South Australian Chamber of Mines and Energy

Tentative Findings Submission

to

Nuclear Fuel Cycle Royal Commission

18 March 2016

Contents

Executive Summary

South Australian Chamber of Mines and Energy (SACOME) welcomes the opportunity to make a submission to the tentative findings released by the Nuclear Fuel Cycle (NFCRC) on the 15 February 2016. SACOME welcomes the tentative findings as they highlight the key issues that face the uranium mining industry in South Australia. While SACOME is in general agreeance of these tentative findings there are a number of findings that will need further development.

The NFCRC needs to avoid the oversimplification of issues and findings where critical context surrounding the relevant finding is omitted from the report. There are instances where the findings outlined in the document are portrayed as absolute where the detail of the evidence indicates that the finding is dynamic, based on modelling uncertainties into the future.

Where this is the case, each finding will need to be further developed to detail the assumptions in the evidence and provide comment on what should be taken note if conditions or assumptions change in the future. By simply stating that a technology is 'uneconomical' without detailing the assumptions that went into that calculation or what scenario in the future could change the finding reduces the comprehensiveness of the work that has clearly been undertaken by the NFCRC. Furthermore, this applies to the discussion on regulation and legislation where each finding noting a change should detail what sections in respective acts will need to change or what will need to be developed as outlined in evidence.

Throughout the tentative findings document the discussion of risk needs to clearly define the hazard that the evidence has identified and the actual risk based on the evidence from management, regulatory oversight, experience, and historical record obtained by the NFCRC. It needs to clearly define that the risk is a function of the hazard, exposure and management.

The final report due in May will be a bookmark for the current knowledge and scientific evidence of the nuclear fuel cycle applied to a South Australian context. The NFCRC should be clear with what the scientific and expert consilience is with respect to each aspect of the nuclear fuel cycle and associated topics, for example radiation. It should not attempt to sit on the fence on issues where there appears to be conjecture or controversy, rather take stock of all the evidence and determine which direction the scientific consilience is heading in.

SACOME has retained the low dose and nuclear prohibition appendices from its previous submission as it provides a scientific consilience perspective for impacts of low doses of radiation and necessary context to the prohibitions in Australia.

SACOME

The South Australian Chamber of Mines and Energy (SACOME) is the peak industry association for companies with business interests in the resources industry in South Australia, including those with business, vocational or professional interests in minerals exploration, mining and processing, oil and gas exploration, extraction and processing, power generation, transmission and distribution, logistics, transport, infrastructure, and those with clients in these sectors. The Chamber also represents interests developing geothermal and wind power. SACOME represents over 270 resource industry and related service members.

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The general direction of the NFCRCs findings outlined in the tentative findings document is welcomed; however, the South Australian Chamber of Mines and Energy (SACOME) has a number of points of query. These relate to the commissioned study that informed the economics and scope of the exploration, extraction and milling industry, community engagement, heritage and radiation risks.

Exploration, Extraction and Milling

Tentative Findings 10 & 11

While it is prudent of the NFCRC to outline the risks of uranium mining it should be made clear to the South Australian public the difference between the hazard and the resultant risk after management of the hazard has taken place. Where a hazard has the potential to do harm to people or the environment, the risk arises when it's possible that the hazard will actually cause harm. It is that possibility that should be based on robust evidence from research and experience that the NFCRC has received.

SACOME in its first submission to the NFCRC made a note to highlight that while hazards exist in mining, the experience of understanding the respective hazard and the effective management ensures that the risk of causing material harm to the environment or people is minimised[1]. This has been demonstrated in the record of incidents that SACOME provided to the NFCRC[2] and are publically accessible through government departments and statutory authorities.

The NFCRC should clearly note the difference between the hazards and the resultant risk in findings on exploration, extraction and milling. The NFCRC would need to further define the risks in terms of management, frequency and exposure in its final report to ensure that the evidence is represented transparently, fairly and openly to the public.

Tentative Finding 18(c)

SACOME welcomes the acknowledgement of this regulatory burden on uranium miners where the evidence on risks highlights that it is no more hazardous than mining other commodities. Nevertheless, as mentioned previously the NFCRC should detail the necessary sections of Commonwealth and State Acts that are at the centre of these findings such as section 22 (d) of the *Environment Protection and Biodiversity Act 1999 (Cth)*. The NFCRFC recommendation should be the repeal of section 22 of the EPBC Act.

Tentative Findings 19-22

SACOME analysed the report commissioned by the NFCRC on the economic modelling compiled by Ernst and Young, which is outlined in the respective summary document. The projections used to 2040, while agreeing with SACOME's projections of the industry, fail to take into account the global uranium industry and sustainability of global production. The report by Ernst and Young notes[3]:

> *"Australia would supply nearly 12kt of Uranium ore to the world market by 2029-30 and 20kt by 2049-50 from its current level of 6kt,* ***assuming the current market share remains unchanged****" (emphasis added)*

Assuming a maintained global production share of 8% to 2040 ignores the fact that global supply to this time will need to be replenished with new mines globally. While Australia has the world's largest Reasonable Assured Resource and Inferred Resource there are other countries that currently produce a large proportion of global uranium, such as Kazakhstan, who are producing at a rate that would see their present resource deplete in this time frame (see Figure 1).

