Nuclear Fuel Cycle Royal Commission
Level 5, 50 Grenfell Street,
Adelaide SA 5000
3rd August 2015

The Medical Association for Prevention of War (Australia) works for the elimination of all weapons of mass destruction and the prevention of armed conflict. We promote peace through research, advocacy, peace education and partnerships. Our professional not-for-profit organisation has branches across Australia, and works globally through the International Physicians for the Prevention of Nuclear War.

We are particularly concerned at the proposed expansion of the nuclear industry in South Australia. There are clear historical links between the industry and nuclear weapons proliferation. Nuclear waste is toxic material that can last for millennia, and despite billions of dollars of research over many decades there are still no safe long term solutions.

The Public Health Association of Australia

The Public Health Association of Australia (PHAA) is recognised as the principal non-government organisation for public health in Australia and works to promote the health and well-being of all Australians. The Association seeks better population health outcomes based on prevention, the ecological and social determinants of health and equity principles.

The PHAA is a national organisation comprising around 1900 individual members and representing over 40 professional groups concerned with the promotion of health at a population level. This includes, but goes beyond the treatment of individuals to encompass health promotion, prevention of disease and disability, recovery and rehabilitation, and disability support. This framework, together with attention to the social, economic and environmental determinants of health, provides particular relevance to, and expertly informs the Association’s role.
Thank you for the opportunity to put in a submission on this very important issue. We have provided responses to some of the questions posed in each of the four issues papers. We have supplied as appendices information and evidence about the health impacts of ionising radiation, the recently revised MAPW policy on disposal of nuclear waste and the current PHAA policy on the nuclear industry.

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Executive Summary

KEY ISSUES

Toxicity
The nuclear industry worldwide has a long and well documented record of errors and accidents leading to toxicity to humans and the environment\(^1\). Workers and others exposed to ionising radiation have increased rates of cancer and other diseases. The medical evidence about the health impacts of radiation shows even low doses of radiation increase risk of malignancy and cardiovascular disease, and as more evidence emerges the toxicities are found to be greater than previously estimated.

Weapons Proliferation
There is a clear link between possession of nuclear power and nuclear weapons proliferation. One only has to look at current concerns about Iran acquiring a nuclear program to see that it is a significant and realistic threat. The majority of nuclear weapons states have acquired their weapons whilst claiming they are using nuclear power for peaceful purposes.

Any enrichment, reprocessing, reactor construction or accumulation of high level waste by Australia will have regional impacts. This may lead to perceptions of proliferation risk by our neighbouring countries, which over time may develop into a nuclear arms race. Clearly this is a highly undesirable outcome.

Waste
After billions of dollars and more than six decades spent on research, there is still no long term solution for the wastes from nuclear reactors. Decades of industry promises of commercial reactors that will use waste as fuel have failed. International research reactors using waste have been very expensive disappointments. Mining, bomb testing and reactor sites have a long history of very poor rehabilitation and leaving areas that are uninhabitable.

Current medical use of isotopes does not justify a waste repository. Medical isotopes can be produced without needing a reactor, and the vast majority have such a short half-life they can be disposed of in normal waste streams after a short period of storage.

Electricity Demand
Australia has excess baseload generating capacity and will have so for a several decades, our grid electricity consumption has been declining over the last seven years due to a combination of efficiencies and renewables, and we are shutting down coal fired plants as a result. There is no economic or market argument for increasing our baseload electricity generation capacity.

Cost
Nuclear power is expensive when compared to other current power sources, despite industry claims to the contrary. Insurance, very long term waste management and decommissioning costs are seldom factored in. Reactors internationally have required major subsidies, contracts with prices more than

\(^1\) Let the facts speak www.letthefactsspeak.org 2012
double current power costs, and massive loan guarantees. Reactors are getting steadily more expensive to build and almost uniformly have major delays in construction. Fuel manufacture and reprocessing markets are reported as oversupplied and not commercially attractive.

**Opportunity Cost**

A focus on the nuclear industry will damage South Australia’s potential to be a world leader in technology for renewable energy sources. It is also likely to cause major damage, by distracting from the urgent need for action on climate change. Any reactor would take roughly two decades to begin to produce power, and even longer to repay the carbon emissions from construction. This is too slow.

With research and international partnerships, South Australia has the potential become world leader in cyclotron/accelerator (non-reactor) production of medical isotopes.

Expenditures and subsidies required by nuclear industries would reduce funds available to South Australians for health, education and other services and critical infrastructure.

Other energy sources create more employment, use less water and have much less potential for major intergenerational toxicities and nuclear catastrophes.

**Declaration of Interests**

It is critical that there is transparency regarding pecuniary interests of the staff (particularly expert advisers) of the Royal Commission. All interests (including past and current grants to academic departments and institutions) relating to the uranium mining and nuclear sector need to be declared, to ensure confidence in the process.

**Governance and regulation**

The South Australian government has a poor history when it comes to governance and regulation of this industry, with the legislation such as the Roxby Downs (Indenture Ratification) (Amendment of Indenture) Amendment Bill 2011 a clear illustration of commercial pressures overriding public health and community interests.
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INTRODUCTION

Our comments on Issues Paper One relate to legacy and risk issues arising from the exploration extraction and milling of nuclear fuel. Specifically we wish to address Section C. Risks and Opportunities, questions 1.8–1.11.

1.8 Would an expansion in extraction activities give rise to new or different risks for the health and safety of workers and the community? If so, what are those risks and what needs to be done to ensure they do not exceed safe levels?

1.9 Are the existing arrangements for addressing the interaction between the interests of exploration and extraction activities and other groups with interests such as landowners and native title holders suitable to manage an expansion in exploration or extraction activities? Why? If they are not suitable, what needs to be done?

1.10 Would a future expansion of exploration, extraction and milling activities create new environmental risks or increase existing risks? If so, are current strategies for managing those new risks sufficient? If not, in what specific respects? How would any current approach need to be changed or adapted?

1.11 Given current techniques of extraction and milling and their regulation, what are the relevant lessons for the contemporary management of environmental impacts that should be learned from past extraction and milling practices?

HISTORICAL CONTEXT

Australia’s uranium extraction industry dates back to the early 20th century. The notable South Australian example from the early period is the Radium Hill mine, starting in 1906. This mine was sourcing radium for medical and industry purposes. It was later discovered that there were serious adverse impacts to workers at this mine including a significant increase in lung cancers. Many of the medical uses for the radium produced were later found to actually be harmful and subsequently abandoned.

HEALTH EFFECTS OF URANIUM MINING

Considerable evidence now exists as to the harmful health effects resulting from exposure to radioactivity. In particular it is well established that workers at uranium mines in Australia and other parts of the world have suffered increased incidences of cancers, particularly lung cancer, and other health problems such as heart disease as a result of their workplace exposure. The radioactive gas, radon, was identified as the cause in the 1950s. Studies of underground miners, especially those exposed to high concentrations of radon, have consistently demonstrated the development of lung cancer in both smokers and non-smokers. On this basis, the International Agency for Research on Cancer (IARC) classified radon as a

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carcinogen in 1988. In 2009, the ICRP stated that radon gas delivers twice the absorbed dose to humans as originally thought and is in the process of reassessing the permissible levels. At this stage, previous dose estimates to miners need to be approximately doubled to accurately reflect the lung cancer hazard.

The Biological Effects of Ionising Radiation VI report (1999) reviewed eleven cohort studies of 60,000 underground miners with 2600 deaths from lung cancer, eight of which were uranium miners in Europe, North America, Asia and Australia. These found a progressively increasing frequency of lung cancer directly proportional to the cumulative amount of radon exposure in a linear fashion. Smokers had the highest incidence of lung cancer, as would be expected, but the greatest increase in lung cancer was noted in non-smokers. The highest percentage increase in lung cancer was noted 5-14 years after exposure and in the youngest miners.

Uranium miners are also exposed to ionizing radiation (IR) directly from gamma radiation and the dose from this is cumulative to that from radon. At the Olympic Dam underground uranium mine, the total dose per miner is approximately 6 mSv, of which 2-4 mSv (allowing for the new ICRP dose coefficients) are due to radon and the balance due to gamma radiation.

Most modern uranium mines have air extraction systems and monitored ambient measures of radon concentrations to ensure levels remain low. Current levels of radon in underground uranium mines are only a fraction of mines of 100 years ago. Miners are now given personal protective equipment (PPE) including masks to filter out the radioactive particulate matter. Yet many underground miners find the masks extremely uncomfortable, especially in the hot underground environment they must contend with. It is estimated that up to 50 per cent of underground uranium miners in Australia do not use their masks, and thus drastically increase their risk of lung cancer while underestimating their actual radiation dose where calculations are made assuming PPEs are used.

The Olympic Dam doses mentioned above are typical of modern mine practices. The average miner at Olympic Dam is in his 20s and stays on average five years at the site. A typical calculation using the linear no threshold model and the latest BEIR-VII figures of radiation carcinogenesis risks indicates miners at Olympic Dam therefore have a 1:420 chance of contracting cancer, most likely lung cancer. Note that the research demonstrates that the risk of developing lung cancer is greater for younger workers. These risks are not insubstantial. Radiation safety and risk principles can be quite complex and it is debatable whether miners have the training to understand the basis, or are even informed of the risks in a comprehensive and accurate manner that they can comprehend and make an informed work decision.

There is also documented evidence that community members living around uranium mines, such as the Navajo Native Americans, have also suffered increased incidences of cancers. There are presently significant concerns that there may be an increased incidence of cancers and stillbirths in the Indigenous populations in the Alligator Rivers Region of the Northern Territory, where there have been several uranium mines over the last 50 years including the Ranger mine and Nabarlek mine.

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3 International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans.
4 Health effects of exposure to Radon. Committee on Health Risks of Exposure to Radon (BEIR VI), National Research Council. 1999. The National Academies Press
6 Tatz, C et al. 2006. Aborigines and Uranium: Monitoring the Health Hazards: Australian Institute of Aboriginal and Torres Strait Islander Studies
Approach to regulation in South Australia

The existing regulation and oversight of the Olympic Dam uranium mine site provides a poor (and salutary) example of lack of transparency, and transparency is a key part of good regulation. Since the passing of Roxby Downs (Indenture Ratification) Act, 19827 and subsequent amended bills, special treatment has been provided for BHP Billiton (BHPB) with regard to the:

- Aboriginal Heritage Act 1988
- Development Act 1993
- Environmental Protection Act 1993
- Freedom of Information Act 1991
- Mining Act 1971
- Natural Resources Act 2004 (including the Water Resources Act 1997)

These many exemptions undermine community expectations that corporations should be regulated to limit the potential damage they can cause and to ensure they remain accountable for their actions. In a response to the SA Ombudsman external review of the FOI determination about the August/September 2007 Slag Tapping (referred to on the following page), BHPB legal advisers submitted that “Disclosure of the documents would establish a precedent that might compromise our client’s ability, moving forward, to provide to SafeWork SA (or to any other government entity) any more information beyond what is legally obliged to be provide.” The Ombudsman commented that he did “not accept that the disclosure of documents would impact on BHPB’s future provision of information to government of such documents. BHPB must continue to provide information to government as required by law.” BHPB legal advisers also submitted “anything that compromises [BHPB’s] relationship with SafeWork SA is contrary to the public interest, given the important role that our clients play in the South Australian economy.” The Ombudsman responded that he “considered there is a public interest in satisfying the objects of the FOI Act and ensuring transparency and accountability particularly in relation to safety issues and Safe Work SA’s investigation of those issues.”

The exemptions in Roxby Downs (Indenture Ratification) Act, 1982 challenge the South Australian Government’s expressed commitment to the “strictest environmental standards” for the Roxby Downs/Olympic Dam mine. The provision of so many exemptions, overriding confidentiality clauses and the resulting lack of transparency bring into question the South Australian government’s ability to manage the substantial risks that have been historically evident in all phases of the nuclear fuel chain.

Given the above, it is impossible to know how many incidents of poor practice are not publicly reported. There are significant concerns regarding worker occupational health and safety, with no transparency that monitoring systems are adequately implemented. There is no transparency regarding whether independent “impromptu” site inspections or site audits even occur. Current corporate reporting of exposures of selected workers and air monitors potentially allows some workers to receive levels of exposure over the current recommended maximum. As noted already, the wearing of respirators in hot and arduous working conditions of inland South Australia is not complied with at times and vital communication and verbal instructions are very difficult while wearing a respirator.

A single example of an incident at the Olympic Dam mine

Obtaining information via the Freedom of Information (FOI) Act about the risks to worker and public health and safety is extremely time consuming, difficult and usually incomplete. One single incident, at Olympic Dam mine in late August/September 2007, identified after media reports and

then by documents applied for under an FOI application, relates to changes to processing, with slag (radioactive molten metals) being tapped from the Flash Furnace and bypassing the Electric Slag Cleaning furnace. This molten material was dropped the ground and thus increased the risk of significant heat, gas and dust (airborne radiation) exposures to nearby workers in the smelter area. These slag releases increased quantities of radioactive dust including the highly toxic alpha emitter Polonium 210. This process of “slag tapping” continued for approximately six weeks whilst repairs were carried out to the Electric Slag Cleaning Furnace. This was necessary after an “Electric furnace roof collapse incident” and an “Electric Furnace Explosion”. 6 workers were treated in hospital for smoke inhalation (radioactive particle levels unclear), with none admitted. Access to Dangerous Occurrence reports from SafeWork SA regarding these two events was refused, as was access to a number of other relevant documents.

Recognising the significantly increased exposure risk from the “slag tapping”, BHPB promised the EPA extra monitoring of personnel, stringent PPE requirements and restrictions on personnel entering the smelter building. They also promised weekly feedback to the EPA, and that if monitoring indicated any significant increase in personnel exposures, the processes would be reviewed to ensure optimisation of occupational exposure. Despite these promises, specifically access to monitoring data for personnel exposures from mid-September 2007 to February 2008 has been refused, citing exemption via confidentiality clause 35 provided by the Roxby Downs (Indenture Ratification) Act, 1982. The preceding Radiation Protection and Occupational Hygiene report for Jul/Aug/Sep 2007 noted a decrease in the number of samples for the quarter, due to staff on the ventilation project being reduced. Thirty six readings exceeded the reporting level giving an average exposure dose of 0.9 mSv with a maximum of 1.6mSv. The sulphur dioxide (SO2) monitoring had 36 of 45 samples over the exposure standard. This is either a dangerous level or a significant error. We have no detail that the EPA attended the site to observe gas and radiation levels and monitor worker respirator use and exposure, nor evidence of a request for submission of a new Radiation Management Plan or Waste Management Plan.

Lack of transparency regarding other adverse events

Other FOI documents acknowledge that tapping the slag has occurred on a number of earlier occasions. Indeed, it is highly likely also to have occurred subsequently on a number of occasions. However we cannot find out how often this process, with its inherent and acknowledged risk of higher worker exposures, has occurred, or is likely to occur in the future. Should the practice of “slag tapping” be prohibited until safer methods are developed? The secrecy around the August/September 2007 episode is just a single example and raises major questions about the health and safety culture at the Olympic Dam Mine. There are also significant questions about transparency and public accountability.

Monitoring

In other reports that were accessed by FOI, worker exposures of airborne dust levels are evaluated by dust sampling at a number of points with several hundred samples per quarter. The siting of sampling areas, collection, laboratory analysis, data base entry and compilation of reports may be subject to error, omission, and potentially statistical manipulation, given the data are presented as an average. These airborne concentration results are then applied to workers in the location at the time, and the dose calculated using the duration of the exposure. We have no evidence these sampling measures are subject to independent impromptu site inspection or audit. Internationally regulatory limits are 20 mSv annually, and BHPB internal site action limit is 10 mSv. In August 2005 twenty employees received a dose greater than 10 mSv, and one employee 17.7 MSv. If an individual worker had a
serious incident of raised Polonium 210 exposure, the only reliable way to detect the episode would be blood and urine testing within weeks. There is no evident reporting on the percentage of time workers collectively or individually actually wear their PPE.

**Outdated Radiation Management Plan**

In documents from May 2013 released under FOI, the Environmental Protection Agency (EPA) commented that the Olympic Dam Radiation Management Plan (submitted to the Minister for Mines in January 1997 and subsequently approved) was overdue for updating. There have been significant technological changes that have occurred in the almost 20 years since the original document was drafted. Now more than two years after the EPA comments there is no evidence that this important document has been updated.

**Lack of transparency about occupational health and safety, and environmental and other risks**

Uranium mining should not continue unless a safe workplace can be shown to be provided. The “lesson from past extraction and milling practices” is that the many exemptions provided by the Roxby Downs (Indenture Ratification) Act, 1982 raise serious questions about the South Australian government’s duty of care and interest in protecting the health of workers.

From a worker health and environmental perspective, given the multiple current regulatory exemptions provided to Olympic Dam, there is clear need for these exemptions to be amended to meet world’s best practice or for the uranium mining industry to be phased out. In the face of concerns, and the opacity surrounding occupational health risks (and environmental and other risks) from the nuclear fuel extraction and milling industries, MAPW and the PHAA strongly believe that there should not be any further expansion of these industries. In addition, it is clear current mining practices need to be rigorously reviewed.

**LEGACY, SAFETY AND REGULATORY ISSUES**

1.9 Are the existing arrangements for addressing the interaction between the interests of exploration and extraction activities and other groups with interests such as landowners and native title holders suitable to manage an expansion in exploration or extraction activities? Why? If they are not suitable, what needs to be done?

**Contaminated sites and inadequate rehabilitation**

The Radium Hill site, as well as the former uranium processing site at Hunters Hill in Sydney, remain contaminated with radioactivity to this day. Many other former uranium mines in Australia remain incompletely rehabilitated, with ongoing radioactive legacies present. The interests of landowners and native title holders are seldom taken into account.

Of the larger current uranium mines operational in Australia, the Ranger mine is an important example of significant risks to human and environmental health. There have been over 200 documented safety incidents at the mine since its opening in 1980. In 2013 more than a million litres of radioactive slurry was spilt when a leach tank burst at the site. At present there are concerns that there is toxic contamination from the mine appearing downstream at the Galangal Creek site. It has been estimated that the rehabilitation of the Ranger mine will cost in the order of $500 million. Energy Resources of Australia who operate the mine have been unable to confirm that they will be
able to fund the mine rehabilitation costs. Fortunately ERA’s parent company Rio Tinto have recently indicated that they will financially back the completion of the rehabilitation; however for a period of time there was uncertainty as to whether these costs would actually be able to be met. In that case it could have fallen on the Territory and Commonwealth Governments to pay a huge sum to rehabilitate the mine.

**Regulatory concerns**

Lack of transparency leads to significant concerns that the regulation of the uranium exploration, extraction and milling industry in Australia is inadequate. In the case of Ranger, the findings of the investigation into the abovementioned 2013 leach tank incident have not been made public and ERA has not been penalised at all for the major incident that took place.

The MAPW and the PHAA believe that the exploration, extraction and milling of radioactive materials in Australia needs to be tightly regulated throughout this phase of the nuclear fuel cycle and that under no circumstances should appropriate rehabilitation be compromised. Given the poor performance to date in both legacy and current operational mines we consider that Australia lacks the maturity to be able to responsibly manage these phases of the cycle.

