



## **Appendix A – Summary of evidence**

1.1 This summary of evidence is divided into the following sections:

- Background on nuclear energy
- Switkowski Review
- South Australian Royal Commission
- Australia's moratorium on nuclear energy
- Economic considerations
- Legal and regulatory frameworks
- Workforce capability requirements
- Environmental considerations
- Waste management
- Public health and safety
- Security and proliferation
- National consensus and community engagement

1.2 This report relies upon draft transcripts of the public hearings (known as 'proof Committee Hansard'). Errors or omissions are possible and readers are encouraged to check final transcripts when they become available on the Committee's website for verification.

### **Background: nuclear energy**

1.3 Nuclear energy is derived from the process of atomic fission. Fission is a process whereby a heavy element in nuclear fuel (such as uranium) becomes unstable and breaks apart, and its particles collide with others, creating a further chain reaction. The fission reaction releases energy

inside a nuclear reactor, which can be harnessed and used to heat water and generate steam to drive turbines, which in turn generate electricity.<sup>1</sup>

- 1.4 Nuclear power has been an energy source overseas since the late 1950s,<sup>2</sup> and supplies around 11 per cent of the world's electricity, with almost 450 plants in operation and many more planned.<sup>3</sup>

## **Nuclear reactor designs by generation**

- 1.5 The design of nuclear reactors has advanced over time. Designs are generally categorised by 'generation'.
- Generation I – early prototype reactors of the 1950s-1960s. No Generation I reactors are still operating.<sup>4</sup>
  - Generation II – large-scale power stations, built from the 1960s-1970s. These represent most reactors operating today.<sup>5</sup>
  - Generation III and III+ – evolutionary designs with better fuel efficiency and safety features, expected to have a longer useful life and reduced costs and timeframes for construction. Several are in use in Japan and South Korea and others are under construction or on order.<sup>6</sup>
  - Generation IV – emerging designs under development. None are operational yet. Design elements will include greater safety and resistance to proliferation, better sustainability, less waste and economic competitiveness.<sup>7</sup>

## **Generation IV reactor designs**

- 1.6 International collaboration on Generation IV reactors is taking place as part of the Generation IV International Forum (GIF), with fourteen member states supporting research and development for these advanced reactor designs.<sup>8</sup>

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1 Nuclear Energy Agency, OECD, 'Nuclear Energy Today', 2<sup>nd</sup> edition, 2012, p. 15.

2 OECD Nuclear Energy Agency, 'Nuclear Energy Today', 2<sup>nd</sup> edition, 2012, p. 7.

3 Ian Hore-Lacy, 'Nuclear Energy in the 21<sup>st</sup> Century', 4<sup>th</sup> edition, 2018, p. 18.

4 John E Kelly, US Department of Energy, 'Generation IV International Forum', slides dated January 2014, p. 8; Ian Hore-Lacy, 'Nuclear Energy in the 21<sup>st</sup> Century', 4<sup>th</sup> edition, 2018, p. 42.

5 John E Kelly, US Department of Energy, 'Generation IV International Forum', slides dated January 2014, p. 8.

6 Ian Hore-Lacy, 'Nuclear Energy in the 21<sup>st</sup> Century', 4<sup>th</sup> edition, 2018, p. 42.

7 Generation IV International Forum, < [https://www.gen-4.org/gif/jcms/c\\_9502/generation-iv-goals](https://www.gen-4.org/gif/jcms/c_9502/generation-iv-goals)>, accessed 20 November 2019; OECD Nuclear Energy Agency, 'Nuclear Energy Today', 2<sup>nd</sup> edition, 2012, p. 23; Australian Nuclear Science and Technology Organisation (ANSTO), *Submission 166*, p. 4.