[1] (Eckermann & Long, 2015)
[2] See pages 55 to 29 in SACOME's submission; (Eckermann & Long, 2015)
[3] (Ernst and Young, 2016)

As noted in SACOME's submission to the issues papers[4], along with the depletion of secondary supplies, there will be a shortage of supply by 2030. Some analysts predict that by 2030, primary resources of uranium mines will decrease more than two fold, where more than half of the remaining resources will be in Olympic Dam[5].

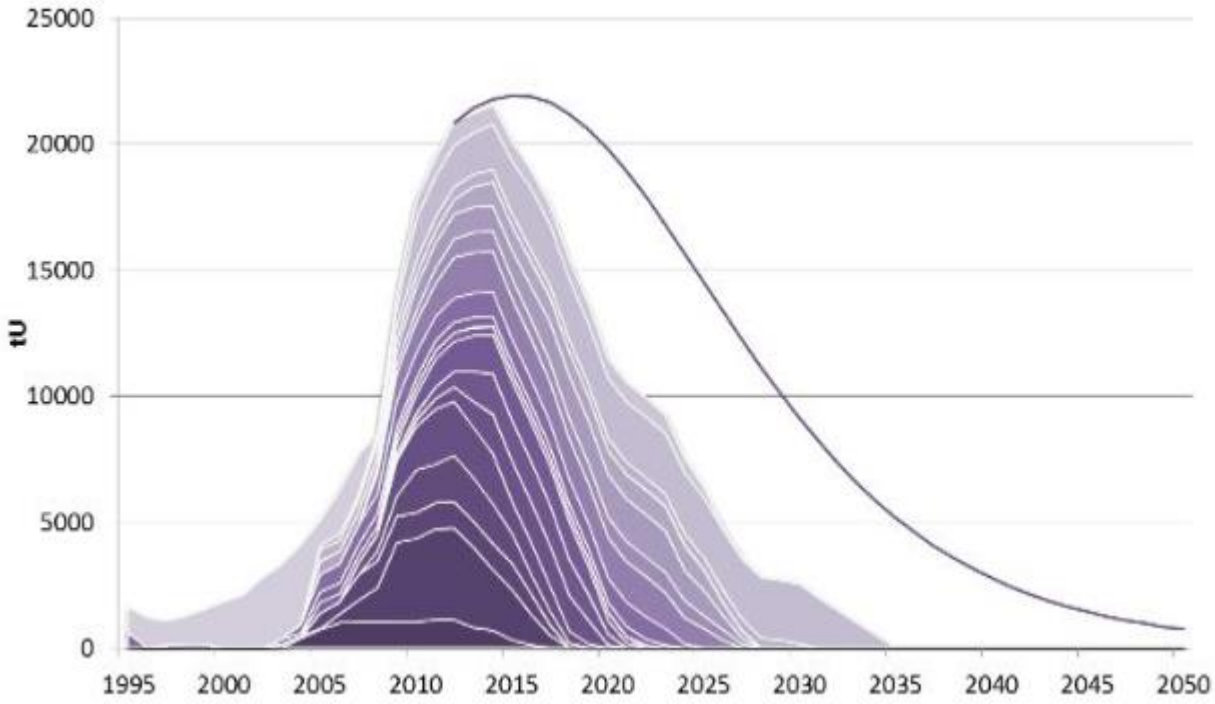

Figure 1 Production scenario based on 2011 Kazakh resources; Arnold, N. & Gufler, K. 2015

There is significant scope where South Australia can remain a significant provider of uranium in the future due to the large endowment of uranium. The depletion of low cost resources identified in the IAEA Red Book and local geoscience authorities will naturally lead to the development of the higher cost deposits. Financial analysis indicates that there will be a long term increase in the global uranium price where reasonably assured resources under the $130/kg U bracket will be developed, with an average price of $198/kg U by 2020[6].

A further point to note is that that Ernst and Young modelling assumes that 92% of 200,000 tonnes of demand would be met by other global sources in 2049-50. This would entail countries with less than 5% of global resources to dramatically increase their Uranium resources when there has been no evidence that this will eventuate.

The International Atomic Energy Agency is presently undertaking a study into the sustainability of uranium production to 2060 following on from a study completed in 2011 projecting to 2050[7]. It would be prudent for the NFCRC to access these analyses, collect the relevant evidence on uranium supply and develop a model where resource and production ratios are developed to assess the long term viability of the top ten producers of uranium in the world.

[4] See page 17 in SACOME's submission; (Eckermann & Long, 2015)
[5] (Boytsov, 2014)
[6] This is an analysis of 17 different commodity trading agencies and uranium analysists projections to 2020. These projections were made by these agencies and analysts between October 2015 and January 2016.
[7] (Tuldidas, 2014)

Electricity Generation

Tentative Findings 38-42

> *"Nuclear power plants are very complex systems, designed and operated by humans, who can make mistakes"*

While SACOME understands the generalisation made here, it ignores the detailed, as opposed to 'complex', engineering and design elements that are made with respect to a nuclear power plant. The use of 'complex' is a subjective term based upon the relative disposition of the readers' knowledge of nuclear power plant systems. The NFCRC needs to avoid this over simplification of this finding as a key component of any nuclear plant design is defence in depth to limit the human operational error. For example, while Three Mile Island suffered a partial core meltdown, there was no significant impact to the surrounding environment confirming that containment design worked to limit the damage as a result of operator error.