**Concerns regarding stakeholders**

Australian uranium mines have a history of Aboriginal land rights and heritage protection being inadequately upheld. An important example is the 1982 South Australian Roxby Downs Indenture Act which sets the legal framework for the operation of BHP Billiton’s Olympic Dam mine in SA. Despite amendments in 2011 the Act retains exemptions from the SA Aboriginal Heritage Act. Traditional Owners were not consulted in relation to these amendments.

The nuclear fuel cycle clearly has inherent health risks at all stages. It is of concern that inadequate consultation with traditional owners and other landholders, residents and interest groups can take place in the lead up to establishment of a radioactive exploratory, extractive or milling process. Relevant stakeholders also include residents of communities where radioactive materials will be passing through on transportation routes, as there is a risk of significant contamination in the event of an accident. Relevant stakeholders need to be comprehensively appraised of the risks involved in the processes as well as the legacy issues that they might expect and have the opportunity to ultimately veto the advancement of any project.

**NUCLEAR SAFEGUARDS**

1.10 Would a future expansion of exploration, extraction and milling activities create new environmental risks or increase existing risks? If so, are current strategies for managing those new risks sufficient? If not, in what specific respects? How would any current approach need to be changed or adapted?

1.11 Given current techniques of extraction and milling and their regulation, what are the relevant lessons for the contemporary management of environmental impacts that should be learned from past extraction and milling practices?
Weapons Proliferation and inadequate safeguards on exported uranium

The MAPW and the PHAA note that nuclear weapons proliferation has not been included in the Issues Papers in this Royal Commission. We consider it vital that this issue be considered as it poses a grave threat to humanity. This will be discussed further in our response to Issues Paper 3.

The former Director-General of the International Atomic Energy Agency Dr Mohammed El Baradei previously said that the Agency's safeguards system for use of uranium suffers from “vulnerabilities” and “clearly needs reinforcement”, that efforts to improve the system have been “half-hearted” and that the safeguards system operates on a “shoestring budget”.

Australia has for many years supplied the raw ingredient for nuclear weapons – un-enriched uranium to a variety of countries, including nuclear weapons states – all of whom are in breach of their obligations under international treaties to disarm. Recent events in the Ukraine have highlighted the dangerous and cavalier nature of Australia’s uranium exports: when the Russian leadership exhibited uncooperative attitudes over the civil war in the Crimea almost overnight their trustworthiness as a recipient of our raw bomb fuel exports fell in to doubt. Exports of uranium to Russia were ceased. Why? Did the safeguards agreements on which those exports were auspiced no longer carry sufficient guarantee against diversion of Australian Obligated Material into Russian warheads? How can we ever trust them? Meanwhile senior officials in both China and India have signaled that Australian uranium will enable them to bolster their nuclear weapons capability with indigenous supplies – a clearly proliferative activity.

At present Australia has signed an agreement to export uranium to India which is a country that has refused to ratify the Comprehensive Test Ban Treaty. India has very limited domestic uranium production. In effect, Australia is indicating that it is prepared to sell uranium to a country which could potentially detonate a nuclear weapon and inflict serious and irreversible damage to humanity and the environment.

K.Subramanyam (former head of India’s National Security Advisory Board), has said “Given India’s uranium ore crunch and the need to build up our minimum credible nuclear deterrent arsenal as fast as possible, it is to India’s advantage to categorize as many nuclear reactors as possible as civilian ones to be refueled by imported uranium and conserve our native uranium fuel for weapons grade plutonium production”. It is also of note that India is not a signatory to the Nuclear Non-Proliferation Treaty (NPT).

Export safeguard agreements with India have come under intense criticism of late, including from the former ASNO Director John Carlson, who argues that the agreement with India "represents a serious weakening of Australia's ... safeguards conditions" and that weaknesses in the agreement "mean Australian material could be used in support of India's nuclear weapon program."8 Under the proposed agreements Australia will inevitably contribute to nuclear instability and facilitate proliferation of nuclear weapons.

Recommendations regarding uranium mining post Fukushima

In September 2011, following the Fukushima disaster, the United Nations Secretary General Ban Ki Moon released a system-wide study, “The implications of the accident at the Fukushima Daiichi nuclear power plant”, calling for uranium producing nations to hold a cost-benefit assessment of the

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8 www.aph.gov.au/DocumentStore.ashx?id=35f7b7f2-904c-4d44-b387-f34e4afbf7f9&subId=301365
environmental and community impacts of mining. This was a recommendation supported by a recent Australian parliamentary review into plans for new uranium sales. To date neither this review, nor a report back to the United Nations, has been conducted.

CONCLUSION

In summary, the MAPW and the PHAA believe that expansion of the nuclear fuel cycle in South Australia in the areas of exploration, extraction and milling is unwarranted and inappropriate, particularly on health and safety grounds.

SARC PAPER 2 - FURTHER PROCESSING AND MANUFACTURE

THE NUCLEAR FUEL CYCLE ROYAL COMMISSION IS TASKED BY ITS TERMS OF REFERENCE WITH CONSIDERING

- THE FEASIBILITY OF FURTHER PROCESSING MINERALS, AND PROCESSING AND MANUFACTURING MATERIALS CONTAINING RADIOACTIVE AND NUCLEAR SUBSTANCES (BUT NOT FOR, OR FROM, MILITARY USES), INCLUDING CONVERSION, ENRICHMENT, FABRICATION OR REPROCESSING IN SOUTH AUSTRALIA,
- THE CIRCUMSTANCES NECESSARY FOR PROCESSING OR MANUFACTURE TO BE Viable,
- THE RISKS AND OPPORTUNITIES ASSOCIATED WITH ESTABLISHING AND UNDERTAKING THAT PROCESSING OR MANUFACTURE, AND
- THE MEASURES THAT MIGHT BE REQUIRED TO FACILITATE AND REGULATE THE ESTABLISHMENT AND CARRYING OUT OF PROCESSING OR MANUFACTURE.

INTRODUCTION

In this section the submission will address the overall feasibility of further processing and manufacture, with particular exploration of the risks and opportunities that are inherent in this area, and emphasis on the health implications.

Particular attention will be given to questions 2.4-2.14

2.4 Projections and feasibility

_What are the projections for future supply and demand for conversion, enrichment, fuel fabrication or reprocessing activities? What is the evidence to support those projections? Might it be viable for one or more of those activities, or an aspect of them, to be established in South Australia in the medium or long term? What is the reason for thinking that would be so? What conditions would be necessary for that to be viable?_

Global oversupply for conversion and enrichment

There is an acknowledged global oversupply of existing capacity for conversion and enrichment. In a report dated April 2015 the WNA noted that “There is a significant oversupply of enrichment capacity worldwide.” Thirteen countries have enrichment capability or near capability, with about 90% of enrichment capacity in nuclear weapons states- UK, USA, China, France and Russia. Along with Germany, the Netherlands and Japan they provide the enrichment services to the commercial market. In July 2014 Steve Kidd (former World Nuclear Association executive) wrote: “the world enrichment market is heavily oversupplied.” This was echoed in February 2015 by Richard Yeeles (former Western Mining executive) “I think there is overcapacity worldwide for conversion and enrichment.” and in March 2015 by Dr Switkowski “There is a lot of enrichment capacity around the world.” Using the World Nuclear Association (WNA) projections for enrichment supply-demand

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10 World Nuclear Association Uranium Enrichment April 2015
balance is likely to be problematic, as they have a focus on the nuclear industry rather than on trends in other sectors such as renewable energy.

**Future prospects and perennially optimistic projections**

Fabrication is reactor specific, and according to BHP’s submission to the 2006 Switkowski inquiry: “BHP Billiton believes there is neither a commercial nor a non-proliferation case for it to become involved in front end processing… The economics of conversion, enrichment or fabrication do not look positive.” Given the post Fukushima slump both in uranium prices and number of operational reactors, the commercial prospects are unlikely to have improved. With a worldwide reactor fleet that is ageing demand is in doubt. The International Energy Agency said in its 2014 World Energy Outlook report “A wave of retirements of ageing nuclear reactors is approaching: Almost 200 of 434 reactors operating at the end of 2013 are retired in the period to 2040, with the vast majority in the European Union, the United States, Russia and Japan.”

IAEA forecasts nuclear capacity growth of 17-94% by 2030, but as shown by the graph below, historically projections of growth have been much greater than what has eventuated, even at the lower estimates.\(^{11}\) These graphs are useful as they contrast the optimistic projections of the industry over many years with the reality as it has happened.

FIG. 4: The Agency's global low (top) and high (bottom) nuclear power projections. Source: IAEA-RDS-1 editions 2005 to 2014.
2.5 Participation in manufacturing

*Could South Australia viably increase its participation in manufacturing materials containing radioactive and nuclear substances? Why or why not? What evidence is there about this issue? What new or emerging technologies are being developed which might impact this decision?*

**Medical isotopes: a manufacturing opportunity**

There is an important commercial opportunity in manufacture (using cyclotrons and/or linear accelerators) of radioactive isotopes for medical and other applications. Expansion of the cyclotron at the South Australian Health and Medical Research Institute would provide supplies for medical imaging and therapies nationally and internationally. Research into the manufacture of smaller cyclotrons for use in regional centres is also a very promising field.

This area has several advantages over other options. Firstly there is no evidence of overcapacity in existing manufacturing worldwide, in stark contrast to the situation with conversion and enrichment technologies. As an illustration, Molybdenum-99 converts to Technetium-99m (Tc-99m), which is the world’s most highly used medical isotope and a key component in more than 75,000 imaging procedures a day. Over the last decade there have been shortages, due to maintenance and repair requirements of existing reactor based manufacturers. One major producer, the Canadian Chalk River reactor, is scheduled for shut down in 2018. The initial shutdown was scheduled in 2016, but has been delayed to help avoid further shortages.

Since a period in 2009-2010 where world supply shortages reached “crisis levels”, Canada has been actively researching alternative methods of manufacture of isotopes. In early 2015, Canada’s national laboratory for particle and nuclear physics, TRIUMF, announced that researchers had demonstrated that the technology can work using a number of different cyclotrons capable of servicing fairly large population centres.

In addition, the use of non-reactor production means that medium and long term waste disposal problems are avoided. Our regional neighbours will not be concerned as there are no significant fissile material proliferation or security risks. Currently it is proposed to build a facility to expand manufacture of isotopes at the Lucas Heights reactor in South Sydney, given future worldwide demand. Ramping up reactor based production in a highly populated area will compound the already significant issues of safety, security and reactor waste, needlessly increasing risk.

Local manufacture of both isotopes and cyclotrons/linear accelerators would provide safe methods of producing Technetium-99m and other isotopes. In addition, given the substantial world demand, commercial viability is more likely than in a market where manufacturing capacity is already exceeding demand. Accelerator-based technologies creating isotopes such as molybdenum-99 would provide decentralised sources of supply allowing medical facilities to avoid relying on one multinational supply chain and enabling them to process radiopharmaceuticals in the basement of the hospital/medical facility. This is especially advantageous where the isotope has a short half-life. For example,

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technetium-99m has a half-life of only six hours, and therefore must be produced nearby and shortly before it is to be used. Transferring this process to a closer proximity of the patients can prevent cancellations or delays in important medical testing services.

2.6 Specific models

*What are the specific models and case studies that demonstrate the best practice for the establishment, operation and regulation of facilities for the conversion, enrichment, fuel fabrication or reprocessing of, or the manufacture of materials containing, radioactive and nuclear substances? What are the less successful examples? Where have they been implemented? What lessons can be drawn from them?*

Research will be needed to establish which particular radio pharmaceuticals and nuclear medicines have the greatest market, and also which technologies are the most promising for their manufacture. The Canadian government approach may provide a useful starting point for the South Australian government\(^\text{15}\text{16}\). A partnership agreement and funding of further research should be explored.

2.7 Building confidence

*What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?*

**A history of poor regulation and many other problems**

Internationally, the nuclear industry has a long history of inadequate regulation, cosy relationships between industry, regulators and political representatives, cost cutting, data falsification, concealment of incidents, human error and accidents and has clear potential for individuals or groups to cause deliberate harms\(^\text{17}\). The sheer volume and ongoing frequency of actual adverse events negates the theoretical “fail safe” mechanisms that have been promised with each new version of nuclear technology.

To quote from “Let the facts speak”\(^\text{8}\), which documents many nuclear accidents and errors:

> “The hazards associated with nuclear reprocessing were highlighted in April 2005 with the revelation of an accident at the THORP reprocessing plant at Sellafield. A broken pipe led to the leaking into a containment structure of 83,000 litres of a highly radioactive liquor containing dissolved spent nuclear fuel. The leakage went undetected for at least eight months.

The accident was classified as Level 3 (‘serious incident’) on the 7-point International Nuclear Event Scale and British Nuclear Group Sellafield Limited was fined 500,000 pounds plus costs after pleading guilty to three serious, prolonged breaches of its licence conditions.

What is significant about the leakage is not the environmental and health risk it posed but the fact that the liquid spill contained 160 kgs of plutonium - enough to build 15-20 nuclear weapons - yet the loss went undetected for at least eight months.

\(^\text{15}\)Natural Resources Canada. Government of Canada’s Action on our Medical Isotopes Supply https://www.nrcan.gc.ca/energy/uranium-nuclear/7793

\(^\text{16}\)Canadian National Laboratory for particle and nuclear physics TRIUMF Website http://www.triumf.ca/

\(^\text{17}\)Let the facts speak www.letthefactsspeak.org 2012
The UK Health and Safety Executive concluded: “An underlying cause was the culture within the plant that condoned the ignoring of alarms, the non-compliance with some key operating instructions, and safety-related equipment which was not kept in effective working order for some time, so this became the norm. In addition, there appeared to be an absence of a questioning attitude, for example, even where the evidence from the accountancy data was indicating something untoward, the possibility of a leak did not appear to be considered as a credible explanation until the evidence of a leak was incontrovertible.”

There have been numerous other serious accidents and incidents at the Sellafield site (previously called Windscale) including the 1957 fire, a data falsification scandal and a serious sabotage incident in the late 1990s. Moreover the site has been a major source of radioactive emissions to the environment and has been the subject of formal complaints and opposition from European Governments.”

**Application of standards essential**

At the risk of stating the obvious, the 2011 IAEA document “Establishing the Safety Infrastructure for Nuclear Power Plants” notes “Standards are only effective if they are properly applied in practice.” As already noted in our response to issues paper 1, the existing regulation and oversight of the Olympic Dam uranium mine site provides a poor (and salutary) example of lack of transparency and evidence of good regulation.

In turn this does little to engender confidence in the South Australian government’s ability to ensure the future safety or regulation of new and more intensely radioactive material processing. It will be very difficult to build confidence in the industry, particularly given the specific and sensitive issues involved in proposals such as enrichment and reprocessing.

**2.8 Risks**

*What additional risks for health and safety would be created by the establishment and operation of such facilities in South Australia? What needs to be done to ensure that risks would not exceed safe levels? Can anything be done to better understand those risks?*

**Health issues with manufacturing**

As noted in 2.7, the nuclear industry has a far from perfect safety record. Further processing of uranium leads to materials with greater radiation hazards, and more catastrophic consequences in the event of error, accident or deliberate harm. Of the manufacturing options proposed, enrichment and reprocessing are the most problematic. There are clear health hazards with radiation exposures, and the exposures risk is linear (ie the greater the exposure the greater the health risk). There is strong evidence there is no safe lower threshold for exposure (see attached medical research summary in Appendix 2).

Nuclear accidents, theft of materials and deliberate harms (due to criminal/terrorist intent, mental illness or other motivation) are difficult to prevent, and adequate safeguards almost impossible.

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18 Establishing the Safety Infrastructure for Nuclear Power Plants International Atomic Energy Agency 2011
In order for the Royal Commission to better understand the risks involved in the nuclear fuel chain in a technologically advanced country, the report of The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission\(^{19}\) needs to be read. This report found:

“It was a profoundly manmade disaster – that could and should have been foreseen and prevented. And its effects could have been mitigated by a more effective human response. How could such an accident occur in Japan, a nation that takes such great pride in its global reputation for excellence in engineering and technology? This Commission believes the Japanese people – and the global community – deserve a full, honest and transparent answer to this question.

Our report catalogues a multitude of errors and wilful negligence that left the Fukushima plant unprepared for the events of March 11. And it examines serious deficiencies in the response to the accident by TEPCO, regulators and the government.

*The accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties.*

South Australia’s many regulatory exemptions for BHP’s Olympic Dam demonstrate that it is just as prone as Japan to cosy relationships between industry and government; with inadequate regulation, cost cutting, human error, wilful ignorance and negligence all potential hazards.

Risk issues will be further discussed in our response to Issues Paper 3.

2.9 Environmental Risks

*What additional environmental risks would be created by the establishment and operation of such facilities in South Australia? Are there strategies for managing those risks? If not, what strategies would need to be developed? How would any current approach to management need to be changed or adapted?*

The environmental risks created by further processing of minerals again include accidents, mishandling, risks associated with transport and other issues as outlined above. The production of isotopes using accelerator/cyclotron would avoid many of these hazards as medical isotopes have a short half-life and relatively rapidly decay to levels where they can be disposed of in the normal waste stream as exempt waste. Manufacture of modular accelerators/cyclotrons will enable isotope production at a local/regional level, which would reduce radioactive material transportation risks. These modular accelerators/cyclotrons will reduce the risk of significant environmental issues, by avoiding reactor based technologies (such as would be used in reprocessing, and currently for isotope production at the NSW reactor at Lucas Heights). Leaks, accidents and waste all remain unresolved issues for reactor based technology.

2.10 Lessons from past practice in South Australia

*Given current techniques for further processing of radioactive and nuclear substances, what are the relevant lessons for the contemporary management of environmental impacts which should be learned from past South Australian processing practices?*

\(^{19}\) The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission 2012
Current and past techniques for processing radioactive materials in South Australia are difficult to scrutinise, given the overriding restrictions on transparency and oversight provided to sites such as the Olympic Dam mine. Past South Australian processing has had some accidents reported, but it is almost certain this does not include many accidents that are not disclosed publicly.

One example of contemporary management of environmental impacts is the remediation works undertaken at Maralinga in the late 1990s. These were poorly done and have left a toxic region with erosion of waste sites releasing material into the wider environment. Files released under FOI in 2011 noted that nearly a quarter of the contaminated debris pits had been eroded or subject to subsidence. Nuclear waste materials are toxic to humans, other animals and flora, disposal is far from straightforward and South Australia has not demonstrated the ability to manage waste effectively. These materials have the potential to remain toxic for tens of thousands if not hundreds of thousands of years.

In South Australia environmental management has been deeply flawed in just the space of a few decades, which echoes experiences worldwide. The environmental lessons to be learned are that the nuclear fuel chain creates many more environmental problems than it solves, and that these will have impacts for many, many generations to come. Internationally countries are struggling to deal with toxic waste in the long term. These externalities must be factored in to any decision making.

2.11 Security Implications

What security implications are created by the activities of conversion, enrichment, fabrication or reprocessing of nuclear fuel, or by further manufacturing activities, in South Australia? What is the evidence which suggests that such risks might materialise? Can they be addressed and by what means?