8 See Generation IV International Forum, < <https://www.gen-4.org/gif/>>, accessed 8 November 2019.

- 1.7 After considering almost 100 design concepts, the GIF selected six reactor designs for further research, ranging from small 20 MW to large 1,500 MW capacities).<sup>9</sup>
- 1.8 These designs are:
- Gas-cooled fast reactors;
  - Lead-cooled fast reactors;
  - Molten salt reactors;
  - Sodium-cooled fast reactors;
  - Supercritical water-cooled reactors; and
  - Very high-temperature reactors.<sup>10</sup>
- 1.9 Australia, as a member of the GIF, is participating in work towards the molten salt reactor and the very high-temperature reactors.<sup>11</sup> Both of these reactor designs aim to provide efficient operation and a reduction in radioactive waste.<sup>12</sup>

## Small modular reactor designs

- 1.10 Small modular reactors (SMRs) do not neatly fit into the above categories. Some forms of small reactors have been developed using Generation III and III+ technology, particularly for military applications. Newer commercial proposals for SMRs may be considered a subset of Generation IV.<sup>13</sup> These reactors are intended to be smaller, scalable reactors that can be produced more efficiently and added to each other to increase capacity over time.<sup>14</sup>
- 1.11 SMRs are generally defined to be nuclear power plants that generate less than 300 MWe.<sup>15</sup> While ANSTO describes its position on the adoption of nuclear power as ‘agnostic’,<sup>16</sup> its submission noted that SMRs could reduce the build costs for nuclear reactors by:

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9 See Generation IV International Forum, < <https://www.gen-4.org/gif/>>, accessed 20 November 2019.

10 See Generation IV International Forum, < <https://www.gen-4.org/gif/>>, accessed 20 November 2019.

11 Joint Standing Committee on Treaties, Report 171, ‘International Trade in Endangered Species – Amendments; Women in Combat Duties – Reservation Withdrawal; Generation IV Nuclear Energy – Accession’, May 2017, p. 37.

12 Generation IV International Forum, ‘Generation IV Systems’, < [https://www.gen-4.org/gif/jcms/c\\_59461/generation-iv-systems](https://www.gen-4.org/gif/jcms/c_59461/generation-iv-systems)>, accessed 20 November 2019.

13 Friends of the Earth Australia, *Submission 36*, p. 2.

14 OECD Nuclear Energy Agency, ‘Nuclear Energy Today’, 2nd edition, 2012, p. 23.

15 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission 166*, p. 5.

16 ANSTO, *Submission 166*, p. 1.

- the elimination of costly active safety systems by using passive safety features or inherently-safe reactor designs;
- shifting the majority of construction off-site to an enclosed factory environment using modular manufacturing techniques;
- reducing plant build times from six to eight years for large reactors to two and a half to four years for SMRs via the use of series-production methods;
- increasing learning rates to be in line with the learning rates of other industries, such as combined cycle gas turbines, shipbuilding, and aircraft manufacturing, where a high proportion of construction is factory-based;
- the use of next-generation technologies, such as reactor coolants with superior thermal characteristics, high-performance alloys, and accident-tolerant fuels; and
- innovative delivery and construction models.<sup>17</sup>

1.12 The World Nuclear Association states that, according to the International Atomic Energy Agency (IAEA), there are fifty SMR designs under development worldwide, three projects are nearing the demonstration stage, and that the first reactors may be commercially available in the next 10-15 years.<sup>18</sup>

## Switkowski Review

1.13 In June 2006, the then-Prime Minister established a taskforce to 'undertake an objective, scientific and comprehensive review of uranium mining, value-added processing and the contribution of nuclear energy in Australia in the longer term'. This review would provide a factual base and framework to encourage community discussion and contribute to a constructive public debate on Australia's future energy needs.<sup>19</sup>

1.14 The Switkowski Review concluded that nuclear power was a viable option requiring serious consideration for inclusion in Australia's electricity market, to assist in meeting growing demand and to reduce greenhouse gas emissions.

1.15 The Review supported the expansion of Australian mining and export of uranium indicating that nuclear power could add \$1.8 billion of value annually if all Australian uranium was processed domestically.

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17 ANSTO, *Submission 166*, p. 6.