The further definition and contextualisation of terms such as 'severe' is required when the impacts of an accident are discussed. While we can see that the economic and business impacts are severe the evidence on the physical human and environmental aspects in post-accident reports, particularly for Fukushima and Three Mile Island, are determined to be negligible[8,9] and in cases overreaching in their response[10]. This is evident in the responses causing more harm than the impact of any radiological release.

The Canadian Nuclear Safety Commission finalised a report in September 2015 detailing the impacts of a hypothetical radiological release from the Darlington CANDU Nuclear Power Plant. This study noted the negligible impact of the radiological release based on the CANDU design and risk management processes and is worth the NFCRC considering in the final report on the risk of nuclear power[11].

Tentative Findings 46-61

The final report should detail the assumptions of analyses that determined the findings in this section. That the use of the AP1000 and NuScale reactors as proxies, thereby utilising financial data from the United States constructions, for the capital costs is not an indicative cost assumption for other nuclear designs offered by vendors currently under construction elsewhere.

The NFCRC has visited countries such as South Korea, United Arab Emirates (UAE) and China where the construction of Nuclear Power has achieved successes where plants are built on time and under budget[12]. A recent study looking into the capital costs of 349 nuclear reactors in several jurisdictions noted that there are elements to each jurisdiction that have escalated costs and using an example such as the United States is not indicative of the evidence from the UAE, and by extension South Korea.

The study by *Lovering, Yip and Nordhaus (2016)* discovered that particularly for the South Koreans that the capital costs of nuclear has been steady declining in contrast to the United States who has had notable increases post 1979 (Three Mile Island)[13]. By undertaking modelling work that excludes other international examples of nuclear construction costs it omits necessary evidence to determine whether the activity is feasible or not. The Chinese are another case where the capital costs for nuclear have decreased. The NFCRC should look to the nuclear regulatory agencies in these jurisdictions to access present financial data on construction costs.

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[8] (UNSCEAR, 2008)
[9] (UNSCEAR, 2014)
[10] (Hollingworth, 2016)
[11] (Canadian Nuclear Safety Commission, 2015)
[12] See for example the post-construction report on the Qinshan CANDU Nuclear project in China at https://canteach.candu.org/Content%20Library/20031701.pdf
[13] (Lovering, et al., 2016); See also Appendix C

Management, storage and disposal of nuclear and radioactive waste

Tentative Finding 73-77

The NFCRC will need to expand the findings with respect to the requirement for geological disposal and outline why geological disposal is considered the international consensus. In finding 78(a) it notes the geological region where this material can be located due to its suitability but does not mention that the province is essentially immobile and therefore the migration of the radionuclide concern is allayed. Furthermore, the discussion makes mention of the waste being in solid form but little mention as to why this is the chosen method.

While the engineered barriers (Tentative Finding 77) are sufficient as the NFCRC noted it should also refer to the Finnish study on the Olkiluoto repository. This report found that if the worst case scenario occurred one thousand years later, the man made barriers (canisters) failed, material somehow underwent a physical transformation to be able to leak into the surrounding rock, a city was built on top of the closed underground storage, the inhabitants ate locally grown food, and spent their entire life in the most radioactive spot they'd receive an additional yearly dose of 0.18 µSv[14] (ARPANSA public dose limit is 1,000 µSv per year).

While the geology, management and physical state of the material (immobile, entombed and solid) provide the necessary barriers to prevent migration of radionuclides or radiation exposure it is noted that the other reason besides preventing migration is to keep it in a location to allow for natural radioactive decay to occur. The findings note:

> *"Within 500 years, the most radioactive elements have decayed. However, because of its radioactivity, used fuel requires isolation from the environment for many **hundreds thousands of years**." (emphasis added)*

The Gawler Craton location noted as suitable (Finding 78(a)) is naturally radioactive in areas that are suitable for a site (e.g. close to infrastructure) and as such this material would be placed in rock that already contains radioactivity. The need to isolate for hundreds of thousands of years is a moot point as after a thousand years the material would be as radioactive as the rock that surrounds it[15]. This would then lead into the findings related to how long community consent is needed for and the responsibility left to future communities, which SACOME notes is negligible as when the facility is shut in there is no further burden based on international experience and scientific analyses.

[14] (Posiva Oy, 2009) p. 137
[15] (World Nuclear Association, 2015h)

Social and Community Consent

Tentative Finding 104

The community consent for repealing the nuclear prohibitions in the relevant Acts[16] would need to ascertain whether these prohibitions were the result of broad community consent at the introduction of these respective sections to justify their removal.

Research undertaken[17] by SACOME uncovered that the decision was not made by what would be termed 'broad public support'. As a matter of fact, the prohibitions were introduced by minor parties' representative of 10% of the Australian voting public in 1998 during a committee inquiry lasting in total two days. As there was no formal vote in the Senate in 1998 it cannot be argued that there was broad public support from the representation of the Senators in Parliament that day. It can be argued that it was a political deal rather than a vote representative of the publics' will.

SACOME in 2013[18] and 2016[19] conducted polling of the South Australian public to ascertain the attitudes towards uranium mining and nuclear power. In both polls the proportion of South Australians supportive of uranium mining and nuclear power was over 50% and 45% respectively and opposition to both propositions under 30%. Essential Research conducted an Australian wide poll in November 2015 where under 40% opposed nuclear power. In both studies efforts were made to ensure neutrality in questions so as to not bias the respondent either way.

SACOME does note that in both surveys that when the respondent was asked what they thought the communities attitude was towards uranium mining and nuclear power and waste they indicated that there was majority public opposition, when the results of personal attitudes showed broad public support. It could be this phenomenon where SACOME believes the NFCRC has led to the conclusions noted in tentative finding104.