Risk of regional destabilisation

Both enrichment and reprocessing industries have been associated internationally with covert nuclear weapons development. If Australia were to have facilities producing fissile materials, there is a significant risk of sparking a regional arms race. Concerns were raised when India started its nuclear program that it would result in a nuclear weapons arms race with Pakistan, and this proved to be the case. Similarly, Israel’s assumed nuclear weapons program and more recently the presence of enrichment facilities in Iran have not only raised serious fears internationally about further weapons proliferation in the Middle East, but also Saudi Arabia has decided to build nuclear power reactors and is publicly contemplating a nuclear weapons program. The United Arab Emirates are also establishing a nuclear power program, which again raises concerns about potential weapons proliferation.

Australia’s neighbours, particularly Indonesia, would be concerned about Australia acquiring either enrichment or reprocessing facilities, and may use this as justification for having its own nuclear facilities producing fissile materials. In the late 1960s then Australian Prime Minister John Gorton considered building a nuclear reactor in NSW, and later acknowledged "We were interested in this thing because it could provide electricity to everybody and it could, if you decided later on, it could make an atomic bomb." 21

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21 Pilita Clark, 1 Jan 1999, 'PM’s Story: Very much alive... and unfazed', Sydney Morning Herald.
In April 2015 the WNA noted “From a non-proliferation standpoint, uranium enrichment is a sensitive technology needing to be subject to tight international control.” 22 In the 2009 Global Fissile Materials Report, reprocessing plants were described as “presenting the greatest dangers to the nuclear weapons free world. They provide the most plausible route to get weapons usable material. A state with a domestic enrichment industry could build a clandestine facility within a year or so, or within a few weeks convert a civilian enrichment plant to produce highly enriched uranium (HEU). A state with already separated civilian plutonium stockpiled at a domestic reprocessing plant under national control would be able to obtain weapon-usable material immediately. The IAEA assumes that plutonium or HEU could be converted into weapons components within 1-3 weeks.” 23 Reprocessing plants, justified by uranium conservation and waste reduction, provided cover for nuclear weapons programs in India, Pakistan and France.24

2.12 Safeguards

What safeguards issues are created by the further participation in South Australia in activities (such as the production of uranium oxide, conversion, enrichment, fuel fabrication or reprocessing) necessary for uranium to be used as a fuel in electricity generation? Can those implications be addressed? If so, by what means? Further, would the possession of those technical capabilities give rise to strategic and policy issues for Australia? If so, what are those issues and how could they be addressed?

Worldwide safeguards have failed historically to provide protection from leaks, worker exposures, major accidents and weapons proliferation25. It is highly unlikely safeguards in South Australia will prevent adverse outcomes, nor convince concerned countries in our region that there is not an underlying possibility of weapons proliferation. The Olympic Dam Mine Indenture example does not inspire confidence in either the political will nor the capacity of the South Australian government in regard to transparent effective regulation or safeguards.

2.13 Financial and Economic modelling

What financial or economic model or method ought be used to estimate the economic benefits from South Australia’s establishment and operation of facilities for the conversion, enrichment, fuel fabrication or reprocessing of, or the manufacture of materials containing, radioactive and nuclear substances? What information or data (including that drawn from actual experience elsewhere) should be used in that model or method?

There is a tendency on the part of nuclear promoters to ignore many of the externalities of the nuclear fuel chain. In addition to radioactive waste there are significant carbon emissions in the nuclear fuel chain26 starting with mining all the way through to long term waste storage. Any economic modelling needs to include the insurance costs for any plant, the decommissioning costs and the costs of waste

24 Feiveson HA et al. Unmaking the bomb MIT Press 2014:51,54
disposal (which is likely to be problematic and require very long term stewardship, potentially for millennia). The many opportunity costs in terms of government expenditures need to be explicitly factored in, particularly in regard to the distraction from urgent action on climate change.

2.14 Impacts on other sectors

Would South Australia’s establishment and operation of such facilities give rise to impacts on other sectors of the economy? What would those impacts be? How should they be estimated and what information should be used? Have such impacts been demonstrated in other economies similar to South Australia?

Taxpayer subsidies and government measures required for setting up enrichment or reprocessing facilities are likely to have a number of adverse effects. They will reduce the focus on renewable energy, an area where South Australia has already demonstrated considerable expertise and which has the potential to create many more jobs and reduce energy costs. South Australia could develop world class facilities as a renewable energy manufacturing hub, and create an export industry without the many risks and toxicities of the nuclear facilities. Diversion and delay will damage opportunities to be a leader in this important and growing sector. The pattern for building nuclear facilities is for major delays and steadily increasing costs to build (this will be discussed further in section 3.1), in comparison with renewable energy, where the set up costs and subsequent electricity costs are steadily getting cheaper.

The distraction provided by the focus on nuclear processes will also delay reductions in carbon emissions, as renewables reduce emissions much faster and more cost effectively. This will in turn have impacts on South Australia’s ability to contribute to slowing climate change—a critical issue in the driest state of the driest continent.

Similarly subsidies will reduce the funds available for other important initiatives in the public interest: for example public health, education and transport.
SARC PAPER 3 - NUCLEAR POWER

THE NUCLEAR FUEL CYCLE ROYAL COMMISSION IS TASKED BY ITS TERMS OF REFERENCE WITH CONSIDERING

- THE FEASIBILITY OF ESTABLISHING AND OPERATING FACILITIES TO GENERATE ELECTRICITY FROM NUCLEAR FUELS IN SOUTH AUSTRALIA;
- THE CIRCUMSTANCES NECESSARY FOR THAT TO OCCUR AND TO BE VIVABLE;
- THE RELATIVE ADVANTAGES AND DISADVANTAGES OF GENERATING ELECTRICITY FROM NUCLEAR FUELS AS OPPOSED TO OTHER SOURCES (INCLUDING GREENHOUSE GAS EMISSIONS);
- THE RISKS AND OPPORTUNITIES ASSOCIATED WITH THAT ACTIVITY (INCLUDING ITS IMPACT ON RENEWABLE SOURCES AND THE ELECTRICITY MARKET), AND
- THE MEASURES THAT MIGHT BE REQUIRED TO FACILITATE AND REGULATE THEIR ESTABLISHMENT AND OPERATION.

INTRODUCTION - Feasibility

As requested this section of the submission addresses the overall “feasibility”, i.e., the degree of easily or conveniently establishing and operating facilities to generate electricity from nuclear fuels in South Australia. It explores the capacity of nuclear energy to contribute safely, cleanly and quickly to the energy transformation imperative, with emphasis on health implications. In so doing it focuses on the necessary circumstances, disadvantages, risks and measures entailed.

Particular attention is given to the following questions:

3.1 Are there suitable areas in South Australia for the establishment of a nuclear reactor for generating electricity? What is the basis for that assessment?

3.8 What issues should be considered in a comparative analysis of the advantages and disadvantages of the generation of electricity from nuclear fuels as opposed to other sources? What are the most important issues? Why? How should they be analysed?

3.9 What are the lessons to be learned from accidents, such as that at Fukushima, in relation to the possible establishment of any proposed nuclear facility to generate electricity in South Australia? Have those demonstrated risks and other known safety risks associated with the operation of nuclear plants been addressed? How and by what means? What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?

3.12 What are the wastes (other than greenhouse gases) produced in generating electricity from nuclear and other fuels and technologies? What is the evidence of the impacts of those wastes on the community and the environment? Is there any accepted means by which those impacts can be compared? Have such assessments making those comparisons been undertaken, and if so, what are the results? Can those results be adapted so as to be relevant to an analysis of the generation of electricity in South Australia?
3.13 What risks for health and safety would be created by establishing facilities for the
generation of electricity from nuclear fuels? What needs to be done to ensure that risks do not exceed safe levels?

3.14 What safeguards issues are created by the establishment of a facility for the generation of
electricity from nuclear fuels? Can those implications be addressed adequately? If so, by what means?

PREAMBLE

Anthropogenic global warming and its anticipated egregious ecological consequences compel human
societies to urgently and comprehensively transform global energy production technologies to zero-
carbon emitters. International governmental deliberations about the importance of addressing climate
change by reducing fossil fuel use and thus carbon emissions have been conducted since 1988. The
World Meteorological Organization and UN Environment Program established the
Intergovernmental Panel on Climate Change in 1988 and the risks of greenhouse gas emissions were
already being addressed by the UN General Assembly and the OECD. A 55-page submission on an
“Australian response to the greenhouse effect and related climate change” which called for a $7.8
million accelerated research effort on global warming was approved by the Hawke cabinet in April
1989.

Recent medical and scientific literature attests to the fact that the impacts of global warming are
already evident and document extensive current and potential human health outcomes. Effects on
individual and societal health and wellbeing occur directly, indirectly, and via economic and social
disruption, including amplification of pre-existing issues:

- increased injuries and deaths from more severe or frequent weather events including heat
  waves, and storms compounded by sea level rise and population shifts
- indirect effects from ecosystem changes in natural cycles and functions
  - the changed range and timing of infectious diseases
  - changed temperature, rainfall and evaporation effects on plants additional to those
    from increased atmospheric CO₂ concentrations
  - sequelae from changes in micro-biota influencing soil fertility
  - changed insect ecology that will effect crop fertilisation and pest prevalence and
    behaviour

All of these are likely to synergistically reduce agricultural output and quality resulting in food
insecurity.

27 https://www.ipcc.ch/organization/organization_history.shtml
29 McMichael AJ. Climate Change in Australia: Risks to Human Wellbeing and Health, Austral Special Report 09-035. Melbourne,
Australia: The Nautilus Institute, RMIT2009.
30 Butler C, Harley D. Primary, secondary and tertiary effects of eco-climatic change: the medical response. Postgraduate Medical
The economic and social consequences of these and other systemic effects will reduce both capacity to respond, including health system capacity, and psychosocial wellbeing.

The essential inference from this evidence is the requirement to replace fossil fuel-reliant systems with alternative energy systems which are:

1. Non-polluting
2. Rapidly deliverable
3. Currently or on the verge of commercial viability
4. Affordable

Australia has to date made marginal progress in addressing these scenarios, making the need all the more urgent. Electricity production contributes approximately 33% to our total carbon emissions, with fossil fuel constituting about three quarters of that output.

A crucial element in the discussion is the cost of a continuing delayed response to global warming: any technology that cannot be installed rapidly now, with a steady increase in output starting now, carries major costs of exacerbating existing climate hazards with all the attendant risks.

Diverting resources – financial, environmental and social - into such delayed (often referred to as ‘emerging’) technologies will cause major additional and unnecessary detriment. Of critical import, the longer the delay, the greater will be the environmental damage and higher the likelihood of catastrophic and unpredictable developments.

THE NUCLEAR OPTION

The proposition that nuclear fission should play a role in replacing the fossil fuel sector gained prominence in the 1990s and the catch-cry of a ‘nuclear renaissance’ was oft repeated throughout the following decade. Meanwhile, according to the World Nuclear Agency (the principal international

31 http://www.phaa.net.au/documents/item/327
organization that promotes nuclear energy): ‘Globally, the share of nuclear in world electricity has showed slight decline from about 17% to 11.5% since the mid-1980s…’ 12 This gloomy assessment was confirmed by the World Nuclear Industry Status Report 2014 13 which documents additional indifferent nuclear capacity projections, including:

- Taking into account reactors in ‘long term outage’34, the number of operational reactors in the world drops by 39 (9 percent) from 427 in July 2013 to 388 in July 2014—50 fewer than at the peak in 2002
- Nuclear power’s share of global commercial primary energy production declined from the 2012 low of 4.5 percent, a level last seen in 1984, to a new low of 4.4 percent.
- The average age of the world’s operating nuclear reactors to increase and by mid-2014 stood at 28.5 years
- Nuclear power plant starts have dropped from 15 in 2010 to 3 in 201435.
- The total of 69 construction sites have encountered delays, often by years. Construction of two units in Taiwan was halted. Five units have been listed as “under construction” for over 30 years.
- Several projects have been cancelled and new programs indefinitely delayed, including in the Czech Republic and in Vietnam.
- Nuclear generating costs jumped by 16 percent in real terms in three years in France, and several existing reactors were shut down in the U.S. because income did not cover operating costs. The economic survival of nuclear plants is also threatened in Belgium, Germany and Sweden.

Nuclear power projections took a savage hit in 2011 when the reactors at Fukushima melted down, triggering a profound global reconsideration of the safety of the reactor fleet and existential questioning about the industry. Germany and Switzerland committed to phasing out their nuclear reactor programs, many countries elected to abandon plans and even the most enthusiastic nuclear builders, eg China, pulled back and have reduced their projected nuclear output.

While it is of course conceivable that nuclear energy can make a substantial comeback, circumstances are clearly militating against that prospect. Despite concerted efforts to label nuclear technologies as ‘clean and green’ many communities remain suspicious of, if not hostile to, its safety and health profile. In addition nuclear fission is rapidly being outstripped by renewables in terms of costs and propagation: in 2013 alone, 32 gigawatts (GW) of wind and 37 GW of solar were added to the world power grids. By the end of 2013, China had 91 GW of wind power and 18 GW of solar capacity installed, solar exceeding for the first time operating nuclear capacity. China added four times more solar than nuclear capacity in the past year. And Spain generated more power from wind than from any other source, outpacing nuclear for the first time. It is also the first time that wind has become the largest electricity generating source over an entire year in any country. Spain has thus joined the list of nuclear countries (including Brazil, China, Germany, India and Japan) that produce more electricity from new renewables—excluding large hydro-power—than from nuclear power.36

A further consideration is the true emissions generated by nuclear power plants. In addition to the significant and long lived radioactive waste generated, there are significant carbon emissions overlooked by nuclear proponents. Mark Deisendorf noted in Feb 2014:

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34 No power generated in previous calendar year and six months of current calendar year
“Unfortunately, the notion that nuclear energy is a low-emission technology doesn’t really stack up when the whole nuclear fuel life cycle is considered. In reality, the only CO₂-free link in the chain is the reactor’s operation. All of the other steps – mining, milling, fuel fabrication, enrichment, reactor construction, decommissioning and waste management – use fossil fuels and hence emit carbon dioxide.

Several analyses by researchers who are independent of the nuclear industry have found that total CO₂ emissions depend sensitively on the grade of uranium ore mined and milled. The lower the grade, the more fossil fuels are used, and so the higher the resulting emissions.

In one such study, the nuclear physicist (and nuclear energy advocate) Manfred Lenzen found that CO₂ emissions from the nuclear fuel cycle increase from 80 grams per kilowatt-hour (g/kWh) where uranium ore is high-grade at 0.15%, to 131 g/kWh where the ore grade declines to low-grade at 0.01%.

Other experts, such as nuclear energy critics Jan Willem Storm van Leeuwen and Philip Smith, using assumptions less favourable to nuclear energy, have reported an increase in emissions from 117 g/kWh for high-grade ore to 437 g/kWh for low-grade ore.

For comparison, the life-cycle emissions from wind power are 10–20 g/kWh, depending upon location, and from gas-fired power stations 500–600 g/kWh. So depending on your choice of analysis, nuclear power can be viewed as almost as emissions-intensive as gas.”

Considering the pattern of growth followed by decline in the industry it is improbable that nuclear can compete with renewables in the medium to longer term. And while nuclear proponents are voluble in ridiculing the capability of renewables to replace fossil fuels - raising concerns about geography, intermittency and capacity - many nations have concluded that debate some time ago, have now moved on and are busy implementing a non-nuclear energy-transformation.

CIRCUMSTANCES

The urgency of the requisite energy-transformation is clear.

The prospects for a speedy transition to nuclear electricity generation and dramatic carbon-emission abatement of a ‘virgin’ nuclear power nation like Australia can be framed via the IAEA document ‘Establishing the safety infrastructure for a NPP’. This paper provides a timeline chart which serves as a (typically buoyant) guide to anticipated timing of such a venture. The guidelines propose that between 11 and 20 years are required to establish appropriate safety infrastructure for a nuclear power program, from initial site survey to commissioning of a reactor. The chart assumes several optimistic timeframes, given recent experience of reactor-builds in nations with similar safety cultures as ours, such as France, Finland and the United States. Faster processing has been achieved in China, but the existence of a one-party state, with very low transparency and multiple safety concerns makes for a poor comparator for a start-up nuclear power nation like Australia. Given the lack of experience, expertise, technology and materials in Australia for a de novo program, even the more conservative IAEA time-frames must be greeted with a degree of skepticism.

The IAEA describes phases 1, 2 and 3 in establishing a new reactor.

According to the IAEA, by the end of Phase 1, an initial site survey and an environmental impact statement will have been completed over a period of 1 to 3 years and then a nation should be “ready to make a decision whether to introduce nuclear power”. The first step articulated here is ‘Site survey’: yet it is inconceivable that an official process to identify suitable sites for nuclear reactors could begin in South Australia before a decision to proceed had already been made. This would presumably require:

- all major State political parties have reached bipartisan agreement on developing a nuclear power program
- attainment of a sufficient State parliamentary majority which can pass enabling legislation
- all major Commonwealth political parties have adopted pro-nuclear power policies
- Commonwealth parliamentary majorities have been attained
- Commonwealth legislative changes have been made
- legal challenges have been successfully rebuffed
- community opposition from civil society has been sufficiently suppressed

At present there is no political consensus about nuclear power in Australia, nothing approaching a bipartisan acceptance at the state or federal level and opinion polls repeatedly suggest the electorate is likely to be resistant in the short to medium term at least.

A recent survey funded by the federal Australian Renewable Energy Agency found that solar panels on rooftops were supported by 87 per cent of respondents, with large-scale solar farms "strongly" or "somewhat" backed by 78 per cent. Wind farms and hydro, at 72 per cent, also far eclipsed backing of just 23 per cent for coal and 26 per cent for nuclear energy.\(^{39}\)

Figure 2.\textsuperscript{40}

Although community opinions about nuclear energy continue to evolve, research by Newspoll and the Australia Institute suggests that a significant proportion of the population who support nuclear power plants being built in Australia are likely to oppose plans to build them in their local area. For example, a Newspoll survey published in The Australian in December 2006 found that 35 per cent of people support nuclear power plants being built in Australia\textsuperscript{41}. However, a survey conducted by


Newspoll on behalf of the Australia Institute found that only 25 per cent of Australians support a nuclear power plant in their local area.\textsuperscript{42}

\section*{3.1 Are there suitable areas in South Australia for the establishment of a nuclear reactor for generating electricity? What is the basis for that assessment?}

Although to date proponents of nuclear power in Australia have generally been unforthcoming in site identification, locations that have reasonable compliance with the IAEA guidelines are few. One comprehensive effort to apply the guidelines of regulators was attempted in the wake of the UMPNER review\textsuperscript{43} in 2006, by researchers at the Australia Institute. In siting a nuclear power plant, there are two main objectives:

\begin{itemize}
  \item ensuring the technical and economic feasibility of the plant
  \item minimising potential adverse impacts on the community and environment.\textsuperscript{44}
\end{itemize}

There are four primary criteria for the siting of nuclear power plants in Australia:

\begin{itemize}
  \item proximity to appropriate existing electricity infrastructure
  \item proximity to major load centres (i.e. large centres of demand)
  \item proximity to transport infrastructure to facilitate the movement of nuclear fuel, waste and other relevant materials and
  \item access to large quantities of water for cooling.\textsuperscript{45,46}
\end{itemize}

Other important siting criteria include demographic, economic, ecological, heritage, security, atmospheric and geological a parameters.