18 World Nuclear Association, *Submission 259*, p. iii.

19 Department of the Prime Minister and Cabinet, *Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia?*, 2006.

- 1.16 Given Australia’s stable geological and political conditions, the Switkowski Review proposed a national repository for burial of low-level waste from all sources including a future nuclear power industry.
- 1.17 The Review assessed that the following matters would need to be addressed prior to establishing nuclear energy in Australia:
- community acceptance through informed discussion;
  - skill shortages and commercial and technology barriers; and
  - government policies, legal prohibitions and regulatory impediments restricting the growth of the industry.
- 1.18 The review stated that ‘nuclear power, and renewable energy sources, are only likely to become competitive in Australia in a system where the costs of greenhouse gas emissions are explicitly recognised’.<sup>20</sup> It added that initial investment may require some form of government support or directive.
- 1.19 The review concluded that ‘the earliest that nuclear electricity could be delivered to the grid would be 10 years, with 15 years more probable’.<sup>21</sup>

## Government Response

- 1.20 In April 2007, to open the way for nuclear power in Australia, the then-Prime Minister announced that Australia would:
- establish a nuclear regulatory regime;
  - remove any regulatory obstacles which might stand in the way of building nuclear power plants;
  - apply to join the Generation IV International Forum, developing advanced reactor designs; and
  - take steps to remove impediments to uranium mining.<sup>22</sup>
- 1.21 In June 2007, the emissions trading taskforce report proposed that Australia move to implement an emissions trading scheme.<sup>23</sup>

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20 Department of the Prime Minister and Cabinet, *Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia?*, 2006, p. 2.

21 Department of the Prime Minister and Cabinet, *Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia?*, 2006, p. 2.

22 Prime Minister Hon John Howard, ‘Uranium Mining and Nuclear Energy: A Way Forward for Australia’, Media Release, 28 April 2007.

23 National Emissions Trading Taskforce, *Possible design for a national greenhouse gas emissions trading scheme: Final framework report on scheme design*, December 2007, at <https://www.caf.gov.au/Documents/nett-final-report.pdf>.

- 1.22 However, following the change of government in 2007 the implementation of an emissions trading scheme and the move towards nuclear power did not proceed.<sup>24</sup>

## South Australian Royal Commission

- 1.23 In 2015 the Government of South Australia established a Nuclear Fuel Cycle Royal Commission to investigate the potential for increasing South Australia's participation in the nuclear fuel cycle in four key areas:
- exploration, extraction and milling of minerals containing radioactive materials;
  - processing and manufacture of minerals and radioactive and nuclear materials;
  - use of nuclear fuels for electricity generation; and
  - facilities for the storage and disposal of radioactive and nuclear waste.<sup>25</sup>
- 1.24 The royal commission's report, presented in May 2016, outlined the 'feasibility, viability, risks and opportunities associated with a potential expansion of the nuclear fuel cycle from the perspectives of the environment, the economy and the community, including regional, remote and Aboriginal communities'.<sup>26</sup>
- 1.25 Key recommendations of the Royal Commission were that the South Australian Government:
- pursue removal at the federal level of prohibitions on nuclear power generation to allow it to contribute to a low-carbon future electricity system, if required;
  - promote and collaborate on a comprehensive national energy policy that enables all technologies, including nuclear, to contribute to a reliable, low-cost, low-carbon electricity network;
  - in collaboration with the Australian Government, commission expert monitoring and reporting on the commercialisation of new nuclear reactor designs; and
  - pursue the opportunity to establish used nuclear fuel and intermediate level waste storage and disposal facilities in South Australia, including

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24 <https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/australia.aspx>

25 South Australia, *Nuclear Fuel Cycle Royal Commission Report*, May 2016.

26 South Australia, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p. xi.

removing the state’s legislative prohibition that would inhibit a thorough analysis and discussion of that proposal.<sup>27</sup>