The natural position of the prohibitions, if it reflected the will of the people today, is that they should not exist and are not based on the consent of broad public support. SACOME questions whether the NFCRC is correct in its assessment that broad public support is needed when the support for the prohibitions is representative of a minority.

The finding should conclude that these prohibitions should be removed as a matter of course and proper regulations should be developed using world's best practices and experiences by other international government bodies to allow for a future scenario where development of nuclear is required as per the finding:

> *"…Nuclear Power may be necessary, along with other low-carbon generation technologies.* ***It would be wise to plan now to ensure that nuclear power would be available should it be required****." (emphasis added)*

Furthermore, the NFCRC should note the surveying undertaken by Bisconti Research in the United States for the Nuclear Energy Institute shows that the closer a resident is to a nuclear power plant support increases to where support is 83% (workers and families were removed for this research)[20]. Indicating that the more experience residents have living near a facility the more aware and supportive they become.

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[16] Section 140A, 146M and 37J of the *Environment Protection and Biodiversity Act 1999*, and Section 10 of the *Australian Radiation Protection and Nuclear Safety Act 1998*

[17] See Appendix B

[18] See Appendix A of SACOME's submission to the issues papers; (Eckermann & Long, 2015)

[19] Final report is being drafted, and preliminary results can be made available to the NFCRC on request.

[20] (Nuclear Energy Institute, 2016)

Risks and challenges

Tentative Finding 117

The NFCRC while acknowledging that at low doses there is debate as to how big the effect upon the human body is, it should make a finding with respect as to where the scientific consilience presently is regarding the effects of low doses of radiation. The NFCRC has heard from radiation experts with experience in the field of nuclear medicine, accidents and research and has assembled a committee to provide input on radiation.

Evidence from reports from the United Nations Committee on the Effects of Atomic Radiation on Chernobyl and Fukushima, and testimony by Carl Magnus Larsson and Professor Geraldine Thomas highlighted that the combined efforts of 80 international experts notes that the uncontrolled release of low doses of radiation (under an effective dose of 100mSv) are minimal in their impact at Fukushima.

The evidence is clear that scientific consilience exists when it refers to impacts of low doses of radiation is negligible. SACOME in its submission detailed a list of exposures that highlights this point further and in Appendix A[21]. Rather than automatically deferring to the precautionary principle the NFCRC should look to the over 60 years of international experience with nuclear science and radiation management and determine what the evidence highlights.

Impacts on other sectors

Tentative Finding 155

The last sentence of this finding notes that the impacts of an accident on other sectors "could potentially be profound". As per previous comments the NFCRC should further define this finding to determine the reasoning for this statement. While it can be argued that the impacts, particularly in Fukushima, are profound the NFCRC has visited this area, heard from witnesses and received evidence of the actual impact versus the perceived impact.

SACOME recommends that the evidence the NFCRC received should be looked at to determine whether the real impact or the perceived impact has a bearing on whether the potential could be profound. From SACOME's research the evidence indicates it's a perception rather than actual impact that creates the notion that the impact could be 'profound'.

[21] See page 20 of SACOME's submission to the issues papers; (Eckermann & Long, 2015)

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Appendix A

Low dose radiation and relative risks

The following paper was authored by Dr Madhava Baht, Chief Physicist of the Adelaide Radiotherapy Centre. It outlines an overview of the relative risk of radiation and discussion on the science and impacts of low doses of radiation. SACOME has permission to republish Dr Baht's essay on radiation risk and supports the conclusion that overly conservative protection measures are costly to administration and company processes.

Fear of Radiation is Frightening

The world's two worst industrial disasters occurred in the early years of my career in radiation physics. The Bhopal gas tragedy was the worst industrial accident and occurred on the night of December 2–3, 1984 at the Union Carbide pesticide plant in Bhopal, India and killed 10,000 people on that one night. The worst ever nuclear accident occurred at the Chernobyl Nuclear Power Plant in Ukraine on 26 April 1986, which led to less than 60 fatalities within 3 months of the accident. These two catastrophic events helped m shape my perception of the risks associated with modern industrial processes. While many have forgotten the Bhopal gas tragedy, the Chernobyl disaster is still fresh in our collective memory.

Last year was the 25th anniversary of the Bhopal gas tragedy and I asked my medical radiation students if they had heard of this event. Not a single student out of the 80 in the class had heard of or read about this event. However, more than a handful of students had heard or read about the Chernobyl disaster. The students were shocked to hear that for every one person killed in the immediate aftermath of Chernobyl one hundred more fatalities were recorded in Bhopal. I often wonder why our perception of the risk associated with ionising radiation is so heavily skewed. Who is responsible for this public anxiety? Is it the media, politicians or scientists? I think the burden of responsibility falls equally on all three sections of society. If our perception of the risk is not balanced, we are predisposed to making incorrect judgments. Such decisions are invariably costly and often lead to exposure to the unknown and perhaps more significant risk elements.