The study identified three potential sites in South Australia, although all three exhibit multiple significant negatives, including:

\begin{itemize}
  \item Mt Gambier/Millicent - the Limestone Coast Tourism Region receives around 550,000 domestic overnight visitors, 630,000 domestic day visitors and 37,000 international visitors each year
  \item Port Adelaide - finding suitable sites with appropriate population buffers may be problematic (approximately 210,000 people were in the Port Adelaide/Enfield and Salisbury LGAs on census night in 2001
  \item Port Augusta/Port Pirie - high earthquake risk.
\end{itemize}

Given recent experience with resistance to CSG and wind-power in Australian neighbourhoods it would seem judicious to assume there would be substantial resistance to nuclear reactor proposals in local communities and more broadly. International experience suggests that siting new reactors is much easier in locations where there are pre-existing facilities – it is safe to assume that developing a

\textsuperscript{44} http://www.tai.org.au/documents/downloads/WP96.pdf
\textsuperscript{45} Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) 1999, Draft Criteria for the Siting of Controlled Facilities, ARPANSA, Commonwealth of Australia, Canberra.
\textsuperscript{46} International Atomic Energy Agency (IAEA) 2003, Site Evaluation for Nuclear Installations: Safety Requirements, Safety Standards Series No. NS-R-3, IAEA, Vienna, Austria
greenfield site would focus pre-existing powerful civil society forces and facilitate recruitment of previously uncommitted citizens to the cause. Whatever disparaging attitudes proponents of such a project might have about “NIMBY-ism”, the reality would surely translate to arduous, drawn-out, divisive and socially disruptive struggles. The failure of the Federal government to site a relatively small amount of low and intermediate level radioactive waste after several decades, with bipartisan political party support, even in perceived “remote”, low-population zones because of community opposition gives some indication of the potential for community resistance and really ought to act as a caution to would-be promoters of the technology.

It is unlikely that a nuclear power program where sites have been identified could achieve State and Commonwealth parliamentary majorities within the next 2 parliamentary cycles. Realistically, given the multiple political impediments, the IAEA time-frame – which begins with site surveys - is not likely to proceed in the next decade.

By comparison, according to official government Energy Ministry projections47, Germany plans by 2020:

- Renewable energies are to achieve an 18% share of gross final energy consumption
- Electricity consumption is to fall by 10%
- greenhouse gas emissions are to be reduced by 40%, and
- by 2025: 40% of Germany’s electricity will be produced from renewables

In the first half of 2014, 28.5% of Germany’s electricity was produced from renewables.

By the end of Phase 2, hypothetically 4 to 10 years after the population has assented to the project, appropriate regulatory frameworks will have been erected and the project will be ready to invite bids from prospective suppliers. Meanwhile, Germany plans to produce a 50% share of its electricity within this timeframe. To date the German renewable transformation has outstripped its schedules.

The IAEA proposes that Phase 3 can be completed within 7 to 10 years, with up to 5 years required to enable appropriate safety and regulatory frameworks to be enabled. A reactor could then be built and ready to install fuel within 3 to 4 years. Assuming the more conservative time frame and ten years to achieve political consensus, the reactor would then begin fission by 2045. But a survey of the past decade of reactor projects in the western world gives cause for considerable caution in accepting even the more conservative estimate of 4 years from concrete to fuelling.

The world leader in nuclear power production is a case in point. The French EPR (Evolutionary Power Reactor) was the first Generation III design to win orders, first in 2003 when the order for Olkiluoto 3 (in Finland) was the first for a nuclear reactor in Western Europe in 15 years. This was followed by the 2006 order for an EPR at Flamanville in France, and two EPRs at Taishan in China in 2007. All three EPR construction projects have suffered cost blowouts or delays or both. The estimated cost of the Flamanville EPR in France has increased from €3.3 billion (US$3.7b) to at least €9 billion (US$10.1b). The first concrete was poured in 2007 and commercial operation was expected in 2012, but that timeframe has been pushed back to 2018 (with further delays likely). In the last two months major faults have been detected in the reactor vessel and then the cooling system valves which will result in further costs blowouts and delay. In 2014 French company Areva recorded massive losses amounting to some €5 billion euros on account of costs linked to delays to its flagship

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47 http://www.germany.info/Vertretung/usa/en/06__Foreign__Policy__State/02__Foreign__Policy/05__KeyPoints/ClimateEnergy__Key.html
EPR reactor, and is now reported as bankrupt. Finland has cancelled its contract for a second EPR. Estimates for construction times in the USA are around ten years duration.

Given the devastating consequences of failure to adequately transition to low/zero carbon by mid-century, it would be sensible to measure our prospects against the international experience. If we experience the same degree of retardation in construction as witnessed in other more prepared countries (cost blow-outs, material and expertise and labour bottlenecks, unexpected developments) – then we should estimate more like 10 years to get from concrete to fission. Even if we assume novice Australian reactor program management can outstrip the French and the Americans, it is hard to see an Australian reactor producing electricity – and thus abating greenhouse gas emissions much before 2050.

Way too late.

Indeed, in the National Electricity Forecasting Report released in June 2015, the Australian Energy Market Operator(AEMO) predicts that the growing uptake of rooftop solar by homes and businesses will reduce grid demand in South Australia on certain occasions to zero by 2023, highlighting the rapid change in the nature of energy markets, and the growing shift from centralised baseload generation.

In South Australia the near 575MW of rooftop solar is already accounting for one-third of total grid demand on certain days in the state. One in four homes in the state already have solar PV. Based on the AEMO medium scenario, within a decade this total could treble, pushing minimum demand required from the grid in the whole state to below 0MW (zero) on some occasions in 2023-24, and for several hours at a time by 2024/25 – when AEMO expects 1864MW of rooftop solar.

South Australia will be a test case for Australia, and indeed the world, because of its high level of “variable renewables” such as wind and solar in its energy mix. It already stands at more than 40 per cent and AEMO expects this to grow. Rapidly evolving battery storage technology is also likely to have major impacts both on centralised grid demand and need for baseload generation.

By 2040, Germany plans to achieve 65% renewable electricity and 80% by 2050. The German case is instructive in that an advanced industrial nation with forty years’ experience in electricity generation using nuclear fission, with massive heavy industry and world-leading technological expertise and highly sought-after industrial products has categorically elected to phase-out its reactor fleet by 2022. According to official government documents:

- The transformation of the energy system is in general leading to a continual reduction in emissions, because the still relatively high share of fossil fuels in the energy supply is successively falling due to the growing use of renewable energies, and energy consumption overall is dropping due to increasing energy efficiency.


• Shutting down the German nuclear power plants has had no negative influence on the EU situation.

• Emissions could, however, increase in Germany by up to 40 million t/year (approx. 3 percent of the baseline emissions) for about 10 years due to additional coal-generated power.

• But the German climate targets still remain attainable: based on energy scenarios, a 44 percent emissions reduction (relative to 1990) would be expected by 2020 without the shutdown of the nuclear power plants; in other words, even with an additional 3 percent of emissions, the German 40-percent target would still be reachable.

• That, however, assumes that further progress is made in the area of efficiency. Without progress in that area, according to expert estimates, Germany would fall short of its reduction target (only approx. 35 – 37 percent reduction).\textsuperscript{30}

There are downsides to this policy, which was a bipartisan decision responding to the Fukushima meltdowns and subsequent environmental contamination, human health risks and social disruption. Independent German and other researchers have produced voluminous data and analysis to address these concerns. A reasonable consensus view is that there will be:

• Increased costs – particularly to industrial consumers
• Short term disruption to European community electricity grid
• Short term increase in CO2 emissions, but – assuming appropriate grid and market and governance actions are initiated – successful achievement of targeted 80% reductions by 2050.

One study concentrates solely on the effect of the nuclear phase-out on electricity prices for industry and households and on CO2 emissions, concluding:

\textit{A life-time extension of nuclear power until 2038 would have reduced emissions in Germany by 45 to 70 MtCO2 between 2015 and 2030 but the Exit2022 scenario still reaches roughly 70% reduction against 1990 by 2030 solely in the power sector.} \textsuperscript{51}

Another paper finds that:

\textit{Despite the increased fossil generation, challenging climate protection goals can still be achieved within the framework of the considered scenarios … We conclude that the generation sector can generally cope with an accelerated nuclear phase-out under the given assumptions. Yet, we emphasize that such a policy requires a substantial and costly transformation of the supply and the demand side.} \textsuperscript{52}

The German experience in developing, promoting and installing renewables is already substantially ahead of Australia and likely to increase especially if we choose to follow a path that the German state has determined is unwise, unsafe and untenable. While nuclear proponents are understandably eager to denigrate the German renewables expansion and nuclear phase-out, the ‘runs are already on the board’ and dismissing the German Energiewende as a ‘scam’ is yet more hot air in an already too warm environment.

\textsuperscript{30}http://www.germany.info/Vertretung/usa/en/06__Foreign__Policy__State/02__Foreign__Policy/05__KeyPoints/ClimateEnergy__Key.html


\textsuperscript{52}EWI_WP_11-12_German_nuclear_policy_reconsidered
Experiences with rapid and successful expansion of renewables is well-documented in other places including Spain, Denmark and California and even China.

A recent authoritative study from Stanford University published in May 2015, examines the prospects in the USA for a similar energy transformation and concludes:

The plans contemplate 80–85% of existing energy replaced by 2030 and 100% replaced by 2050. Year 2050 end-use U.S. all-purpose load would be met with 30.9% onshore wind, 19.1% offshore wind, 30.7% utility-scale photovoltaics (PV), 7.2% rooftop PV, 7.3% concentrated solar power (CSP) with storage, 1.25% geothermal power, 0.37% wave power, 0.14% tidal power, and 3.01% hydroelectric power. Based on a parallel grid integration study, an additional 4.4% and 7.2% of power beyond that needed for annual loads would be supplied by CSP with storage and solar thermal for heat, respectively, for peaking and grid stability.

Converting would also eliminate 62 000 (19 000–115 000) U.S. air pollution premature mortalities per year today and 46 000 (12000–104 000) in 2050, avoiding $600 ($85–$2400) bil. per year (2013 dollars) in 2050, equivalent to 3.6 (0.5–14.3) percent of the 2014 U.S. gross domestic product. Converting would further eliminate $3.3 (1.9–7.1) trl. per year in 2050 global warming costs to the world due to U.S. emissions.

These plans will result in each person in the U.S. in 2050 saving $260 (190–320) per year in energy costs ($2013 dollars) and U.S. health and global climate costs per person decreasing by $1500 (210–6000) per year and $8300 (4700–17 600) per year, respectively.

The new footprint over land required will be 0.42% of U.S. land. The spacing area between wind turbines, which can be used for multiple purposes, will be 1.6% of U.S. land.

100% conversions are technically and economically feasible with little downside.53

The issue of timeliness is not just academic, because failure to achieve the optimistic timeframes laid out in the IAEA Establishing the safety infrastructure for a NPP guideline and those proposed by other promoters of nuclear electricity generation means catastrophic climate disruption. Whilst there are vociferous opponents of the principle that our electricity can be powered in the medium term by 80-100% renewables, there is strong evidence to support the proposition and more importantly many nations are already well on the way to achieving this. There are clearly significant hurdles and barriers to this, but it is a genuine alternative.

DISADVANTAGES AND RISKS

There are a several other factors a play which are major barriers to the nuclear power, which simply do not apply in the case of renewables

3.8 What issues should be considered in a comparative analysis of the advantages and disadvantages of the generation of electricity from nuclear fuels as opposed to other sources? What are the most important issues? Why? How should they be analysed?

3.13 What risks for health and safety would be created by establishing facilities for the generation of electricity from nuclear fuels? What needs to be done to ensure that risks do not exceed safe levels?

DEMAND

53 http://web.stanford.edu/group/efmh/jacobson/Articles/I/USStatesWWS.pdf
Australia has excess baseload generating capacity and will have so for a several decades. Our grid electricity consumption has been declining over the last seven years due to a combination of efficiencies and renewables, and we are shutting down coal fired plants because of this.\textsuperscript{54}

There is no economic or market argument for increasing our baseload electricity generation capacity.

This is what Ian McFarlane, the responsible minister said last year, "We have 9,000 megawatts (nine big power stations equivalent) of excess capacity in electricity generation … We have more than 15% overcapacity in generation in Australia.\textsuperscript{55}"

The Australian Energy Market Operator's (AEMO) 2014 report\textsuperscript{56} states that even with a high growth scenario (although Australians are using less electricity each year) we would still have the equivalent of 3 power stations of excess capacity by 2025.

Planning to introduce large amounts of excess power capacity, even if it is in another 30 years, would be economic vandalism on the current renewables market and would quash any investment in the future too. It is important to note that SA has the highest proportion of renewables (30%) electricity generation of any of the states or territories. Does the SA government really want to kill one of the few industries that is thriving in their state?

**COST**

Despite many claims to the contrary, worldwide nuclear plants have required massive government subsidies, uncompetitive pricing and loan guarantees. For example in the UK the Hinkley Point C reactors will require between 4.8 and 17.6 billion pounds subsidy, with electricity price guaranteed at more than twice the current wholesale rate\textsuperscript{57}. In the USA, USD $12.5 billion in taxpayer backed loan guarantees have been required to encourage the building of new nuclear power plants\textsuperscript{58}.

**EMPLOYMENT**

One of the underlying issues in the calling for a Royal Commission has been the loss of manufacturing employment and other jobs in South Australia. Nuclear power generation has been put forward as a possible solution. In a recent economic analysis of the energy sector, Mark Cooper\textsuperscript{59} from the Institute for Energy and the Environment in Vermont noted evidence in the electricity sector, which shows that nuclear creates many fewer jobs than efficiency and solar and about the same number of jobs as wind, as shown in Figure 3.

\textsuperscript{54} http://www.esaa.com.au/policy/data_and_statistics_-energy_in_australia
\textsuperscript{55} http://theconversation.com/factcheck-does-australia-have-too-much-electricity-31505
\textsuperscript{56} http://www.aemo.com.au/Electricity/Planning/Electricity-Statement-of-Opportunities
\textsuperscript{59} Cooper M. Power Shift. Institute for Energy and the Environment June 2015
South Australia is the driest state in the world’s driest continent. With climate change it is predicted that the southern part of Australia will get drier. Nuclear power stations require large amounts of water. A 2006 parliamentary library research paper quoted a 2006 Australian Nuclear Science and Technology Organisation (ANSTO) report. The plant referred to in this report was an Advanced Pressurized Water Reactor (AP1000) developed by Westinghouse. This plant would have an operating output of between 1,115 and 1,150 megawatts depending on the cooling technique employed.

The paper then used a report by the US Department of Energy which published estimates of the likely cooling water requirements of this sort of plant. These were stated to be between 450,000 to 750,000 US gallons per minute. This equates to an annual average usage rate of between 779 and 1,338 megalitres per megawatt which is consistent with existing nuclear power plants. To try to give this figure some meaning, annual use would be between 347,000 and 615,000 Olympic swimming pools.

Per megawatt, existing nuclear power stations use and consume more water than power stations using other fuel sources. Depending on the cooling technology utilised, the water requirements for a nuclear power station can vary between 20 to 83 per cent more than for fossil fuel power stations. Most renewable energy sources, such as wind and PV solar power, do not require water when generating electricity.

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60 Water requirements of nuclear power stations Department of Parliamentary Services Parliament of Australia December 2006, no. 12, 2006–07
NUCLEAR REACTORS AND RADIATION

The nuclear reactor core containing nuclear fuel rods (and where heat is generated through nuclear fission) is highly radioactive, and hence is heavily shielded accounting for virtually no ionising radiation to the surrounding region. Every day, however, in the course of their activity nuclear reactors routinely produce radioactive gases and liquids which are captured and stored on-site until their activity decays to a sufficient level to enable their release into the environment ensuring the activity is below regulatory limits. These amounts are highly regulated and tritium is the largest of the nuclide emissions, by activity, from civilian reactors, apart from noble gases in some types of reactors. The radioactive effluents almost completely account for all radioactive emissions from nuclear power plants. The per capita dose to regional populations (less than 50km) surrounding nuclear power plants is 0.0001mSv (compared to around 2mSv natural background dose) and up to 0.02 mSv for specific groups up to 1km from a nuclear reactor61. These are thus very small doses. Doses from nuclear power reactors to local and regional populations decrease over time because of lower discharge levels.

NUCLEAR POWER AND CANCER

LOCAL POPULATIONS

The role of civilian nuclear power in the induction of cancer, and specifically leukaemia, in the general public has been a major controversy over the last three decades and remains unresolved. Leukaemia is malignancy of the blood forming cells and is notable in the context of IR induction in appearing before solid cancers with a latency of around 4 years (compared to >10 years for solid cancers). Although there is little doubt that exposure to radiation increases the risk of developing leukaemia (BEIR VII 2006; United Nations Scientific Committee on the Effects of Atomic Radiation 2006; IARC 199962), there is disagreement as to whether the amount of exposure received by children living near nuclear sites is sufficient to increase risk.

The first epidemiological study to raise concern of a link was in Great Britain. This addressed an unexpected observed increase in cases of leukaemia in children aged under ten between 1954 and 1983 at Seascale, three kilometres from a reprocessing plant and other nuclear facilities at Sellafield63. Published by the epidemiologist, Martin Gardner in 199064, it suggested there was a connection between the increased incidence of leukaemia and Sellafield. Specifically, preconceptional exposures of the fathers of 46 cases of leukaemia, born in west Cumbria and diagnosed there between 1950 and 1985, were compared with those of 564 controls. An association was found between the exposure and leukaemia (Gardner’s hypothesis), but this was dominated by four case fathers with high exposure (>100 mSv). In 1993 a new report by the British Health and Safety Executive found the rate of childhood leukaemia in Seascale was fourteen times the national average. Two further studies examined leukaemia clusters in Dounreay and Aldermaston although could not correlate paternal exposure levels and leukaemia incidence at these nuclear sites. Furthermore, the increased incidence of leukaemia at Seascale was also occurring in children of unexposed fathers. Additionally, children born outside of Seascale, to Sellafield workers did not have an increased incidence to leukaemia.

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62 International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans.
further study in Canada also failed to demonstrate a link between childhood leukaemia and preconceptional paternal irradiation, or even ambient radiation.

Several studies since 1990 have found mixed results. A congressionally mandated study by the US National Cancer Institute studied the incidence of cancers including leukaemia in 107 counties with nuclear facilities within or adjacent to their boundaries, assessing incidence before and after commencement of operation from 1950-1984. Each county was compared to three similar ‘control’ counties. There were 52 commercial nuclear reactors and 10 Department of Energy facilities. It found no evidence to suggest the incidence of cancer or leukaemia was higher in the study counties compared to the control counties. It did however, acknowledge shortcomings in its methodology including not accounting for the potential for at risk populations to be smaller than the specific county study populations, and thus potentially masking underlying increases. Many studies confirmed increased rates of childhood leukaemia in proximity to nuclear power plants, however, could not confirm a correlation with radiation dose.

A meta-analysis of 17 research studies involving 136 nuclear sites in the UK, France, USA, Spain, Japan, Germany and Canada65 of the incidence and mortality of childhood cancer in relation to their proximity to nuclear power plants confirmed an increased incidence of leukaemia. The significance of this meta-analysis is that it not only stratified the distance from the nuclear plants, albeit in coarse terms, but also stratified the age groups of children, arguing that since the peak susceptibility to childhood leukaemia is under the age to ten, this group should be independently assessed. Therefore, any broader age groups could conceal an increase in incidence. They found in children up to 9 years old, leukaemia death rates were from 5 to 24 per cent higher, and leukaemia incidence rates were 14 to 21 per cent higher.