## South Australian Government response

- 1.26 Following the release of the Royal Commission report, the South Australian Government conducted a community engagement program between May and November 2016, which included constituting two ‘Citizens’ Juries’, and holding meetings in 130 locations around the state.<sup>28</sup>
- 1.27 The SA Government then issued its response to the Royal Commission in November 2016, supporting nine of its 12 recommendations. These included the recommendations related to uranium mining and exploration, increased use of nuclear medicine, and monitoring the development of new nuclear reactor designs, as well as collaboration on a comprehensive national energy policy.<sup>29</sup>
- 1.28 Recommendations that were not supported included the removal of existing prohibitions on nuclear power generation in the state and the removal of restrictions on nuclear fuel cycle activities, citing the finding that nuclear power generation would not be cost-effective in the state.
- 1.29 The Government supported ‘continued investigation’ of the proposal to establish an international high-level waste storage facility in South Australia, while saying that this would require ‘bipartisanship and broad social consent, secured through a statewide referendum’.<sup>30</sup>

## 1. Australia’s moratorium on nuclear energy

### Legal framework of the moratorium

- 1.30 Commonwealth law prohibits nuclear energy generation in Australia.
- 1.31 The *Australian Radiation Protection and Nuclear Safety Act 1998* (Cth) (ARPANS Act) prohibits the ‘construction or operation’ of a number of nuclear installations:
- A nuclear fuel fabrication plant;
  - A nuclear power plant;

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27 South Australia, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, pp. xiv-xvi.

28 See <https://nuclear.yoursay.sa.gov.au/know-nuclear/background>.

29 Government of South Australia, *Response to the Nuclear Fuel Cycle Royal Commission*, November 2016.

30 Government of South Australia, *Response to the Nuclear Fuel Cycle Royal Commission*, November 2016, p. 22.

- An enrichment plant; and
  - A reprocessing facility.<sup>31</sup>
- 1.32 The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) also expressly prohibits the Minister from approving the ‘construction or operation’ of the same facilities.<sup>32</sup>
- 1.33 Additionally, a number of states and territories have legislation that prohibits nuclear power or restricts uranium mining.<sup>33</sup>
- 1.34 The federal prohibitions were introduced in late 1998<sup>34</sup> and have formed a longstanding bipartisan moratorium.<sup>35</sup>

### Effects of the moratorium

- 1.35 Evidence was received explaining that the ban on nuclear power limits Australia’s ability to research its suitability or its potential impact on electricity markets.
- 1.36 Dr Alex Wonhas from the Australian Energy Market Operator (AEMO) said that future energy planning does not currently include nuclear energy:

One of AEMO's responsibilities is informing the design of Australia's future energy system through the preparation of the Integrated System Plan, or ISP in short. The ISP provides an integrated roadmap for the efficient development of the National Electricity Market over the next 20 years and beyond. ...

The ISP currently does not include an assessment of nuclear, as it is at the moment a technology that is not permitted in Australia. Should this change, AEMO will include nuclear in its ISP assessment. We expect the inclusion of nuclear in the ISP to make only make a small difference, if any, to what's the end of the outlook period. For nuclear investment to be the optimal choice for Australia it will have to demonstrate, among many other things, that it is more cost-effective compared to alternative technologies and that it is sufficiently flexible so it can be integrated in what we expect to be a highly dynamic future energy market.<sup>36</sup>

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31 *Australian Radiation Protection and Nuclear Safety Act 1998* (Cth), s. 10.

32 *Environment Protection and Biodiversity Conservation Act 1999* (Cth), s. 140A.

33 Australian Workers’ Union, *Submission 290*, pp. 13-14.

34 Bright New World, *Submission 168*, pp. 34-40.

35 Dr Tom Biegler, *Submission 56*, p. 2.

36 Dr Alex Wonhas, *Committee Hansard*, Sydney, 29 August 2019, p. 18.



- 1.37 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) told the Committee that an effect of the moratorium was that public money cannot be spent on research and investigation into relevant topics surrounding nuclear power.<sup>37</sup>
- 1.38 Dr Jim Green (Friends of the Earth Australia) was sceptical that lifting the moratorium would result in benefits to Australia:
- The only thing that would actually change in Australia if the ban against nuclear power were repealed is that nuclear companies would descend on Canberra to try to gouge as much taxpayer money as they could possibly get from the federal government. That would be the one practical change...company representatives would be lined up outside ministerial offices trying to stitch together a package of direct and indirect taxpayer subsidies.<sup>38</sup>