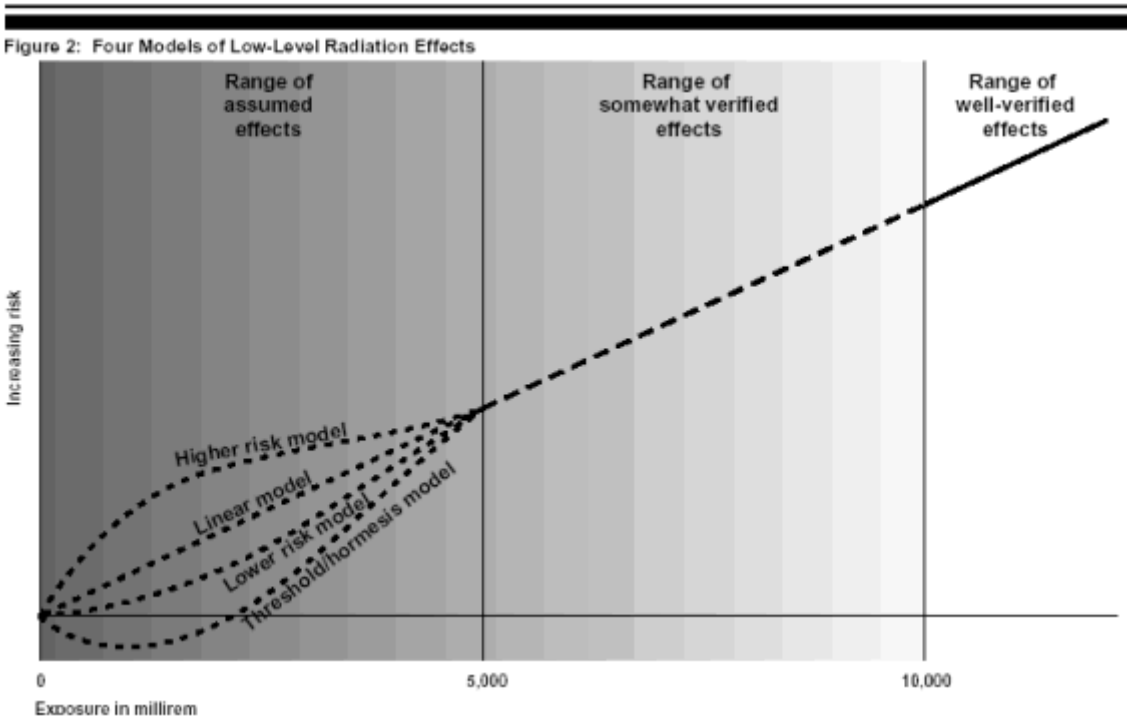
After more than 100 years of research, the risk radiation poses to humans is still poorly understood at 'low dose' level. Most people regard a dose less than 100mSv as low dose. Public fear of radiation began to develop after the dropping of the A-bombs on Japan during WW2. The fear has been propagated by the blatant lies of the anti-nuclear campaigners and was and is still supported by the mass media seeking sensationalist stories. The saying 'Never let a fact get in the way of a good story' unfortunately holds very true when applied to events involving ionising radiation. It is nearly impossible for a scientist to get anything in the mass media that contradicts the prevailing falsehoods.

My own experience illustrates that even professional radiation physicists are not spared from radiation phobia. On one occasion I was working near the door of a high dose rate (HDR) brachytherapy room, where the dose rate out of the shielding container is typically 5µSv/h. My colleague, a physicist, insisted that I move away from that area as they considered the area to be characterized by a 'high radiation level'. I obliged, as at the time, it was easier than to explain why it was safe for me to work there.

I was born in Kerala where the natural background radiation level is as high as 4 lGy per hour. I was continuously exposed at this dose rate until the age of 24 when I relocated to a different place. HDR treatment exposure has a typical duration of about 5 min and my presence for the duration of the patient treatment would have led to an exposure of 0.3 lSv above natural background radiation. If I had attended 100 such procedures in a year my total dose would be 30 lSv. This small occupational radiation dose is well within fluctuations observed in the background radiation level often a result of

sunspot activity and cosmic ray intensity. Furthermore this level of exposure represents less than 0.2% of the maximum annual dose limit prescribed for a radiation worker by the statutory radiation protection authority.

Current ionising radiation protection standards are based on the simple Linear-No-Threshold (LNT) hypothesis. The LNT hypothesis states that the dose–response relationship through all bands is linear and that there is no safe threshold level of exposure. The LNT hypothesis was developed on the basis of an extrapolation of our knowledge of pathology at high doses of radiation; e.g. high dose exposure to early radiation workers, impacts of exposure on the survivors of the Hiroshima and Nagasaki atom bomb. It is important to note that the LNT hypothesis is not based on any scientific data at low levels of radiation exposure. I therefore consider the adoption of this model for radiation protection to be based on illegitimate grounds.



Different models of radiation impacts. From the Agency for Toxic Substances and Disease Registries

To illustrate this point I would like to refer to the transcript of a conference held some 50 years ago. Colonel Pickering from the School of Aviation Medicine of Randolph Air Force Base, USA was presenting a paper on research conducted in his department in the Conference on Research in Radiobiology and Radiation Medicine, December 1 and 2, 1958—Washington, D. C. He made the following statements at the end of his discourse.