The most recent of these studies and also the most compelling was sponsored by the German government in response to public pressure to examine the issue of childhood leukaemia and nuclear power reactors6667. This was commissioned by the Federal Office for Radiation Protection (BfS) in 2003. The KiKK case–control study examined all cancers near all of the 16 nuclear reactor locations in Germany between 1980 and 2003, including 1592 under-fives with cancer and 4735 controls, with 593 under-fives with leukaemia and 1766 controls. The main findings were a 0.61-fold increase in all cancers, and a 1.19-fold increase in leukaemia among young children living within 5 km of German nuclear reactors. These increases are statistically significant and are much larger than the cancer increases observed near nuclear facilities in other countries. The study is notable also for measuring the distance of each case from the nuclear reactor so that a distance-risk relationship could be computed. This was the first study of this kind, previous studies having either grouped all cases or coarsely stratified the distance data. The study found not only that risk is greatest closest to the plants but that small increased risk extends up to 70km from the nuclear power plant. Their conclusions discounted the role of radiation in the development of leukaemia due to the emissions being too low. However, an independent review panel appointed by the BfS criticised them for this conclusion arguing that the dose and risk models assumed by the Kikk authors did not necessarily reflect the actual exposures and possible radiation risks, and thus warranted further research before being

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dismissed as a cause. In other words, they implied that doses might be higher than are currently being measured.

There is reasonably strong evidence now of a link between the proximity of nuclear power plants and childhood leukaemia. There is no significant evidence for solid cancers either in children or adults. Clearly further research is warranted, particularly to elucidate the leukaemia causation. Policy makers therefore need to factor this increasingly strong scientific evidence into their decision-making. Legislators considering introducing or expanding nuclear power should consider these health implications. Nuclear regulators also need to revisit their assumptions and consider revising standards at existing nuclear plants. Local populations are unlikely to find this information reassuring.

NUCLEAR ACCIDENTS

3.9 What are the lessons to be learned from accidents, such as that at Fukushima, in relation to the possible establishment of any proposed nuclear facility to generate electricity in South Australia? Have those demonstrated risks and other known safety risks associated with the operation of nuclear plants been addressed? How and by what means? What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?

The German studies and similar studies in UK and France reflect disturbing possibilities of nuclear power plants in so-called normal or routine function. But of far greater significance is the potential for large scale radioactive contamination resulting from unplanned releases, caused by deliberate or accidental events. Public awareness of these potential incidents has been raised by the recent events in Japan at the Fukushima Daiichi complex. This builds on previous international experience at Chernobyl in the Ukraine in 1986 and at the Three Mile Island complex in Pennsylvania in 1979 which, although not leading to large scale loss of life, was a major influence in the stagnation of the US NPP. Other unplanned events have also led to loss of life as well of loss of confidence in the capacity of NPP to safely address modern urban electricity generation requirements. These have included partial core meltdowns at:

- **NRX** (military), Ontario, Canada, in 1952
- **EBR-I** (military), Idaho, USA, in 1955
- **Windscale** (military), Sellafield, England, in 1957
- **Santa Susana Field Laboratory** (military), Simi Hills, California, in 1959
- **SL-1**, Idaho, USA in 1961. (US military)
- **Enrico Fermi Nuclear Generating Station** (civil), Newport, Michigan, USA, in 1966
- **Chapelcross, Dumfries and Galloway**, Scotland, in 1967
- **Lucens reactor**, Switzerland, in 1969
- **A1 plant** at **Jaslovske Bohunice**, Czechoslovakia in 1977

FUKUSHIMA

The consequences of the Fukushima nuclear disaster highlight the severe consequences that can occur. Some 80,000 people remain evacuated from the 20km exclusion zone and may never return to their homes, with the land now uninhabitable. There is also the potential for more evacuations further away in highly contaminated zones. Total economic costs are estimated at $300bn, comparable to that of the earthquake and tsunami that precipitated the nuclear disaster. Heroic (and expensive) plans are afoot to remove contaminated soil from over 2,500km² to reclaim as much land as possible in the
densely populated country. The total volume of the contaminated soil waste will approximate that of all the high level nuclear waste ever generated in the history of nuclear power (30 million cubic metres). The former prime minister, Naoto Kan, revealed that there was a real possibility of requiring the evacuation of 35 million Tokyo residents were the fallout to threaten the capital. It was dumb luck that it didn’t, given that the prevailing winds in the first week of the disaster were offshore, dumping most of the fallout in the sea and preventing an unimaginable catastrophe. Recall, nuclear fallout does not respect national boundaries – neighbouring countries might be the biggest victims of a nuclear accident.

As noted in our response to Issues Paper 2, the Fukushima reactor disaster was a combination of inadequate safety culture, mismanagement and deception on the part of regulators and operators, confronting a natural event of devastating but not unpredicted or unique proportions. What Fukushima has done is demolish the nuclear power industry’s standing exhortations that they should be trusted with the welfare of millions of citizens because their industry is inherently safe. Japan is one of the most technologically advanced countries in the world, with a mature nuclear power industry dating from the middle of last century – long enough to “work out the bugs”. The country is also a mature democracy, so there are structural checks and balances. Furthermore, with a Transparency International (TI) ranking of 17 on the Corruption Index, Japan’s public sector corruption should not be a major issue. Japan has also been subject to regular IAEA (International Atomic Energy Agency) inspections. If Japan couldn’t prevent this disaster, what are the prospects for most of the new reactors planned for Asian and Middle Eastern Countries which lack any semblance of transparency or accountability, long-term experience, and have TI rankings far below that of Japan?

The root cause of the Fukushima nuclear disaster was an insular, politically well-connected nuclear industry which was intertwined with a nuclear regulator that lacked the will and ability to fulfil its role of protecting the public. Many nuclear utilities’ engineers and senior management sit on the regulator’s safety committee. In essence, the Japanese nuclear regulator became captive to the government and industry’s goal of nuclear promotion at any cost, leading to a poor safety culture. The organisational structure of the industry corrupted the normal checks and balances vital to ensuring safety. The nuclear regulatory agency was an arm of the ministry responsible for nuclear promotion. TEPCO, the operator of the Fukushima Daiichi nuclear plant, and indeed the whole Japanese nuclear industry, has revealed a long history of poor safety, falsified maintenance and safety records, as well as fraudulently concealed accidents over many decades. In 2002, TEPCO, the operator of the Fukushima nuclear plant, admitted it had falsified repair reports at nuclear plants for more than two decades, It was not alone. The revelation follows the confession by all four companies – TEPCO, Chubu Electric Power, Japan Atomic Power and Tohoku Electric Power – that they concealed flaws in their reactors from government regulators.1

Unfortunately, the Japanese nuclear power industry was portrayed during this time as the face of a vibrant, responsible and safe utility by the World Nuclear Association (the industry lobby group) and Japan a role model for all countries to follow. The IAEA, which is responsible for overseeing the industry, sadly failed in its responsibility to alert the public, instead keeping its assessments closed to the general public. Its obligations only extend to informing the governments of its member states. Freshly revealed reports from the IAEA, dating from the 1990s, describe safety precautions at Japanese nuclear reactors as “dangerously weak”. IAEA inspectors visited four reactors in 1992 and 1995, finding 90 deficiencies in safety procedures.

In a recently revealed WikiLeaks cable, an official from the IAEA said in December 2008 that Japanese nuclear safety rules were out of date and strong earthquakes would pose a “serious problem” for
nuclear power stations, which were only rated to withstand a 7.0 earthquake (compared to the recent 9.1 earthquake) and tsunamis of only 5 metres (compared to the 14m recent tsunami). This was seen as a compromise between safety and commercial viability. In other words, it would have significantly eroded the economic viability of the plant if it was rated to a higher standard. Note that the Richter scale is a logarithmic scale, so that every one point increase in earthquake severity equates to a ten-fold increase in its destructive potential – thus the costs of earthquake defence increase exponentially.

Flaws in the boiling water reactors typical for Fukushima were known for several decades. The cascade of events at Fukushima had been foretold in a report published in the United States two decades ago. The 1990 report by the US Nuclear Regulatory Commission (NRC), an independent agency responsible for safety at the country’s power plants, identified earthquake-induced diesel generator failure and power outage leading to failure of cooling systems as one of the “most likely causes” of nuclear accidents from an external event. Documents from 1972 of the Atomic Energy Commission (AEC), the precursor of the NRC, reveal that an AEC safety expert raised concerns about the vulnerability of the boiled water reactor's less robust containment capability that would make it vulnerable to a hydrogen explosion — the same scenario occurring in the Fukushima fiasco. There was an internal sympathetic response from Joseph Hendrie, later the leader of the NRC, who told his colleague who had suggested a ban on the GE design that, while such a ban might be “attractive”, it would “be the end of nuclear power”.

Whilst the Japanese nuclear industry is rightfully portrayed as dangerous and its regulator incompetent and ineffectual, it is clear that without the tacit complicity of the IAEA and other national regulators that enabled Japan to avoid proper international scrutiny and accountability, its deficiencies would have been made public decades ago, perhaps averting this disaster. Rather than full transparency and accountability, the hallmarks of a good safety culture, the nuclear industry is wrought with a culture of obfuscation and opaqueness.

RISK ASSESSMENT

The estimated probability of major nuclear accidents, which was considered very small in the past has increased significantly. The pre-Fukushima estimate for the probability of a major nuclear accident with significant release of radioactivity was roughly 1 in 100,000 for each of the 440 reactors in operation per annum. Of course, probabilistic risk assessments on which the industry estimates are based, and which often rest heavily on nothing more than best guesses, have always been problematic. Now we know they are next to useless. The likelihood of core melt and containment failure had been underestimated: the accidents in Chernobyl and Fukushima amount to catastrophic meltdown in four nuclear reactors over the past few decades, more than originally assumed.

Furthermore, given that, in the history of nuclear energy, 582 reactors have operated for a total of 14,400 years (counting each year of operation by one reactor as a reactor-year), a core-damage accident has happened once every 1,309 years of operation with a total of 12 core melts. With 400 reactors operating worldwide, the rate would yield a core melt an average of once every three calendar years, and a major accident with release of radioactivity once every 9 years. Based on the earlier estimate, we were expecting one major accident with radioactive release over a 100-year period, and a core melt with no loss of containment every 10 years, with the current reactor fleet.

Tripling the fleet, as the nuclear industry advocates propose, would increase these risks three fold, i.e., one core melt every year and a major accident with loss of containment every three years.
Globally, there have been at least 99 (civilian and military) recorded nuclear reactor accidents from 1952 to 2009 (defined as incidents that either resulted in the loss of human life or more than US$50,000 of property damage, the amount the US government uses to define major energy accidents that must be reported), totalling US$20.5 billion in property damages (this excludes the costs associated with Chernobyl and Fukushima). Property damage costs include destruction of property, emergency response, environmental remediation, evacuation, lost production, fines, and court claims. Because nuclear reactors are large and complex, accidents onsite tend to be relatively expensive.

Therefore, we should be very sceptical of the nuclear industry’s risk estimates for its Generation III reactors (which have no operational history) of one major accident per reactor every million years, i.e., ten times safer than the current Generation II.

We should be equally sceptical of industry claims that the accident numbers are skewed by accidents early in the evolution of nuclear power and that the industry has improved its safety credentials. Remember, the two worst nuclear disasters (Chernobyl and Fukushima) have occurred in the last 25 years over an almost 60 year history. Just as unconvincing is the claim that new nuclear reactors are safer than the older current reactors. The vast majority of plants under construction around the world, 47 in all, are considered Generation II reactor designs—the same 1970s vintage as Fukushima Daiichi.

And only 15 of the nuclear reactors operating in the world possess passive safety systems (allegedly safer because they require less human input). It is misleading to imply that the Fukushima plant was somehow unique in the world’s nuclear fleet as a mitigating factor in its failure – nearly all nuclear plants around the world, existing and planned, are of the same vintage and design as the Fukushima plant. Why? Because advanced redundant safety systems dramatically increase the cost of a nuclear power plant and nuclear power is already uneconomic.

A nuclear accident has the potential to bankrupt many countries. The cost of a worst-case nuclear accident at a plant in Germany, for example, has been estimated to total as much as €7.6 trillion ($11 trillion), while the mandatory reactor insurance is only €2.5 billion.

Japan has decided not to build any further nuclear plants and will progressively become less reliant on nuclear power as existing plants are decommissioned. Several OECD countries (Belgium, Germany, Italy, Japan and Switzerland, among others) have already decided to either not commence or phase out existing nuclear reactors at the end of their useful life and have cancelled plans for new ones.

In the event of a solar farm undergoing a major disaster the results could be significant in terms of energy supply – but will not involve the contamination of the surrounding environment with identified carcinogens for many generations hence, or require the permanent evacuation of hundreds of thousands of civilians as has occurred already on 2 occasions from NPP.

**NUCLEAR TERRORISM AND DELIBERATE HARM**

In the modern era it is necessary for planners and legislators to anticipate and plan for deliberate attacks on infrastructure. To date there have been no major incidents involving war or terrorism but multiple attempts and minor incursions, including involving the research reactor in Sydney. A major coolant loss caused by accident or malice could cause a massive release of radioactive isotopes in to the surrounding environment, with profound consequences for the inhabitants and South Australia in terms of morbidity, mortality, social disruption, tourism and agriculture as has been evident in the Fukushima prefecture of Japan.
A successful terrorist attack on the scale of those carried out on September 11, 2001, could lead to a major release of radiation. The US Nuclear Regulatory Commission (NRC) considers the likelihood of this kind of attack occurring as small. The NRC furthermore considers that nuclear power plants are difficult targets due to them being low lying and the reactor core being a small target. However, we should not forget that the probability of the World Trade Centre towers collapsing due to the impact of civilian aircraft was also considered to be small before they fell. It is disingenuous for the NRC to surmise firstly that the risk of such an event is low. The most that can be reliably stated is that the probability might be low, however, we just don't have the data to make any more than educated guesses.

It is equally fallacious for the NRC to claim that the consequence of an aircraft impact is unlikely to lead to a breach of containment. For example, a sudden shutdown of a nuclear reactor ('scram') in the event of a terrorist attack does not necessarily guarantee the reactor core will not continue to increase in temperature and melt, particularly if the impact has disabled the emergency cooling systems. If the containment structure has been breached from an aircraft impact, this could lead to a major release of radioactive contaminants into the atmosphere. Additionally, it does not consider the consequences of an impact on the spent fuel cooling ponds which may ignite if there is a loss of cooling water and disperse radioactivity into the atmosphere. As a result of the World Trade Centre attacks, the Design Basis Threat of US nuclear reactors was upgraded in 2007 to include various terrorist attacks. However, controversially the NRC did not include aircraft attacks, despite internal staff strongly advocating it although being overruled. It instead insisted ambiguously that only new reactors be able to withstand an aircraft attack. If this had been included in the upgraded DBT all existing reactors would have been required to be retrofitted accordingly, which the NRC insisted was not required. Hence, ironically, all current US reactors are vulnerable to commercial aircraft terrorist attacks and will be for their operational life due to the nuclear regulator’s opposition to safety upgrades.\(^6^8\)

In addition, according to Yukiya Amano, director general of the International Atomic Energy Agency (IAEA) Nuclear facilities around the world are facing daily cyber-attacks on their systems. “Reports of actual or attempted cyber-attacks are now virtually a daily occurrence,” he said. “Last year alone, there were cases of random malware-based attacks at nuclear power plants and of such facilities being specifically targeted … staff responsible for nuclear security should know how to repel cyber-attacks and to limit the damage if systems are actually penetrated. The IAEA is doing what it can to help governments, organizations, and individuals adapt to evolving technology-driven threats from skilled cyber adversaries”\(^6^9\).

In addition to the threat of terrorist attack, deliberate sabotage by operating staff or others is also possible. There have been a number of airline mass deaths due to deliberate pilot decisions, presumed to be due to mental illness. The most recent of these was the Germanwings crash earlier this year. These types of attack are extremely difficult to prevent.

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\(^6^9\) http://www.scmagazine.com/international-conference-on-computer-security-hosted-for-first-time/article/418241/
NUCLEAR WEAPONS

3.14 What safeguards issues are created by the establishment of a facility for the generation of electricity from nuclear fuels? Can those implications be addressed adequately? If so, by what means?

In terms of catastrophic events associated with the nuclear fuel chain, nothing compares in magnitude to the explosive capacity of a nuclear fission explosion. The impact of one small explosion has been extensively documented at Hiroshima and Nagasaki. Recent authoritative research has demonstrated that the detonation of 100 Hiroshima-sized nuclear bombs - less than one per cent of the global nuclear arsenal - would generate more than five million tons of soot and smoke if targeted at cities. In addition to local devastation and widespread radioactive contamination, the climate and environmental impacts would be catastrophic. Global cooling would persist for over a decade, decimating global agriculture. On top of that there would be hoarding of food; food riots; intrastate and potential interstate conflicts over food supplies; the disease epidemics that inevitably spread through malnourished populations; disruption to trade and the complex international supply chains for agricultural inputs – seed, fertiliser, pesticides, fuel and machinery.

World grain reserves currently range between 60 and 70 days supply. The 870 million people in the world who are chronically malnourished today have a baseline consumption of 1,750 calories or less per day. Even a 10% decline in their food consumption would put this entire group at risk. In addition, the anticipated suspension of exports from grain growing countries would threaten the food supplies of several hundred million additional people who have adequate nutrition today, but who live in countries that are highly dependent on food imports.

Finally, more than a billion people in China would also face severe food insecurity. The number of people threatened by nuclear-war induced famine would be well over two billion.70

Such global nuclear famine is well within the capacity not only of the US and Russian arsenals, with between them more than 90 per cent of the world’s 17,300 nuclear weapons, but also the smaller arsenals of China, France, UK, India, Israel and Pakistan – in fact all the current nine nuclear-armed states except for North Korea.

The technologies of fission whether civil or military are the same. Enriched nuclear fuel is employed to generate a reaction – either controlled in the civil case or uncontrolled in the case of an explosion. The fuel is the same, the expertise is the same and the technologies can and often have been shared. Multiple examples of the dual use capability of the fuel, expertise and technology abound. The ongoing concerns surrounding the Iranian nuclear program attest to this – and to the enormous hazards associated with enrichment of uranium, irrespective of the articulated purpose of such practices.

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The historical interrelationships between the civilian and military sectors exist to this day. They include, but are not limited to:

- the dual nature of uranium enrichment capabilities (it is easier to enrich low enriched fuel grade uranium to weapons grade uranium than it is to produce the fuel enriched uranium),
- the ability to extract plutonium from nuclear reactor fuel rods (for maximum plutonium production the fuel rods are normally kept in the core for no longer than ninety days and then sent to a reprocessing plant, compared to around 18 months for exclusively electricity production), and
- the difficulty in thus determining the true intentions of a country’s nuclear program, as evidenced by the nuclear program in Iran. Often the first indication that a country has developed weapons-grade uranium is their announcement. The IAEA acknowledges it is underfunded for the task, and furthermore, can only engage in physical inspections of a miscreant state if they grant permission. Even if a state with nuclear power has not developed nuclear weapons, the infrastructure’s dual purpose means that weapons development is only months to a few years away if desired.

