPNER), established by the Howard Government, compiled an excellent compendium of information about the nuclear industry. The review included the following findings:

- If government policies and legal prohibitions restricting the growth of the industry were addressed, it would have been feasible for 25 reactors to be producing about a third of the nation's electricity by 2050;
- This electricity would be more expensive than from coal without carbon capture and storage, but likely to be competitive with gas or renewable sources;
- Australia has areas suitable for disposal of high-level waste including spent nuclear fuel.

These findings were misrepresented by the media as recommendations and were strongly opposed by anti-nuclear groups. No action was taken in response to the UMPNER Report

In 2016, the South Australian Nuclear Fuel Cycle Royal Commission:

- Found that South Australia could safely increase its participation in nuclear activities;
- Found that the storage and disposal of used nuclear fuel in South Australia was likely to deliver substantial economic benefits to the South Australian community;
- Recommended that the SA Government should pursue removal at the federal level of existing prohibitions on nuclear power generation;
- Recommended that the SA Government should promote and collaborate on the development of a comprehensive national energy policy that enables all technologies, including nuclear, to contribute to a reliable, low-carbon electricity network at the lowest possible system cost.

However, the "Citizens' Jury" rejected these findings and recommendations of the Royal Commission and no action was taken on them.

Recent parliamentary inquiries in NSW, Victoria and at federal level have all recommended conditional removal of existing prohibitions of nuclear power generation.