> ***Colonel Pickering:*** *Continuing in the applied area, work has been going on using radiation and so-called other stresses that may be of importance in Air Force operations. One of these has been the investigation of low level radiation conducted by Dr. Carlson, at the University of Washington, wherein he has used about 8/10 r per day Cobalt-60 gamma radiation and studied animals at five degrees, 28, and 35, with an endpoint of radiation and its effect on metabolism. Perhaps an interesting note with respect to these low levels of exposure, at the present time Dr. L. Carlson's exposed animals are outliving his control animals. I understand other individuals are finding this to be true in certain of the low levels of exposure. As a matter of fact the contract was extended to wait for the radiated animal to die.*

> ***Dr. Lauriston Taylor:*** *I am interested in the remarks you made at the last, Dr. Pickering, about the longer survival of slightly irradiated animals compared with some of the controls. This keeps bobbing up. Is it being looked at systematically? Do you believe your results?*
>
> ***Colonel Pickering:*** *I believe Dr. Carlson's results, yes sir. May I say just this – I am sure there are others who have opinions on this, but there are several experiments of which I am aware where, as you say, it has bobbed up continually. One in particular which Dr. Gerstner in our own laboratory conducted, a bit different from this. Namely, if one administered one large dose of radiation and measures the survival, and then complements this experiment by administering a small dose to a second group of animals followed by a second large dose, it takes a larger dose to produce the same mortality than in the first experiment. I am certain that this has been demonstrated by Dr. Lautit, and I am sure Col. Hartgering has some words on this. I do not know other than our own small attempt whether this is being systematically followed. These scientists were discussing the phenomenon we know today as adaptive response or hormesis. Hormesis is a dose–response relationship characterised by low-dose stimulation and high-dose inhibition. This phenomenon is broadly applicable for a range of toxic agents including chemical, biological and radiation. This is exemplified by the risks and benefits of exposure to ultraviolet radiation; too much exposure leads to the development of melanomas and other serious medical problems, however suboptimal exposure inhibits the synthesis of Vitamin D in the body, which can also lead to health impacts such as osteoporosis.*

Hence, many radiobiologists today question the validity of the LNT model at low dose. At the twelfth international congress of the International Radiation Protection Association, which took place in Buenos Aires, in 2008, Professor Christian Streffer presented the Sievert Lecture entitled 'Radiological Protection: Challenges and Fascinations of Biological Research'. Prof. Streffer admits the limitations faced by epidemiological studies in providing low dose radiation effects information. In the lecture he said:

The data generally show fluctuations around the linear dose response below doses of about 100 mSv. This can be explained by two possibilities:

> **(1)** No cancers are induced after exposure to such low radiation doses.
> **(2)** Cancers are induced after these low doses but the effect is so small that it is hidden by fluctuations in spontaneous cancer rates.

The congress, however, decided to stay with the LNT hypothesis for want of more evidence. Radiation protection regulations based on the LNT model coupled with the general anxiety regarding radiation hazards created by the mass media have led to a prevailing public attitude that all radiation is harmful, no matter how small the dose. Accordingly we adopted the 'ALARA' principle (As Low As Reasonably Achievable) and have taken a very conservative approach to radiation protection. We use this conservative approach when designing and building radiotherapy bunkers, diagnostic X-ray rooms and other industrial radiation producing installations that generally exceed the requirements of the current radiation protection regulatory framework. As a result occupational exposure to radiation is practically at a noise level of background radiation to almost all radiation workers.

The application of the LNT model has come at a huge financial cost to our community with no demonstrable epidemiological benefits. Billions of dollars have been spent around the world to meet (and often exceed) very conservative radiation safety standards. There are many regions where natural background radiation far exceeds present radiation protection standards, in some cases these background levels are 50–200 times higher. For example: Guarapari in Brazil, Ramsar in Iran and Kerala in India have a very high background radiation. Furthermore various epidemiological studies have indicated that high natural radiation in these areas is not harmful to the inhabitants. The LNT

model, at low dose levels, has little or no foundation in science; yet almost all regulatory bodies formulate their rules based on the assumptions therein. The weak scientific foundation upon which we have built our radiation protection standards and our lack of commitment to finding a better dose–response model has led to an exacerbation of public anxiety.

A few years ago, the US Department of Energy (DOE) began investigating the effects of low dose radiation. A number of new phenomena like the radio-adaptive response and the radiation-induced bystander response were uncovered. Preliminary evidence confirms that low levels of radiation exposure are not as harmful as the LNT hypothesis would lead us to believe. At low doses, DNA repair mechanisms are stimulated and these findings may assist with developing evidence-based approaches to modifying our radiation protection regulations. I was fortunate to be part of the low dose research study at Flinders University, Flinders Medical Centre and the Royal Adelaide Hospital under the leadership of Professor Pam Sykes funded by the Low Dose Radiation Research Program, Biological and Environmental Research (BER), U.S. Department of Energy where we studied the effects of a wide range of whole-body X-ray doses on chromosomal changes in mice. The non-linear results obtained in that study supported a hormetic dose response [1].

Blind faith in the LNT model has a negative influence on how we allocate our limited healthcare resources. Investing large sums of capital mitigating overestimated risks does not benefit the community; and in many instances has an adverse effect by reducing focus on more pertinent public health endpoints.

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Appendix B

Nuclear Prohibition History

The following article was written by Dayne Eckermann, Senior Policy Analyst SACOME, in September 2012. This article provides the context to the nuclear prohibitions in Australia during the creation of the *Australian Radiation Protection and Nuclear Safety Act 1998 (Cth).* It was originally published on the Decarbonise SA blog on the 12th September 2012. Any opinions published in this article are that of the author.

Why a prohibition on nuclear power reactors in Australia?

The answer lies in the historical context of electricity production in Australia and the anti-nuclear movement within the Senate during the 1990's.