### Arguments for maintaining the moratorium

- 1.39 Reasons to retain the moratorium largely related to concerns about costs and unproven technologies, consequences such as nuclear accidents, fears of weapons proliferation and a lack of community support.
- 1.40 A joint submission by a number of environmental groups and conservation councils supported retaining the moratorium, arguing that nuclear power:
- is costly;
  - does not have community support;
  - would disempower traditional landowners;
  - brings environmental problems associated with radioactive waste; and
  - would delay the development of better climate change policies.<sup>39</sup>
- 1.41 Mr Dave Sweeney from the Australian Conservation Foundation argued that lifting the moratorium was not necessary for the nuclear debate to take place; rather, that the ban had saved Australia significant costs:
- ...the prohibition hasn't stopped debate or discussion. It hasn't stopped a whole range of dialogue and engagement around nuclear issues. But it has stopped us having a major cost burden,

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37 Mr John Phalen, Chief Research Consultant, Science Strategy, Commonwealth Scientific and Industrial Research Organisation (CSIRO), *Proof Committee Hansard*, Canberra, 16 October 2019, p. 5.

38 Dr Jim Green, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 2.

39 Submission by nine national environment groups and state conservation councils, *Submission 219*, pp. 6-8.

having more waste and having an imposed industry that leaves a massive intergenerational burden.<sup>40</sup>

- 1.42 Ms Brenda Huggett submitted that the moratorium should remain, particularly until any new technologies are proven:

During these *Watch and Learn* years, there should absolutely be no lifting of our moratorium on the development of nuclear energy – a moratorium that has no doubt frustrated some, but has clearly satisfied an overwhelming majority of Australians as poll after poll has shown.<sup>41</sup>

- 1.43 Ms Elicia O'Reilly raised concerns about nuclear accidents as a reason to keep the moratorium. She highlighted the example of Fukushima, and said that 'the best way to guard against similar disasters occurring here is to retain the moratorium on nuclear power.'<sup>42</sup>

- 1.44 The International Campaign to Abolish Nuclear Weapons Australia (ICAN) was concerned that 'moves towards nuclear power could be read as a proliferative signal to our neighbours', and recommended that Australia reject nuclear power.<sup>43</sup>

- 1.45 Mr Tim Buckley from the Institute of Energy Economics and Financial Analysis (IEEFA) told the Committee that:

Any such discussion would unleash a massive level of community unrest. It would work directly against the goal of achieving bipartisan energy policy support, and that is what we need to unleash the tens of billions of dollars of capital that need to be invested in the coming decade to modernise, decarbonise and lower the cost of electricity for all Australians.<sup>44</sup>

- 1.46 Ms Noel Wauchope submitted that there was no support to lift the moratorium:

There is no social licence to introduce nuclear power. There's no general movement for overturning the laws that have been passed, to protect Australians from this industry - its health and environmental hazards, its costs that are passed on to future generations. The push for nuclear comes from small sectors of Australian society, the industry itself, and from those in politics

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40 Mr Dave Sweeney, *Proof Committee Hansard*, 1 October 2019, p. 11.

41 Ms Brenda Huggett, *Submission 236*, p. [2].

42 Ms Elicia O'Reilly, *Submission 247*, p. 2.

43 International Campaign to Abolish Nuclear Weapons Australia (ICAN), *Submission 157*, pp. 9-10.

44 Mr Timothy Buckley, Director, Energy Finance Studies, Institute of Energy Economics and Financial Analysis (IEEFA), *Proof Committee Hansard*, Sydney, 9 October 2019, p. 41.

and in the defence sector, who see nuclear power as the pathway to nuclear weapons.