The International Panel on Fissile Materials, an authoritative independent international group of experts has observed that:

“A phase-out of civilian nuclear energy would provide the most effective and enduring constraint on proliferation risks in a nuclear weapon-free world.” (IPFM, 2009)

This conclusion was underlined by the Board of Sponsors of the Bulletin of the Atomic Scientists - which includes 19 Nobel laureates - in 2010:

“...the world is not now safe for a rapid expansion of nuclear energy. Such an expansion carries with it a high risk of misusing uranium enrichment plants and separated plutonium to create bombs.”

Nuclear power programs facilitate weapons proliferation: Australia’s own brief and curtailed flirtation with nuclear energy was acknowledged at the time by the enthusiastic Prime Minister as a disguised nuclear weapons program. John Gorton had military ambitions for a nuclear power reactor he wanted to have constructed in the late 1960s at Jervis Bay. He later said: "We were interested in this thing because it could provide electricity to everybody and it could, if you decided later on, it could make an atomic bomb." Given this history and the nature of international nuclear diplomacy, any move towards enhanced nuclear fuel processing or enhanced nuclear fission would be a proliferative signal to our neighbours. A concerted effort to develop Australian nuclear reactors would potentially contribute to a nuclear arms race in our region.

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73 Pilita Clark, 1 Jan 1999, 'PM’s Story: Very much alive... and unfazed', Sydney Morning Herald.
NUCLEAR WASTE

3.12 What are the wastes (other than greenhouse gases) produced in generating electricity from nuclear and other fuels and technologies? What is the evidence of the impacts of those wastes on the community and the environment? Is there any accepted means by which those impacts can be compared? Have such assessments making those comparisons been undertaken, and if so, what are the results? Can those results be adapted so as to be relevant to an analysis of the generation of electricity in South Australia?

The radioactive waste management experience to date - internationally and nationally - should alert policy makers and legislators to the enormity of the task of dealing with this aspect of the nuclear fuel chain. At this point it is worth observing that there is nothing particularly ‘cyclical’ about the nuclear fuel industry – it starts with mining uranium, progresses to enrichment and fuel fabrication through reactors and weapons to waste. The idea that there is a ‘cycle’ comes from proposals to harvest and reprocess the waste stream and thus close the loop; this is barely more than a fantasy after 60 years of the industry. What we have instead is mountains of radioactive waste all over the planet and only 4 countries with anything like a program to deal with it. The most advanced – Finland - is working on the first of a necessary five deep geological repositories to deal with its own reactor waste alone.

The average nuclear power reactor produces 300 m$^3$ of low and intermediate level waste per year and some 30 tonnes of high level solid packed waste per year.74 Every year, there is 12,000 tonnes of spent fuel (high level) being produced globally, which will triple if the so-called nuclear renaissance occurs. As of 2010 there exists approximately 350,000 tonnes of nuclear fuel derived waste around the world. Currently this is being stored on-site in dry casks at most nuclear power plants, or at reprocessing facilities such as La Hague (France), as an interim solution. Greatly complicating this task are the very long half-lives of some of the radionuclides present in this waste (for example plutonium-239 – half-life of 24,000 years, technetium-99 – half-life of 212,000 years, cesium-135 – half-life of 2.3 million years, and iodine-129 – half-life of 15.7 million years). These are highly hazardous to humans and require ultimately isolation from the biosphere for hundreds of thousands to a million years. The aim is to prevent water reacting with the waste since this is the main mechanism by which the waste can re-enter the biosphere. The IAEA states that deep geologic disposal using a system of engineered and natural barriers to isolate the waste is the best method. The principal features of the geological repository concept is to place packaged waste in a stable formation several hundred meters below the surface with engineered barriers around and/or between the waste packages and the surrounding rock.

Worldwide there is no deep geological repository currently in operation despite the nuclear power industry being in existence for over 50 years. Internationally, no country currently plans to have a repository in operation before 2020, and all proposals have encountered problems.

High level waste (including spent fuel) accounts for 2% by volume although 90% by radioactivity and requires permanent storage in deep geological formations for a few hundred thousand years.75 Due to the complexity of the problem and the long time periods considered, the ability of a repository to retain radioactivity has a significant degree of uncertainty. Similar to assessing the safety of a nuclear reactor, conceptual and statistical models are employed. Furthermore, similar assumptions usually based on insufficient or absent data are made to simulate the behaviour of a repository over an arc of time orders of magnitude beyond that of recorded human history.

74 http://www.iaea.org/Publications/Factsheets/English/manradwa.html#note_c
75 To put this in perspective, the Egyptian pharaohs were in power only five thousand years ago, and homo sapiens are understood to have appeared in East Africa between 100,000 and 200,000 years ago.
Meanwhile, Australia has been trying for decades unsuccessfully to manage its relatively small volume of waste; under no circumstances should building a reactor commence if we have not identified and approved the site for deep geological disposal of the HLW. And that would add another decade at least to the IAEA framework of safe nuclear power plant development.

**CONCLUSION**

Erecting and operating nuclear reactors in South Australia would certainly not be easy or convenient. Medical isotope production is not a justification for a nuclear reactor in Australia, as these can be safely imported or produced from non-reactor sources.

Given the climate imperative and the perils inherent in failing to meet reduced emissions targets, pursuing the dream of nuclear power would be unwise. Furthermore, the problems associated with routine function of nuclear reactors, the associated health risks, the potential for catastrophic incidents involving radionuclide dispersal, and the proliferative influence of NPPs together make nuclear energy an irresponsible electricity generating pathway for South Australians.

Fortunately there are well articulated, affordable and feasible – though not problem-free or simple in themselves – alternatives to nuclear power.
INTRODUCTION

Our comments on Issues Paper Four relate to legacy and risk issues arising from the management, storage and disposal of nuclear and radioactive waste.

Particular attention will be given to Sections B 4.2 and 4.3 and C. 4.5-4.10.

BACKGROUND

Radioactive waste can be radioactive for long periods and continue to be a hazard to humans, animals and the environment for many thousands of years.

MAPW and the PHAA concur with the following principles established by the International Atomic Energy Agency76:

“Radioactive waste shall be managed in such a way:

- as to secure an acceptable level of protection for human health.
- as to provide an acceptable level of protection of the environment.
- as to assure that possible effects on human health and the environment beyond national borders will be taken into account.
- that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.
- that will not impose undue burdens on future generations.”

We do not consider that current management of nuclear and radioactive waste anywhere in the world is consistent with these principles.

The questions posed in the Royal Commission’s Issues Papers do not give appropriate attention to these principles.

We have major concerns with the health and environmental impacts of storage and disposal. Nuclear waste has issues of toxicity, longevity, heat production and for high level waste in particular, contains fissile materials like plutonium (which can readily be made into nuclear weapons). Nuclear waste streams are made up of materials that are both chemically and radiologically toxic. These toxicities have the potential to cause very substantial damage to human health and to the environment, and they persist for very long periods of time. There is no threshold level of “safe” exposure to radioactivity [see Appendix 1].

Nuclear waste is produced at many points in the nuclear fuel “cycle”. We consider that the pathway taken by nuclear fuels is not a cycle, and to label it as such connotes a level of safety that is not justified. The materials in nuclear fuels are on a one-way journey; they are extracted, processed, used, and then disposed of. Disposal must be permanent, because even with reprocessing, there is waste that must be kept well separated from humans and from the environment for very long periods of time; in practical terms forever.

76 International Atomic Energy Agency, 1995
Nuclear power stations each produce about 300m³ of low and intermediate level waste per year, and 30t of high-level waste. By 2010, some 350,000t of high-level waste had accumulated worldwide.

High level waste (including spent fuel) accounts for 2% by volume although 90% by radioactivity and requires permanent storage in deep geological formations for a few hundred thousand years. Due to the complexity of the problem and the long time periods considered, the ability of a repository to contain radioactivity has a significant degree of uncertainty. Conceptual and statistical models are employed, similar to assessing the safety of a nuclear reactor. These assumptions are usually based on insufficient or absent data and are made to simulate the behaviour of a repository over an arc of time orders of magnitude beyond that of recorded human history.

4.2 Are there nuclear or radioactive wastes produced in Australia which could be stored at a facility in South Australia? In what circumstances would the holders of those wastes seek to store or dispose of that waste at facilities in South Australia?

Australia’s nuclear waste burden

Nuclear waste is categorised as low level waste (LLW), intermediate (ILW) or high level (HLW), depending on the degree of radioactivity and heat it generates. However there is no precise boundary between LLW and ILW.

Australia’s nuclear waste burden is low-level and intermediate level, and it is accumulating at the Lucas Heights reactor and at numerous other facilities around the country. HLW typically arises from nuclear power and nuclear weapons production; Australia has no high level waste and does not produce any.

ILW (and some short-lived ILW) in Australia include defence department waste from nuclear tests in the middle of last century, a repository at the old Radium Hill uranium mine in SA, contaminated soil from ore-processing research, and operational waste stored at the Lucas Heights site.

ILW includes spent fuel rods from Lucas Heights that were sent to France and Scotland for reprocessing (extraction of plutonium and uranium) and returned to Australia from 2015 onwards, scientific equipment, stockpiles of radium (see below), thorium and uranium residues from mineral sands processing and disused sources from medical and research equipment.

Much medical nuclear waste is short-lived and decays on the medical facilities’ premises until its activity is virtually nil and it is then classified as “exempt waste” and can be disposed of without special treatment. (An exception to this is the significant stockpiles of radium, not used medically since 1976 but constituting intermediate level waste sitting at various hospital sites around the country and requiring long term safe disposal).

Harm minimisation and cradle-to-grave strategy needed

Australia needs to dispose of this radioactive waste legacy appropriately and minimise further waste burdens on future generations and the environment. As a society we need therefore to move towards

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77 http://www.iaea.org/Publications/Factsheets/English/manradwa.html#note_c
78 To put this in perspective, the Egyptian pharaohs were in power only five thousand years ago, and homo sapiens are understood to have appeared in East Africa between 100,000 and 200,000 years ago.
a sense of pro-active stewardship and “harm-minimisation” with “disposal” being the final option. A fundamental principle must be that no new activities involving radioactive materials should be introduced without a full life-cycle waste management plan, with exploration of alternatives, minimisation of waste, and a proper disposal plan: the so-called 'cradle-to-grave' strategy. A crucial aspect of this approach is to pursue the alternatives to nuclear power and nuclear medicine’s use of reactor-produced radioisotopes to minimise the future production of radioactive waste. Eliminating reactor production will eliminate waste related to the production of medical isotopes.

Disposal solutions and international best practice

Disposal solutions must be made on the basis of international best practice and Australia’s legal obligations. Australia is a signatory of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, a legally binding treaty. In addition, Australia participates in the development of international safety standards from which international best practice is derived. Despite international best practice standards there still remain unpredictable geological, environmental, social and technological variables which may impact on the situation.

Current best practice suggests that:

- LLW can be buried from surface level down to about 30 metres (“near surface disposal”), requiring isolation for periods of up to several hundred years; it can contain both short- and long-lived radioisotopes
- ILW should be buried at a depth of 30 to 300 metres (deep geological disposal), in geologically stable ground well away from groundwater. This is because it contains long-lived isotopes in quantities that need a high degree of containment and isolation from the biosphere tens of thousands years. Current scientific modelling cannot predict geological stability for this time frame.

However current plans for Australia’s intermediate waste are for above-ground storage with institutional controls required indefinitely. The latter requirement alone – institutional control over prolonged periods, even hundreds of years let alone thousands - is fanciful.

While nuclear proponents generally downplay or deny the risks of unexpected consequences, evidence indicates that, even in the short term, plans and predictions can go awry. Even deep geological disposal can only be regarded as the best currently available option, not a perfect solution. Policy makers and politicians should be well apprised of the scientific principles on which these proposed practices are based, and their limitations.

Retrievability

It is important that any long-lived nuclear waste that has been stored or disposed of be able to be retrieved. This allows for inspection and maintenance of the disposed radioactive waste if required and also allows for improvements in waste disposal techniques in the future. Ongoing security will also be required to ensure that the retrievability of the nuclear waste is not taken advantage of for unsanctioned purposes.

Consultation
Disposal solutions must also be made with genuine consultation and fully informed consent of all affected communities. Current practice falls well short of providing either. The provision of basic health and educational services should not be used as inducements to landowners to accept a repository – these should be provided to all citizens anyway.

**Burden already suffered by Indigenous Australians.**

Australia’s aboriginal people in particular have already suffered from imposition of radioactive contamination. The British nuclear bomb tests at Maralinga and other sites in the 1950s were conducted with scant regard for their welfare, and the “clean-up” of their lands left plutonium-contaminated debris in shallow burial trenches. Many of these have subsequently eroded and are now releasing material into the wider environment.79

4.3 Would the holders of nuclear or radioactive waste outside Australia seek to store or dispose of that waste in South Australia? Who holds that waste? What evidence is there that they are seeking options to store or dispose of wastes elsewhere including in locations like South Australia? If so, what kinds of waste and what volumes might be expected? What would the holders be willing to pay and under what arrangements?

Australia should not become the recipient of international nuclear waste.

The establishment of a nuclear waste industry is promoted as a revenue opportunity for SA, with nuclear industry proponents claiming countries will pay millions for us to take their waste. They then state that this waste will be a valuable resource and we can generate electricity from it. If the waste is to become so valuable, why would countries pay for its disposal? Clearly at least one of these proposals is not accurate. Decades of research, including various very expensive experimental reactor programs, have failed to find a safe long term method of disposal.

It is worth noting that the Nuclear Waste Storage Facility (Prohibition) Act 2000 currently prohibits importing nuclear waste. MAPW and the PHAA consider that the public health and environmental concerns around a nuclear waste industry are formidable and that the Act should not be repealed. In addition, Australia is a signatory of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, a legally binding treaty, which states that waste should be disposed of in the country in which it was generated.

Additionally, the economics of very long term waste disposal are extremely perilous, as is long-term temporary storage. The price nations will pay to reduce their nuclear waste burden is almost certain to only be a small measure of the true costs of long term toxicity, and result in considerable intergenerational liability for Australians.

4.5 What are the specific models and case studies that demonstrate the best practice for the establishment, operation and regulation of facilities for the storage or disposal of nuclear or radioactive waste? What are the less successful examples? Where have they been implemented in practice? What new methods have been proposed? What lessons can be drawn from them?

There are no long-term high level nuclear waste facilities in operation anywhere in the world.

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A major problem for the use of nuclear fuels is that, as yet, no system to deal with high level nuclear waste for the periods of time that are required is in operation anywhere in the world. The vast majority of nuclear fuel waste has been placed in temporary storage, pending a solution for permanent disposal. This has been the case for over 60 years, and it is very concerning that waste continues to be generated while a permanent disposal solution has not yet been developed. Indeed, given the many millennia that such a solution needs to be effective, it is hard to see how nuclear waste will be stored without leaving unacceptable liabilities and toxicities for future generations.

Radioactive waste must be separated from the biosphere at all stages of its journey to final disposal. Because many of the radioisotopes are radioactive for very long periods of time, this means separation of these isotopes from the biosphere over geological time periods.

**Major safety and groundwater/environmental contamination issues**

Disposed waste is not intended to be retrieved, and has minimal reliance on active controls such that active management is not required and that passive mechanisms are sufficient to maintain safety. Deep geological emplacement is the current preferred means of disposal, but its safety depends on permanent isolation of radioactive materials from the environment. Deep water contamination by radioactive waste after corrosion of waste containers is a major issue, yet good understanding of hydrogeology is lacking, especially over very long time periods.

**Major problems internationally**

Groundwater contamination has already been a problem in waste storage sites. For example, after less than two decades Germany is in the process of retrieving waste from a deep geological repository because of water seepage. Three shallow repositories in the US have been closed for environmental reasons. The planned high level waste repository in Nevada has been abandoned, despite 20 years of work and over US$10 billion spent. Reasons were numerous, and included falsification of data in regard to ground water modelling. A deep repository in New Mexico will be closed for at least four years, after a fire and a separate episode of radiation release. The US government report found the New Mexico facility was hampered by a failure to understand, characterise and control the radiological hazard, compounded by a degradation of key safety management programs and safety culture.

However, because final disposal is an untested technology, reversibility needs to be part of the design. As illustrated by the waste repository in Germany, there may be an unanticipated future need to retrieve waste materials that have been disposed of, so this capability should be a key part of the design of any waste repository.

**Radioactivity remains an issue beyond predictable geological modelling**

The demands of radioactive waste storage are unprecedented. No other human activity has been required to continue over such time periods. Reaction products in spent fuel continue to be radioactive for very long periods of time. The half-life of plutonium-239 is 24,000 years; technetium-99 has a half-life of 212,000 years; caesium-135 a half-life of 2.3 million years; and iodine-129 a half-life of 15.7 million years. This means that substantial additional radiological hazards will continue until these radionuclides have decayed to a point where they emit only background levels of radiation. In practice this is about a million years after disposal of spent nuclear fuel. As stated earlier, current scientific modelling cannot reliably predict geological stability for this time frame.
4.6 What are the security implications created by the storage or disposal of intermediate or high level waste at a purpose-built facility? Could those risks be addressed? If so, by what means?

Fissile material from high level waste a major long term security issue

High level waste, particularly plutonium, creates a threat of the diversion of nuclear waste into various forms of weapons, from nuclear weapons to environmental contaminants. This means that all waste must be secure from unauthorized interference, which must also be maintained over extremely long time frames. Such interference may come from state or non-state actors, and will require legal, physical and operational measures to enhance security. It is highly likely that there will be an unacceptable social cost to establishing such measures. It is important to recognise the substantial risk that in establishing a waste repository, the desire to make financial and political gain in the short term will override the enormous long term risks and liabilities.

4.7 What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?

Nuclear industry safety record

As noted in our response to issue paper 2, the nuclear industry world-wide has a long history of inadequate regulation, cosy relationships between industry, regulators and political representatives, cost cutting, data falsification, concealment of incidents, human error and accidents and has clear potential for individuals or groups to cause deliberate harms80. The sheer volume and ongoing frequency of actual adverse events negates the theoretical “fail safe” mechanisms that have been promised with each new version of each stage of nuclear technology.

The 2011 IAEA document “Establishing the Safety Infrastructure for Nuclear Power Plants” notes “Standards are only effective if they are properly applied in practice.”81 As already noted in our response to Issues Paper 1, the existing regulation and oversight of the Olympic Dam uranium mine site provides a poor (and salutary) example of lack of transparency and evidence of good regulation.

In turn this does little to engender confidence in the South Australian government’s ability to ensure the future safety or regulation of storage, particularly of high level waste. It will be very difficult to build confidence in the industry.

4.8 Bearing in mind the measures that would need to be taken in design and siting, what risks for health and safety would be created by establishing facilities to manage, store and dispose of nuclear or radioactive waste? What needs to be done to ensure that risks do not exceed safe levels? Can anything be done to better understand those risks?

4.9 Bearing in mind the measures that would need to be taken in design and siting, what environmental risks would the establishment of such facilities present? Are there strategies for managing those risks? If not, what strategies would need to be developed? How would any current approach to management need to be changed or adapted?

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80 Let the facts speak www.letthefactsspeak.org 2012
81 Establishing the Safety Infrastructure for Nuclear Power Plants International Atomic Energy Agency 2011
Currently Australia does not generate high level waste.