During the nuclear reactor boom in the 1960's and 1970's Australia was a relatively small country of between 10 and 14 million people and our energy needs could be met by developing abundant coal and gas deposits in each State for electricity generation. There was a proposal to build one reactor at Jervis Bay but with a changing government this plan was scrapped based on the cheap sources of coal and gas in the region and fiscal constraints.

In 1998 the Australian parliament debated, and voted on legislation to centralise the task of radiation protection and safety to an independent regulatory body. Before this legislation there were two regulatory agencies, the Australian Radiation Laboratory and the Nuclear Safety Bureau, which upon the passing of the Bills would become the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) governed by the *Australian Radiation Protection and Nuclear Safety Act 1998 (Cth)* . It is in this piece of legislation intended to create a regulatory environment where radioactive materials and devices are safely managed that the outright prohibition of nuclear power occurs.

Section 10 of the ARPANS Act 1998 states:

10 Prohibition on certain nuclear installations

(1) Nothing in this Act is to be taken to authorise the construction or operation of any of the following nuclear installations:

(a) a nuclear fuel fabrication plant;

(b) a nuclear power plant;

(c) an enrichment plant;

(d) a reprocessing facility;

(2) The CEO must not issue a licence under section 32 in respect of any facility mentioned in subsection (1)

A similar section arises in the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act) under section 140A(1)(a)-(d), that was copied over when the EPBC Act was created.

How did we get to this absolute prohibition?

It all begins during the process of the ARPANS Bill moving through the Federal Parliament in 1998. First two key contextual elements must be noted about this time and space:

1) There is a strong undercurrent of anti-nuclear activity in Australia and as such to utter the slightest hint of supporting the nuclear attracts unwarranted negativity. Thus it is perceived to be a poison chalice in Australian politics.

2) During the 1990's Australia was taking note of the French Nuclear testing in the Pacific, the Rainbow Warrior incident, the process of siting a nuclear waste repository for our localised medical and industrial

nuclear waste, and the leaking of a project to site spent fuel and disposed nuclear weapon material in Australia by Pangea Resources. A detailed history can be found here.

The ARPANS Bill entered parliament on the 8th of April 1998 with the intention to amalgamate the Austrlaian Radiation Laboratory (ARL) and the Nuclear Safety Bureau (NSB) into one body, now known as the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), and to introduce regulatory controls for all radiation and nuclear safety activities.

The Bill passed through the House of Representatives on the 12th of November 1998 after a break in sitting occurred due to a Federal election in October. The debate in the House of Representatives mainly focused on the replacement of the Lucas Heights reactor and its perceived implications.

The Senate at this time was in the same situation it is presently in where a minority party has the balance of power in issues of partisanship. The Australian Democrats and Greens parties had this balance of power and both shared anti-nuclear policies. It is this balance of power and policy that facilitated the introduction of an amendment by the Greens party to outright prohibit nuclear power. Before amendments were made the Bill was sent to committee to hear from stakeholders and experts with an interest in the Bill.

The discussion and questioning of experts in the Senate committee was a short half day hearing with submissions and testimony from stakeholders in the nuclear industry, in the council where Lucas Heights is located, and anti-nuclear advocates. After two days a report was tabled from this committee outlining that amendments be made to the definition of a nuclear Installation and that the report from the minority parties outlined that it also should include a prohibition of nuclear power.

The Greens amendment was voted on with no formal division (a record of ayes and noes) and was passed on voice vote alone. In other words, no Senator put their name on record for, or against, the amendment. However amendments made to Bills in the Senate sent the Bill back to the House of Representatives to be voted on a final time. The Bill was passed in the House of Representatives without division.

After a three-and-a-half hour committee meeting, a several-page report drafted over two days, one hour and 36 minutes of debate post-prohibition recommendation, and six minutes of considering the amendments (see detailed chronology below) it was decided that Australia should not go down the nuclear path.

Australia prohibited nuclear power based on the ideological position of a minority and a misperceived stigma.

[A more detailed summary of the process can be found below following the conclusion of this article, in chronological order with reference links to the readings, committee, and debate in Hansard]

On the other hand, just eight years later in 2006 nuclear power came back into the political landscape before the 2007 election. In November of 2006 the Australian government published the following report from the Standing Committee on Industry and Resources:
Australia's uranium – Greenhouse friendly fuel for an energy hungry world

This is a 729 page report outlining the entire nuclear fuel cycle, radiation, and issues therein with input from 87 witnesses and experts over 11 days in differing capital cities, and 93 submissions. It is worthy of a read and another blog post. It is especially heavy on common sense, pragmatism, and objectivity through weighing up all the submissions and witness testimonies to derive recommendations for the establishment of a nuclear industry in Australia.

If only we had this level of detail on *that* day in December.

The following is what occurred in chronological order. Dates are hyperlinked.

8th April 1998

The ARPANS Bill was read for a first and second time in the House of Representatives, a fairly procedural matter. An outline of the Bill was given indicating:

> *"This Bill introduces regulatory controls for all Commonwealth radiation and nuclear safety activities for the first time in Australia. It is designed to protect the health and safety of persons and the environment from the harmful effects of radiation practices undertaken under the auspices of the Commonwealth."*
> – Hon. Trish Worth

14th May 1998

The debate on the Bill continues with main focus residing around the Lucas Heights reactor and its future replacement. Debate is adjourned.

11th November 1998

After a federal election on the 3rd of October the debate is resumed, where members of parliament make their second reading speeches.