1.47 The submission continued:

To get a national consensus in favour of introducing nuclear power will require a major propaganda effort. No wonder that the industry wants those laws repealed. That would allow them to launch a campaign for the hearts and minds of Australians.<sup>45</sup>

1.48 The Committee also received over 405 short submissions via Friends of the Earth Australia, stating a desire to retain the moratorium. The submissions stated that nuclear power is unpopular, dangerous and carries environmental, safety and security risks.<sup>46</sup>

### Arguments for lifting the moratorium

1.49 Evidence in favour of lifting the moratorium suggested that removing the legislated bans would allow for a well-considered debate about a future nuclear industry.<sup>47</sup>

1.50 Dr Ziggy Switkowski said that the moratorium should be lifted:

Should we change the Environmental Protection and Biodiversity Conservation Act? Absolutely... We should not be making decisions in 2019 based upon legislation passed in 1999 reflecting the views of 1979.<sup>48</sup>

1.51 SMR Nuclear Technology submitted that the moratorium was ‘put into place at a time when there was no real appreciation of the contribution that modern, safe nuclear power plants could make to energy security, affordability and emissions reduction’.<sup>49</sup>

1.52 Dr Tom Biegler submitted that the moratorium is:

...an expression of Australia’s embedded cultural and political antipathy to nuclear energy.<sup>50</sup>

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45 Ms Noel Wauchope, *Submission 72*, p. [5].

46 Sample of the Friends of the Earth campaign submission (405 received), *Submission 306*, p. [1].

47 Mr Logan Smith, *Submission 107*, p. [4]; Nuclear for Climate Australia, *Submission 135*, p. 30.

48 Dr Ziggy Switkowski AO, *Committee Hansard*, Sydney, 29 August 2019, p. 3.

49 SMR Nuclear Technology, *Submission 39*, p. 14.

50 Dr Tom Biegler, *Submission 56*, p. 2.

## 1.53 Dr Biegler added:

The global context is that Australia is one of only around 15 countries with some kind of formal opposition to nuclear energy. In contrast, there are around 450 nuclear power stations operating in 31 countries, with a further 50 or so planned or under construction.<sup>51</sup>

## 1.54 Dr Switkowski was in favour of removing the ban to encourage modelling and assessment of the industry:

In my opinion, at a minimum we should ensure that there aren't any obstacles to having nuclear technology in front of us and available to financiers and other organisations to model and compare with alternative scenarios. It should be in the mix, as it is in other countries, and it should be able to be analysed alongside all the other alternative platforms, and then the energy strategy can be optimised accordingly.<sup>52</sup>

## 1.55 Mr Tony Wood from the Grattan Institute said that the moratorium represents a 'significant barrier' to modelling being undertaken:

...it does seem to be a little difficult to have a modelling discussion around nuclear, at least in this country. When I was involved with the Garnaut review, it was effectively made clear that it was inappropriate for us to model nuclear in that scenario, because it was illegal in Australia. We had to go and do it separately from the government's remit. So it does provide, I think, a significant barrier, even though it may not be a legal barrier, to being able to have that conversation.<sup>53</sup>

## 1.56 StarCore Nuclear submitted that the moratorium prevents proper discourse and discourages investment:

While the moratorium remains in place it effectively mutes any real discussion on the installation of nuclear facilities. Investors require certainty and while there is a barrier to nuclear power there is little point in even considering the possibility. StarCore has first-hand experience of this. In discussion with companies with mining projects and operations around Australia about the potential for the application for Small Modular Reactors (SMRs) at their operations, the conversation stops at the ban.<sup>54</sup>

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51 Dr Tom Biegler, *Submission 56*, p. 2.