**Principles of Waste management**

Waste disposal problems vary with the classification of waste. The principles of waste management are

- to isolate chemically and radiologically toxic waste from the environment
- to allow radiological decay to occur under safe conditions

These requirements impose unprecedented waste management conditions on the handling of nuclear waste. For high-level waste, including spent fuel from nuclear electricity generation, the problems are due to the

- very high chemical and radiological toxicities of the spent fuel
- very long half-lives of the main emitters of ionizing radiation in spent fuel
- the production of substantial quantities of heat, especially in the first months after the removal of spent fuel from reactors.

The journey of spent nuclear fuels is long. A long and complex sequence of activities is required after production of waste from nuclear facilities:

- characterization of the waste to determine its safety profile
- pre-treatment of the waste to allow handling
- treatment of the waste to allow storage
- conditioning or packaging of the waste into suitable containers
- interim storage on the earth’s surface
- transport to long term storage
- emplacement into long term monitored storage
- emplacement into final sealed disposal.

All steps before final disposal require:

- a very high level of continuing management
- a high level of technology
- a high level of security

and all of these must apply over substantial periods of time. Substantial amounts of heat are generated by spent fuels. Temporary storage (probably for several decades) is necessary in order to dissipate heat and to control radiation.

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82 Feiveson H, Mian Z, Ramana M V, von Hippel F. 2011
The heat generated prevents final disposal, which cannot be contemplated until the heat has reduced to manageable levels. This requires continuing active management. Open-ended storage is problematical. At Fukushima, a major issue developed with radiation leakage from temporarily stored spent fuel\(^8\)\(^3\).

**Timelines of storage**

Because of the major difficulties with final disposal, temporary storage may become, *de facto*, permanent storage. Continuing maintenance of storage systems requires continued good governance, geological stability and effective functioning of storage institutions over extremely long time periods. This seems inconceivable and world history is not reassuring in this regard.

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Future generations of Australians are at risk of being left a toxic legacy that may contaminate land and aquifers and have major impacts on farming and remote communities.

Final disposal has to be designed and operated to ensure that containment of radiological and chemical contamination and maintenance of security continues over geological time frames.

A nuclear fuel “cycle” is a myth until satisfactory solutions to these problems are found, constructed and implemented. Despite more than 60 years of nuclear power generation, there is as yet no final disposal facility for high level nuclear waste anywhere in the world. It is a principle of good design that a final waste disposal solution is implemented before a nuclear industry is developed.

4.10 What are the risks associated with transportation of nuclear or radioactive wastes for storage or disposal in South Australia? Could existing arrangements for the transportation of such wastes be applied for this purpose? What additional measures might be necessary?

Transport

Transport of nuclear waste to centralised storage or disposal facilities greatly increases the risk of accidents, theft, sabotage and contamination. The risk of illegal access is greatest during this phase.
The manufacture of a “dirty bomb” (radioactive material dispersed by conventional explosive) would be a relatively easy task for a terrorist organisation once it has obtained the radioactive material. International transport represents the greatest risk, and even transport within Australia must be minimised.

Transportation of radioactive material for disposal should be in accord with all radiation safety standards and jurisdictional safety requirements. If there is to be such transport, there must also be consultation with all those communities along the proposed route, including emergency, police, health and environmental protection services and a requirement that community consent for the process be obtained.

Radioactive waste transport, storage or disposal should not be imposed on unwilling communities. All residents in the broad region involved must be in a position to give fully and properly informed consent and the process of obtaining this should be transparent and open to public scrutiny.

CONCLUSION

MAPW and the PHAA consider that taking nuclear waste from other countries is clearly unsafe and very ill-advised given the extremely long term toxicities. Despite more than 60 years of nuclear power generation, there is as yet no final disposal facility for high level nuclear waste anywhere in the world.

Australia’s own existing nuclear waste will at some stage need a repository. An independent and evidence based Australian national radioactive waste management authority should be established with adequate funding and autonomy to develop, implement and oversee a radioactive waste management policy, based on international best practice. There should be broad stakeholder representation in its governing board. Storage must only be used for short-lived radionuclides, and as an interim stage for longer-lived radionuclides until a permanent disposal solution can be found. Disposal solutions must also be made with genuine consultation and fully informed consent of all affected communities84.

Any activities which produce radioactive waste requiring long term disposal should be minimised and ceased as an urgent priority. Reduction at source (waste minimisation) is the fundamental principle in reducing the risks of environmental contamination from nuclear waste. The vast majority of current medical radiological practice uses short lived isotopes and does not justify the creation of a waste repository.

We consider that long-term storage is inherently high risk, requiring very long term good regulation, governance, well researched and trustworthy geological data, consent of affected populations and long-term active management and security. We consider that the technology for permanent disposal has not yet been developed or tested.

84 MAPW Radioactive Waste Policy 2015 Revised April 2015 (Appendix 3)
Appendix 1

Health overview

Four major health issues:

1. All phases of the nuclear power industry have inherent long term toxicities: impacts on workers, communities, the environment and any waste site. Endemic poor regulation and corporate cost pressures compound these issues.
2. Inevitable accidents and deliberate harms
3. Nuclear weapons proliferation and risk of catastrophic humanitarian disaster
4. Opportunity cost: Emissions reductions with new nuclear reactors will take decades to happen, and delay cheaper, faster and more effective measures to reduce carbon emissions, while the huge subsidies required mean other social expenditures (eg on health and education) are reduced.

HEALTH IMPACTS OF IONISING RADIATION

One of the common disparagements levelled at sceptical communities is that of so-called ‘radio-phobia’, suggesting that opponents of nuclear power have ill-founded concerns about the hazards associated with the technology, in particular the health hazards associated with ionising radiation.

Ionising radiation (IR) arises from many sources. Nuclear fission which powers nuclear reactors is one. It is postulated ionising radiation imparts its deleterious health effects through two mechanisms: transference of its energy to atoms in biological tissue which then becomes electrically charged, leading to the formation of free radicals which then damage the cell’s genetic blueprint (DNA) leading to genetic mutations; and direct DNA disruption along the track the ionising radiation traverses through the cell’s nucleus. The most mutagenic (causing genetic mutations) of these are double stranded breaks (DSB) where both strands of the double helix DNA molecule are simultaneously disrupted resulting in a high likelihood of mutations. This then predisposes to the initiation of cancer when the regulatory mechanisms of the cell fail.

Cancer may not appear for 10-40 years (latency), although can be as short as 5 years for leukaemia. Ionising radiation is classified as a Class 1 carcinogen by the International Agency for Research in Cancer (IARC) of the World Health Organisation (WHO), the highest classification consistent with certainty of its carcinogenicity.

Two types of IR health effects are recognised:

- The severity of deterministic effects is directly proportional to the absorbed radiation dose. These include skin damage and blood disorders. The higher the dose, the worse, for example is the skin radiation burn. These have a threshold below which they do not occur, although this may vary between individuals. This threshold is around 100mSv at which blood production begins to be impaired.\(^5\)

- Stochastic effects are ‘probabilistic’ in nature. In other words, the higher the dose the greater the chance of them occurring, however, one they occur their severity is the same irrespective of the original dose. The main stochastic effect is cancer. The lower the dose of IR, the lower the chance of contracting cancer, however, the type and eventual outcome of the cancer is

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\(^5\) Compared with a current per capita average of approximately 2mSv from natural background radiation.
independent of the dose. It can thus be seen that the high dose deterministic effects of IR
were readily observable early after the discovery of radioactivity, however, the concept of a
stochastic effect as a mechanism for the development of cancer, took several decades to be
understood.

The quantification of stochastic effects has occupied scientific debate throughout most of the
twentieth century and is still being played out. The distinction is critical to understanding the health
impacts of low-dose\textsuperscript{86} radiation, particularly when radiation doses to workers and the general
population are below deterministic levels, and why there is considerable controversy over its
significance.

The BEIR VII report (2006) defined low dose as less than 100mSv\textsuperscript{87}. Since the previous report in
1990 much new information had come to light reinforcing their original heightened assessment of the
risk of cancer and leukaemia, and stated:

"… there is a linear dose-response relationship between exposure to ionizing radiation and the development of solid
cancers in humans. It is unlikely that there is a threshold below which cancers are not induced."

The report relied on updated data from the Hiroshima and Nagasaki atomic bomb survivors, medical
exposure studies, and nuclear workers exposed at low doses and dose rates. Importantly, and contrary
to previous assertions that most of the risk estimates were mere extrapolations from very high doses
in atomic bomb survivors, more than 60\% of exposed survivors experienced a dose of less than
100mSv, and 45\% less than 50mSv, well within current cumulative occupational regulatory limits.

WORKERS

Cancer is a common disease accounting for 25\% of all mortality in the general population. Therefore,
there is much statistical ‘noise’ obscuring small relative increases in cancer mortality consequent to
ionising radiation exposure. In fact, the size of the study population required increases exponentially
at lower radiation doses (because the number of cancer cases is commensurately less). In other words,
if we are to detect a small increase in cancer risk at low doses, we need very large study populations to
achieve statistical significance. Furthermore, given the latency period for radiation induced cancer,
long follow-up periods are required. Occupational studies therefore can be difficult to perform and
often have weak statistical power to prove a detriment. It is thus important to note that failure to
establish statistical significance does not rule out the existence of a detriment, merely that the sample
size was not large enough or the follow-up was not long enough.

Many studies of mortality, and in some instances cancer, have been made over the last twenty years
among nuclear industry workers (excluding mining). Studies have covered workers in Canada, Finland,
France, India, Japan, Russia, Spain, the United Kingdom, and the United States. In general, exposure
in most of these studies was due to external radiation (x-ray and gamma ray). Internal contamination
(through inhalation, ingestion, skin absorption, or wounds) by tritium, plutonium, uranium, and other
radionuclides occurred in some subgroups of workers but attempts to reconstruct internal doses have
been incomplete.

86 Low-dose is defined as less than 100mSv for the purposes of this paper in keeping with the BEIR VII report (2006), National
Academy of Sciences.
87 NAS (National Academy of Sciences), Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation. 2006.
Studies of nuclear industry workers are unique in that personal real time monitoring of exposure has been occurring since the 1940’s with personal dosimeters. More than 1 million workers have been employed in this industry since its beginning. However, studies of individual worker cohorts are limited in their ability to estimate precisely the potentially small risks associated with low levels of exposure. Risk estimates from these studies are variable, ranging from no risk to risks an order of magnitude or more than those seen in atomic bomb survivors.

However, the 15-country study of nuclear industry workers (excluding mining) published in 2005, the largest study of nuclear industry workers ever conducted, was able to arrive at statistically significant conclusions confirming the increased risk of cancer and leukaemia in nuclear industry workers, even at low dose. This involved analysing dosimetric records of over 407,000 workers and correlating with solid cancer and leukaemia mortality with a total followup of 5.2 million person years. The average cumulative dose was 19.4mSv, with 90% receiving less than 50mSv. Recall these are within the current permissible dose limits (50mSv in any one year, provide that there is no more than 20mSv per annum averaged over five years ie 100mSv total). The results indicated that there was an excess risk for solid cancers of 9.7% per 100mSv exposure, and an excess risk of 19% for leukaemia. The risks were dose related and they were consistent with the estimates from the Atomic Bomb studies. They estimated that 1-2% of all nuclear worker deaths were probably radiation related.

The overwhelming international scientific consensus is that ionising radiation – including at low-levels - is a health hazard. Those who dismiss this understanding are adopting precisely the approach of climate-deniers who denigrate scientific consensus in the discipline of climatology, dismissing the consensus of IPCC and other august bodies. The ICRP, the NAS and IARC have all repeatedly recognised the deleterious impacts of exposure to ionising radiation. This consensus has been built up and regularly reaffirmed over the past five decades.

The relatively recent developments in the field of molecular genetics, and computer modelling have permitted a much enhanced understanding of the pathways to pathology - the damage to DNA leading to cancer and non-cancer illnesses.

Multiple extensive studies have by now clearly demonstrated excess cancer rates at levels well below 50 mSv, including at ‘occupational’ exposure rates. A recent Australian study of over 10 million children exposed to low level radiation by CT scanning revealed excess rates of many different kinds of cancer - (digestive organs, melanoma, soft tissue, female genital, urinary tract, brain, and thyroid); leukaemia, myelodysplasia, and some other lymphoid cancers. The study found a risk for solid cancer other than brain cancer around ten times higher than that documented in young hibakusha (atom bomb survivors), and with greater statistical precision.

The increase in cancer risk was already apparent in the one to four years after first exposure. Overall cancer incidence was 24% greater for exposed than for unexposed people, and most disturbingly the average effective radiation dose per scan was estimated as just 4.5 mSv.  


A just published study of patients exposed to >7.5 mSv of radiation from cardiac computed tomographic angiography demonstrated evidence of DNA damage, which was associated with programmed cell death and activation of genes involved in apoptosis (a genetically directed process of cell self-destruction that is marked by the fragmentation of nuclear DNA) and DNA repair.  

These findings are not supportive of the reduced harm often assumed to apply for a given radiation dose delivered over a longer rather than a shorter period of time. In fact the most recent data from Japanese hibakusha (atomic bomb survivor) show an unexpected trend of increased risk for a given radiation dose at low doses, in addition to a linear dose-response relationship of increasing cancer cases throughout life with no evidence of a threshold of radiation dose below which no risk was found.  

NON-CANCER DISEASES

Ionizing radiation is also known to increase the risk of occurrence and death from some non-cancer diseases, including cardiovascular and respiratory disease. Recent evidence strongly indicates that circulatory disease mortality also increases at low total doses and dose rates, such as occur in many nuclear industry workers. The increased risk of death from heart and other circulatory diseases is comparable in magnitude to the radiation cancer risk, meaning that the total extra risk of dying because of exposure to radiation is likely to at least double the increased risk of death from cancer alone.  

HIGH RISK INDIVIDUALS

Infants are about four times as sensitive to radiation cancer-inducing effects as middle-aged adults (NAS 2006). A single X-ray to the abdomen of a pregnant woman, involving a radiation dose to the fetus of about 10 mSv, has been shown to increase the risk of cancer during childhood in her offspring by 40 percent. Moreover, adult females are overall at close to 40 percent greater cancer risk as males for the same dose of radiation, and this difference is greatest in young children. For cardiovascular disease risk, the most recent systematic review and meta-analysis indicate that the increased lifetime risk of death from circulatory disease estimated for the British population is about ten times higher for a child exposed to radiation before ten years of age compared with exposure

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occurring after age seventy. In the same study, the risk of death from solid cancer following radiation exposure before age ten was estimated at more than twenty times the risk for exposures occurring above age seventy. These differences relate to both increased sensitivity in the young and the generally longer remaining years of life for effects to become manifest.

In terms of evolving knowledge of radiation carcinogenesis, women who are carriers of BRCA1/2 gene mutations, which put them at high risk of developing breast cancer, have recently been shown to have heightened sensitivity to increased cancer risk from exposure to radiation.95

Other genetic markers of increased vulnerability to cancer induction from radiation largely remain to be characterized.

**GENETICS**

Ionising radiation is a powerful cause of genetic damage. Many genetic effects are also heritable, and genetic influences on disease occurrence are often complex, interact with environmental factors, and affect multiple body systems. Previously, studies of children born to those exposed to the nuclear bombings in Hiroshima and Nagasaki have not demonstrated an increase in diseases attributable to radiation-induced mutations. However, there is extensive evidence of radiation-induced transmissible mutations in other animals, and there is no reason to believe humans are immune to such harm.96 Evidence is emerging of an increased risk of leukemia in children whose parents were both exposed to the atomic bombings in Japan.97

**TREND**

A consistent and continuing trend in our understanding of radiation health effects has been that the more we know, the greater the risks. Radiation risk estimates and radiation protection standards over time have always been raised, never lowered. As evidenced by the foregoing discussion, new evidence continues to emerge of damaging radiation health effects beyond those expected. Indeed, the recently released guidelines from the International Atomic Energy Agency has revised down the dose limits for occupational exposures to the eye, commenting some of the earlier epidemiological studies, on which limits were based may not have had sufficient follow-up to detect either radiation-induced lens changes or visual disability requiring cataract surgery. In addition, better techniques for detecting, quantifying, and documenting early radiation-associated lens changes, as well as better dosimetry, may have been factors that contributed to the more recent findings of radiation-induced cataracts at low exposures. The equivalent dose limit for the lens of the eye for occupational exposure in planned exposure situations has been reduced from 150 mSv per year to 20 mSv per year, averaged over defined periods of five years, with no annual dose in a single year exceeding 50 mSv.

This reduction in the dose limit for the lens of the eye follows the recommendation of the International Commission on Radiological Protection (ICRP) in its statement on tissue reactions on 21 April 2011. In the longer term, the interim guidance provided and experience gained in its application will be used as input to a number of Safety Guides that are currently being revised - both on occupational radiation protection, and on radiation safety in the medical uses of ionizing radiation.0 It is expected that these Safety Guides will be published in 2015–2016.

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96 NAS - 2006.

Appendix 2

Current research evidence about health problems from radiation
July 2015

Executive Summary

- Even at low doses of radiation there is clear evidence of increased risk of cancer and cardiovascular disease. Additional radiation exposure results in increased risk.
- The risk of increased cancers has been clearly shown in studies with very large numbers of people: Workers in the nuclear industry, children having CT scans, survivors of Nagasaki and Hiroshima, mine workers and householders exposed to raised levels of radon gas and in unborn children when their mothers had had abdominal X-rays.
- The risk of death from cardiovascular diseases is similar to that of dying of cancer, and the role of radiation causing other types of illness is currently being researched. As a result the overall excess risk of dying from exposure to low doses of radiation may be twice (or more) than that currently assumed from cancer alone.
- The trend in research over the last couple of decades, as each bit of new evidence emerges, is that the risks are greater than previously thought. There is now clear evidence that low dose exposures are harmful, and the greater the exposure the greater the risk.

Nuclear Industry Workers

In June 2005, the British Medical Journal published a review of the risk of cancer from low doses of ionising radiation to workers in the nuclear industry in 15 countries which demonstrated a definite excess risk of cancer⁴. 407,391 workers were individually monitored for external radiation with a total follow-up of 5.2 million person years. The excess relative risk for cancers other than leukaemia was 0.97 per Sv (i.e. 97% increase - almost double per Sievert). The excess relative risk for leukaemia excluding chronic lymphocytic leukaemia was 1.93 per Sv (i.e. 193% or almost triple per Sievert).

On the basis of these estimates, 1-2% of deaths from cancer among workers in this cohort may be attributable to radiation. These estimates, from the largest study of nuclear workers ever conducted, are higher than the risk estimates used for current radiation protection standards. The results suggest that there is a small excess risk of cancer, even at the low doses and dose rates typically received by nuclear workers in this study (90% of workers received cumulative doses less than 50 mSv).

These results indicate that a cumulative exposure for adult workers of 100 mSv – the current recommended 5 y occupational dose limit – would lead to a 10% increase in mortality from all cancers, and a 19% increased mortality from leukaemia (of types other than chronic lymphatic leukemia). While the fact that the risk from low level radiation exposure may be ‘small’ in any particular individual, when this risk is translated across populations, the increase in numbers of cancers can be considerable.