12th November 1998

The ARPANS Bill was read for a third time and passed onto the Senate for further consideration. It is important to note the House of Representatives is comprised of members from federal electorates over Australia, whereas Senators represent their respective States.

23rd November 1998

The Bill is read a first and second time in the Senate, under procedural matters. A brief overview of what the Bill entails was published in Hansard.

26th November 1998

Upon the movement of Sen. Dee Margetts (WA Greens) and affirmed by Sen. Sue Knowles (Liberal Party) the Bill is sent to the Senate Community Affairs Legislation Committee to hear from witnesses with an interest in the Bill on the 30th November 1998.

30th November 1998

The Senate committee comprised of 7 Senators and heard from 12 witnesses: Two Liberal Party, two Labor Party, two Democrats, and one Greens Party Senators; five representatives from ARPANSA (interim body), Nuclear Safety Bureau, Australian Radiation Laboratory and ANSTO; four councillors from the Sutherland Shire council (location of Lucas Heights reactor); and three anti-nuclear advocates, Dr. Jim Green (FoE), Ms. Jean McSorley (Greenpeace), and Mr. Larry O'Loughlin (ACF).

The transcripts of their questioning can be read in the Hansard records. Needless to say a detailed and robust discussion of Nuclear Power is clearly absent.

2nd December 1998

The Committee's final report was tabled in the Senate. In this report it recommends that:
Amend the definition of "nuclear installation" to delete the references to nuclear power reactors and to reprocessing facilities, and to add references to the following:

- *a spent fuel conditioning plant*
- *a nuclear isotope production facility*
- *a nuclear waste storage facility*
- *a nuclear waste disposal facility.*

This recommendation did not clarify for what reason, however paragraphs from the opposition (Labor Party) and minority parties (Democrats and Greens) are the first indication that there will be an amendment to the Bill prohibiting particular facilities, specifically from the Democrats and Greens:

> *"The recommendation to exclude nuclear power reactors from the legislation is an improvement in accountability. The Greens and Australian Democrats, however, are concerned that licenses for `a nuclear fuel fabrication plant', `an enrichment facility' `a fuel storage facility' and `a reprocessing facility' remain possible under this legislation, albeit with the approval of the CEO. These activities should either be specifically prohibited under this legislation, or at the least, should not be able to take place without full and separate Parliamentary scrutiny."*

Thus, Prohibition was decided at the Committee stage after three and a half hours of witness testimony. Regardless, the amendment still has to be voted on in the Senate, and then passed back into the House of Representatives for a final vote before being declared an Act.

9th December 1998

The debate in Senate resumed on the ARPANS Bill, with the main focus being on the controversy surrounding the Pangea Resources leaked promotional video declaring Australia to be the best place in the world to host a high-level nuclear waste site. After this discussion it turned to the amendments, first one considered was Greens (WA) amendment No. 1, the prohibition section outlined above. The reasoning for this is outlined in Sen. Dee Margetts 2nd reading speech and comments in committee debate.

10th December 1998

After two sessions discussing the Bill the Greens (WA) amendments were up for vote. The following is how it played out:

Sen. Margetts (Greens WA) restated and introduced her amendments where upon Sen. Forshaw (ALP) indicated that the opposition would support Greens amendment No. 1 (prohibition) as

> *"We understand that there is no either medium-term or long-term intention on the part of the government to proceed to construct such facilities"*

There was a technicality brought up with respect to the Greens and Labor party amendments clashing on the definition of a "nuclear installation", however this was resolved.

At 12.09pm on the 10th of December 1998 the Senate voted on Greens (WA) amendments No.1:
The TEMPORARY CHAIRMAN (Senator Watson)—The question before the chair is that the Greens amendment which concerns clause 9A subclauses (1)(a), (b), (c), (d) and (2) be agreed to.

Amendment agreed to.

That was that. *Note that it was referred to clause 9A but was published as section 10 in the Act.*

The party breakdown of the Senate on that day was; 31 Liberal Party, 29 Labor Party, 7 Democrats, 2 Greens, 5 Nationals, 1 Country Liberal Party, and 1 Independent. The federal election on the 3rd of October that year didn't affect the Senate at this time as Senators who were retiring do so on the following year; Sen. Dee Margetts was one of those retiring.

The Labor Party, Greens and Democrats all have anti-nuclear policies in some form or another, that's 38 anti-nuclear votes. The Country Liberal Party candidate indicated that he could *"…accept the balance of the amendment"* proposed by the Greens and ALP, hence 39 votes and at a minimum the amendments passed. Even if it had been decided in the following year the Democrats gained two more Senators, and thus the anti-nuclear majority would have been retained.

This vote is also peculiar as votes that are this close tend to go to a division to sort out the 'ayes' from the 'noes', putting Senators names down in Hansard indicating their vote on the matter. However this didn't occur. This was a case of the poison chalice perception.

After a three-and-a-half hour committee meeting, a several-page report drafted over two days, one hour and 36 minutes of debate post-prohibition recommendation, and six minutes of considering the amendments it was decided that Australia should not go down the nuclear path.

As stated previously amended Bills from the Senate move back to the House of Representatives to be voted on again. Unfortunately due to the poison chalice perception, and the waste dump issues energising the anti-nuclear base the following occurred:

Dr WOOLDRIDGE (Health and Aged Care) (11:38 PM) —I move:
That the amendments be agreed to.

And they were, no division.