A follow up study published in June 2015 examined deaths caused by blood cancers, which are highly radiation sensitive, among nuclear workers in the US, France and UK, which contributed over 80% of the deaths from leukemia in the above 15 country study⁴. The cohorts have been updated through inclusion of new workers and particularly through longer follow-up, so that even though the present study includes about 75% as many workers (308 297 compared with 407 391 for the 15 country study), the total follow-up is 8.22 million person years, significantly greater than the total in the 15 country study of 5.2 million person years. Its findings thus have significantly greater precision and statistical power.
The key finding was that the excess relative risk for leukemia was 50% higher than in the 15 country study, so that per unit of total radiation exposure, the risk of leukemia is almost quadrupled.

It supports a model for increased leukemia risk at low and very low doses, with no safe lower dose, and increased exposures causing increased risk.

**Medical Tests in Children (CT Scans)**

In May 2013 a study in the British Medical Journal examined the cancer risk in children and adolescents following exposure to low dose ionising radiation from computerised tomography (CT) scans. The records of 10.9 million children and adolescents were identified between 1985 and 2005. Of these, 680,211 individuals had a CT scan at least one year before a cancer diagnosis.

Overall cancer incidence was 24% greater for exposed than for unexposed people. These included brain tumours, many solid tumours (eg bowel, melanoma, female genital and thyroid), leukaemia and lymphoid cancers. The risks increased for those exposed at younger ages. The increased rates of cancer were continuing in the later years of follow up. There was no follow up after the trial concluded, so the total lifetime risk of cancer cannot be determined.

The average dose of radiation per person was 4.5 mSv, and the average follow up after exposure was 9.5 years. This large study confirms that low dose ionising radiation has significant adverse health effects. The follow up time is short—more cancers are likely as these children get older.

**Hiroshima and Nagasaki Survivors**

This report from 2012 covers deaths 1950-2003, so represents very long term follow up of events in 1945. 86,611 people are included in this cohort. This study shows there is an increased risk of dying of cancer throughout life, and this risk increases proportional to radiation dose as the group ages. The dose response is approximately linear – i.e. twice the exposure dose = twice the risk, four times the exposure dose = four time the risk. Outcomes are worse for women compared to men, and worse again for those exposed as children.

Enrolment began in 1950, and cancer data began to be collected in 1958, so any early adverse outcomes are not included.

The risk of cancer mortality increased significantly for most major sites, including stomach, lung, liver, colon, breast, gallbladder, oesophagus, bladder and ovary. An increased risk of other diseases including the circulatory, respiratory and digestive systems was observed, but more research is needed to show this is from radiation. Most significantly is that there is no safe lower dose— even low dose exposure showed increased risk.

**Cardiovascular Disease (mostly strokes and heart attacks)**

This 2012 review drew on eligible research papers published since 1990 looking at cardiovascular disease. It looked at individuals who had low dose whole body exposures (cumulative average less than 0.5 Sv whole-body exposure, or exposures at a low dose rate (i.e., less than 10 mSv/day). They were all either atomic bomb survivors or occupationally exposed. The estimates of risk of increased deaths from circulatory disease are similar to those for radiation-induced cancer. The overall excess risk of dying after exposure to low doses or low dose rates of radiation may be about twice that currently assumed due to radiation-induced cancers alone.

**Radon gas exposure**

Worldwide everyone is exposed to radon gas naturally, but levels vary widely from place to place. Radon is known as a lung carcinogen. Radon is a naturally occurring radioactive gas which can accumulate in enclosed places, including houses and other buildings. Uranium ore releases radon gas. Protective gear and ventilation reduces exposure in mines.
In 2006, with particular reference to radon (and especially relevant to uranium miners), new studies found direct evidence of a lung cancer risk from the presence of radon gas in many homes, prompting a revision of safety levels, according to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)\(^6\). UNSCEAR reports ample evidence of carcinogenic effects of radiation not only in the occupational dose range (up to 20mSv/annum) but also in the overall lesser residential dose range (of 1-10mSv per annum depending on where in the world you live). In fact, for the first time, studies have measured increases in lung cancer in the general public from radon mainly in their homes (previously, the risk was extrapolated from the old data from uranium mining where the doses were very high).

It finds that despite all the problems with such research, there is now remarkably strong similarity in the evidence from both types of exposure. This shows that with increasing exposure to radon gas there are increased rates of lung cancer with rates varying between 9.4% and 18% increased risk per 100 Bq/m\(^3\)

Additionally, the UNSCEAR paper predates the doubling of the radon lung cancer risk that the ICRP (International Commission on Radiological Protection) has recommended. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is currently surveying workers' exposures at Olympic Dam uranium mine to update previous studies done in 1990. With the new radon risk levels, it is possible that some of the highest exposures might even exceed the occupational limits even in open pits, if weather conditions (inversion layers which keep gas close to the surface) occur to trap the radon.

**Risk of childhood cancer from X-ray before birth**

Initially reported in 1956, many studies have since confirmed that low dose ionising radiation increases risk of childhood cancer\(^7\). This 1996 paper by Doll and Wakeford reviewed the evidence and found that one abdominal X-ray of a fetus increased the risk of childhood cancer by 40%. More recently doses of radiation from X-rays have reduced. However there was no lower dose threshold that has been shown to be safe. The evidence has been supported by both a dose response relationship (i.e. as the exposure increases the risk of cancer increases) and by animal models.

**Confirmation that there is no “safe” low dose or irradiation**

In 2006 a comprehensive review of the effects of exposure to low levels of ionizing radiation, BEIR VII was published\(^8\). The BEIR (Biological Effects of Ionizing Radiation) reports are a series of publications by the National Academy of Sciences in the USA. The BEIR committee reviewed recent epidemiologic studies of the atomic bomb survivors, as well as recent studies of populations exposed to radiation from medical studies, from occupational exposures and from exposure due to releases of radioactive materials into the environment. BEIR VII reconfirmed that the linear no threshold model (i.e. there is no safe lower dose, and the higher the dose the higher the risk of adverse health effects) is the most practical model to estimate radiation risks, especially for radiation protection purposes.

**Childhood leukemia and nuclear power plants**

There is now very clear evidence of increased risk of childhood leukemia for children under five living near a nuclear power plant. A German study from 2008\(^9\) found increase in leukemia cases, and this was also found by a French study published in 2012\(^10\). The link has not been shown to be proportional to dose of radiation, but there is a clear association of higher rates of leukemia for this group of the population living within 5 kilometres of a normally functioning nuclear power plant.

**Cell death and DNA damage with medical imaging exposures**

A July 2015 US study of 67 patients exposed to >7.5 mSv of radiation from cardiac computed tomographic angiography demonstrated evidence of DNA damage, which was associated with programmed cell death and activation of genes involved in apoptosis (a genetically directed process of cell self-destruction that is marked by the fragmentation of nuclear DNA) and DNA repair\(^11\).
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Appendix 3

MAPW Radioactive Waste Policy 2015

Revised April 2015

Background

Nuclear waste is a long-lived and serious environmental hazard. It remains a problem in every country in which nuclear fuel cycle activities operate, especially those related to nuclear power and nuclear weapons. Although much radioactive waste is low-level waste, which is mostly short-lived and can be managed and disposed of responsibly, no country has implemented a permanent disposal solution for the most hazardous radioactive waste: intermediate-level and high-level waste.

No safe level of radioactive waste

There is no level of radioactive waste that is regarded as risk-free, hence the need for appropriate management. Even low-level exposure to ionising radiation poses a small but finite risk of harm, especially the development of cancers. The 2005 report of the National Academy of Sciences in the US, BEIR (Biological Effects of Ionising Radiation) VII, stated “A comprehensive review of available biological and biophysical data supports a “linear-no-threshold” risk model – that the risk of cancer proceeds in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans.” This risk is greater for children than for adults, and greater for females than for males. There are also risks of genetic damage to humans and other life forms.

Globally, the vast majority of nuclear waste has been created during the production of nuclear power and nuclear weapons. However MAPW recognises that nuclear technologies and expertise play a role in medicine and some areas of science. Australia has a radioactive waste legacy from industrial, research, military and medical activities.

Australia’s nuclear waste burden

Nuclear waste is categorised as low level waste (LLW), intermediate (ILW) or high level (HLW), depending on the degree of radioactivity and heat it generates. However there is no precise boundary between LLW and ILW.

Australia’s nuclear waste burden is low-level and intermediate level, and it is accumulating at the Lucas Heights reactor and at numerous other facilities around the country. HLW typically arises from nuclear power and nuclear weapons production; Australia has no high level waste and does not produce any.

LLW (and some short-lived ILW) in Australia include defence department waste from nuclear tests in the middle of last century, a repository at the old Radium Hill uranium mine in SA, contaminated soil from ore-processing research, and operational waste stored at the Lucas Heights site.

ILW includes spent fuel rods from Lucas Heights that were sent to France and Scotland for reprocessing (extraction of plutonium and uranium) and returned to Australia from 2015 onwards, scientific equipment, stockpiles of radium (see below), thorium and uranium residues from mineral sands processing and disused sources from medical and research equipment.
Much medical nuclear waste is short-lived and decays on the medical facilities’ premises until its activity is virtually nil and it is then classified as “exempt waste” and can be disposed of without special treatment. (An exception to this is the significant stockpiles of radium, not used medically since 1976 but constituting intermediate level waste sitting at various hospital sites around the country and requiring long term safe disposal.98)

Harm minimisation and cradle-to-grave strategy needed

Australia needs to dispose of this radioactive waste legacy appropriately and minimise further waste burdens on future generations and the environment. As a society we need therefore to move towards a sense of pro-active stewardship and “harm-minimisation” with “disposal” being the final option. A fundamental principle must be that no new activities involving radioactive materials should be introduced without a full life-cycle waste management plan, with exploration of alternatives, minimisation of waste, and a proper disposal plan: the so- called ‘cradle-to-grave’ strategy. A crucial aspect of this approach is to pursue the alternatives to nuclear power and nuclear medicine’s use of reactor-produced radioisotopes to minimise the future production of radioactive waste. Eliminating reactor production will eliminate waste related to the production of medical isotopes.

Disposal solutions and international best practice

Disposal solutions must be made on the basis of international best practice and Australia’s legal obligations. Australia is a signatory of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, a legally binding treaty. In addition, Australia participates in the development of international safety standards from which international best practice is derived.

Despite international best practice standards there still remain unpredictable geological, environmental, social and technological variables which may impact on the situation.

Current best practice suggests that:

- LLW can be buried from surface level down to about 30 metres (“near surface disposal”), requiring isolation for periods of up to several hundred years; it can contain both short- and long-lived radioisotopes
- ILW should be buried at a depth of 30 to 300 metres (deep geological disposal), in geologically stable ground well away from groundwater. This is because it contains long-lived isotopes in quantities that need a high degree of containment and isolation from the biosphere tens of thousands years. Current scientific modelling cannot predict geological stability for this time frame.

However current plans for Australia’s intermediate waste are for above-ground storage with institutional controls required indefinitely. The latter requirement alone – institutional control over prolonged periods, even hundreds of years let alone thousands - is fanciful.

While nuclear proponents generally downplay or deny the risks of unexpected consequences, evidence indicates that, even in the short term, plans and predictions can go awry. Even deep geological disposal can only be regarded as the best currently available option, not a perfect solution. Policy
makers and politicians should be well apprised of the scientific principles on which these proposed practices are based, and their limitations.

**Retrievability**

It is important that any long-lived nuclear waste that has been stored or disposed of be able to be retrieved. This allows for inspection and maintenance of the disposed radioactive waste if required and also allows for improvements in waste disposal techniques in the future. Ongoing security will also be required to ensure that the retrievability of the nuclear waste is not taken advantage of for unsanctioned purposes.

**Consultation**

Disposal solutions must also be made with genuine consultation and fully informed consent of all affected communities. Current practice falls well short of providing either. The provision of basic health and educational services should not be used as inducements to landowners to accept a repository – these should be provided to all citizens anyway.

**Burden already suffered by Indigenous Australians.**

Australia’s aboriginal people in particular have already suffered from imposition of radioactive contamination. The British nuclear bomb tests at Maralinga and other sites in the 1950s were conducted with scant regard for their welfare, and the “clean- up” of their lands left plutonium-contaminated debris in shallow burial trenches.

**Transport**

Transport of nuclear waste to centralised storage or disposal facilities greatly increases the risk of accidents, sabotage and contamination. The risk of illegal access is greatest during this phase. The manufacture of a “dirty bomb” (radioactive material dispersed by conventional explosive) would be a relatively easy task for a terrorist organisation once it has obtained the radioactive material. Therefore transport must be minimised, and undertaken with great attention to safety and security.

**Policy**

1. Any activities which produce radioactive waste requiring long term disposal should be minimised and ceased as an urgent priority. Reduction at source (waste minimisation) is the fundamental principle in reducing the risks of environmental contamination from nuclear waste. Medical isotope use produces short lived waste which can be safely disposed after short term storage.

2. Reactor production of medical isotopes creates LLW and ILW and should cease as soon as practicable. Non-reactor production of the most commonly used medical isotopes is feasible. These should be exclusively produced in this manner once local needs are able to be met, with importation of any shortfall. For other isotopes there must be urgent and ongoing Australian research into alternatives, with importation of such isotopes as an interim solution. Medical isotope production is not a justification for a nuclear reactor in Australia.

3. An independent and evidence based Australian national radioactive waste management authority should be established with adequate funding and autonomy to develop, implement and oversee a radioactive waste management policy, based on international best practice.
There should be broad stakeholder representation in its governing board.

4. All radioactive waste must be dealt with according to international best practice. Storage must only be used for short-lived radionuclides, and longer-lived radionuclides as an interim stage until a permanent disposal solution can be found. Storage should never be planned to be for an indeterminate time period.

5. Any permanent disposal solution must have retrievability built in to its design.

6. Australia should not become the recipient of international nuclear waste.

7. Transport of existing waste should be avoided until definitive and acceptable geologically suitable volunteered site/sites is/are found for permanent disposal. In the meantime, existing interim stores of radioactive waste should remain at their current location.

8. Transportation of radioactive material for disposal should be minimised wherever possible, and in accord with all radiation safety standards and jurisdictional safety requirements. If there is to be such transport, there must also be consultation with all those communities along the proposed route, including emergency, police, health and environmental protection services and a requirement that community consent for the process be obtained.

9. Radioactive waste transport, storage or disposal should not be imposed on unwilling communities. All residents in the broad region involved must be in a position to give fully and properly informed consent and the process of obtaining this should be transparent and open to public scrutiny.

10. Radioactive waste storage facilities and practices should be subject to regular independent audits and public review to increase transparency and ensure compliance with Australia’s policies, international obligations and best practice including proper consultation with affected communities.

References


Appendix 4

PHAA Nuclear Industry Policy

Public Health Association of Australia:

Policy-at-a-glance – Nuclear Industry Policy

**Key message:**

1. That all Australian governments should introduce a no further uranium mining policy in their jurisdictions and the Commonwealth Government should introduce policy to not grant any further uranium export licences.

2. The Australian government should not renew uranium export licences for existing mines which produce uranium on expiry of current contracts.

3. That the Commonwealth government should maintain a policy of no nuclear power generation, and should commence the closure of the Lucas Height Nuclear Reactor.

4. That the locating of any radioactive waste management facility should only proceed with full and informed local community and relevant State and Territory consent- this includes communities through which waste is proposed to be transported.

5. In line with international trends that Australia move to non-reactor based sourcing of nuclear medicine isotopes and that the Australian government support research and development in alternative isotope production and diagnostic technologies.

**Summary:** There are public health risks associated with the nuclear chain, particularly in relation to nuclear power generation and reprocessing. This policy seeks to outline a series of principles and tangible actions designed to mitigate these risks.

**Audience:** Australian, State and Territory Governments, policy makers and program managers.
Responsibility: PHAA’s Ecology and Environment Special Interest Group (SIG)

Date policy adopted: September 2013

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Nuclear Industry policy

The Public Health Association of Australia notes that:

1. There are public health risks associated with the nuclear chain (mining, processing, nuclear power, waste and weapons proliferation) particularly in relation to nuclear power generation and reprocessing.1, 2, 4, 5, 6.

2. There is no known safe levels of exposure to ionising radiation to avoid health risks.7

3. The links all along the nuclear chain between the nuclear power industry, waste production, nuclear weapons proliferation and hence the risk of nuclear war, are inextricable.

4. In a time of environmental degradation and climate change, the threat of nuclear weapons makes the disengagement from the nuclear industry one of the highest priorities for protecting humanity, complex society and the environment.18

5. The consequences to the environment of the nuclear chain include increased radioactive contamination of the environment.8

6. The risks of radioactive spillage and environmental contamination, however low, are inherent in transporting nuclear waste.9

7. Nuclear power is not the solution to mitigate global warming.10, 11, 12, 15, 16

8. In an age of increasing globalisation and political tension, nuclear facilities provide a source of nuclear material for terrorists to use in weapons.12, 13, 14
9. There is a greater risk of adverse impact on Indigenous people in Australia, as elsewhere, from the nuclear industry. Because Aboriginal and Torres Strait Islander peoples are already the most disadvantaged group in Australia, and less likely to benefit from the nuclear industry, their voices should be actively listened to on nuclear industry issues.  

The Public Health Association of Australia affirms the following principle that:

10. Expansion of the nuclear industry is not in the best interests of the health of people in Australia or globally.

The Public Health Association of Australia believes that the following steps should be undertaken:

11. That all Australian governments should introduce a no further uranium mining policy in their jurisdictions and the Commonwealth Government should introduce policy to not grant any further uranium export licences.

12. The Australian government should not renew uranium export licences for existing mines which produce uranium on expiry of current contracts. Where uranium is extracted in conjunction with other minerals, ongoing mines should rebury it.

13. That the Commonwealth government should maintain a policy of no nuclear power generation, and should commence the closure of the Lucas Height Nuclear Reactor.

14. That the locating of any radioactive waste management facility should only proceed with full and informed local community and relevant State and Territory consent—this includes communities through which waste is proposed to be transported.

15. In line with international trends that Australia move to non-reactor based sourcing of nuclear medicine isotopes and that the Australian government support research and development in alternative isotope production and diagnostic technologies.  

The Public Health Association of Australia resolves to undertake the following actions:

The Public Health Association of Australia will:

16. oppose expansion of all aspects of the nuclear industry in Australia, in particular mining and waste disposal from overseas.

17. oppose the location in the absence of community approval of any radioactive waste management facility.
18. collaborate with other organisations with similar aims.

19. act to further implement its related policy on Climate Change.

ADOPTED 2013

This policy was originally developed and adopted as part of the 2010 policy review process. Reviewed and re-endorsed in 2013.

References:


6 Vakil, C & Harvey L. 2009. Human Health Implications of Uranium Mining and Nuclear Power Generation


Williams, B 2008 Radiation & Health fact sheet 12 energyscience.org.au


11. Green, J *Nuclear Power No Solution to Climate Change*, FoEA, ACF, Greenpeace et al, 200

12. Caldicott, H 2006 *Nuclear power is not the answer to global warming or anything else.* Melbourne University Press.


19 Statement of the PreCongress ‘Sacred Land, Poisoned Peoples’ to the 19th IPPNW World Congress Rebecca WingfieldBear (Australia) and Charmaine White Face (USA) to the Closing Plenary, August 29, 2010, at the University of Basel, in Basel, Switzerland.