52 Dr Ziggy Switkowski AO, *Committee Hansard*, Sydney, 29 August 2019, p. 3.

53 Mr Tony Wood, Energy Program Director, Grattan Institute, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 34.

54 StarCore Nuclear, *Submission 128*, p. 4.

- 1.57 Similarly, SMR Nuclear Technology Pty Ltd submitted that:
- The legislative prohibitions preclude any serious consideration of the merits of nuclear power generation in Australia. SMR vendors will not treat Australia as a potential market whilst the prohibitions remain. Although government reports have repeatedly endorsed the merits of “technology neutrality” in power system planning, the legislative prohibitions have prevented its accomplishment.<sup>55</sup>
- 1.58 The ANU Energy Change Institute advised that a national symposium of around 70 participants held in 2017 discussed the findings of the South Australian Royal Commission. In relation to the moratorium, the symposium’s view was that:
- ...legislated prohibition is inconsistent with widespread government practice of supporting technology neutrality, and is an inhibiting factor in the free and open discussion of options available to society.<sup>56</sup>
- 1.59 Down Under Nuclear Energy submitted that:
- Amending the legislation is not equivalent to mandating nuclear. It simply means that it will become possible for energy providers to consider nuclear as part of our energy mix. Without a change in legislation we cannot have an informed set of choices about our future and decisions cannot be made on either social benefit or commercial grounds. It is a basic principle in mathematics that decision making under constraints can never be better than unconstrained choice.<sup>57</sup>
- 1.60 The Australian Taxpayers Alliance (ATA) submitted that the moratorium should be lifted to encourage research and investment.<sup>58</sup> The ATA said:
- ... this moratorium should be lifted regardless of whether the government is approached with a business case. Rapid innovations mean that the costs of nuclear power and hence the difficulties of establishing nuclear projects in Australia, will decrease over time with the removal of the moratorium supplying the catalyst for proposals and research in the longer-term... Although lifting the moratorium may not provide sufficient

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55 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 14.

56 ANU Energy Change Institute, *Submission 160*, pp. [3-4].

57 Down Under Nuclear Energy, *Submission 159*, p. 4.

58 Australian Taxpayers’ Alliance, *Submission 263*, p. 2.

certainty for private investors by itself, it is a pre-condition for ensuring commercial certainty.<sup>59</sup>

1.61 The ATA added:

The ATA further notes that nuclear power plants produce a fraction of the greenhouse gas emissions of solar or wind farms, according to the UN Intergovernmental Panel on Climate Change. It is therefore submitted that Australia's current and easily reversible moratorium on nuclear power is not only an act of economic vandalism, but of environmental vandalism which stymies innovations in the climate policy space.<sup>60</sup>

1.62 The Minerals Council of Australia submitted:

Repealing the legislated ban on nuclear energy in the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is critical if Australia is to seriously embrace all technologies so our future energy mix is affordable, reliable and cleaner. Similarly, removing uranium mining and milling from the definition of nuclear actions in the EPBC Act and lifting the state-based prohibitions on uranium exploration and mining is critical to not just removing discriminations against uranium mining, but also as part of a broader recognition that Australia is joining the International Panel on Climate Change (IPCC) in acknowledging uranium-fuelled nuclear energy as a critical part of global efforts to reduce greenhouse emissions.<sup>61</sup>

1.63 Dr Donald Higson was strong in his assertion that the moratorium has contributed to Australia's 'energy crisis':

These prohibitions have been significant contributors to our energy crisis. If there was ever any justification for them, it certainly does not exist today.<sup>62</sup>

## The future of the moratorium

1.64 A number of submissions suggested that either a referendum or plebiscite should be conducted to ascertain the public's views as to whether

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59 Australian Taxpayers' Alliance, *Submission 263*, p. 15.

60 Australian Taxpayers' Alliance, *Submission 263*, p. 2.

61 Minerals Council of Australia, *Submission 266*, p. 5.

62 Dr Donald Higson, *Submission 139*, p. [1].

Australia should move towards nuclear power or retain the current prohibitions.<sup>63</sup>

- 1.65 However, while most acknowledged the need for public support, a public vote was not universally supported.<sup>64</sup>

## 2. Economic considerations

- 1.66 The Committee was provided with costings and analysis based on procurement of 1000MWe nuclear reactors or, alternatively, procurement of small modular reactors (SMRs).

- 1.67 Mr Barrie Hill, for example, favoured a 1000MWe reactor:

The standard reactor plant recommended for installation in Australia is the South Korean Advanced Power Reactor 1000MWe (APR1000) an evolutionary pressurised water reactor (PWR) which has been developed from the proven design of the Optimum Power Reactor 1000MWe (OPR1000).<sup>65</sup>

- 1.68 NuScale Power favoured its small modular reactors (SMRs):

NuScale's plant has a significantly lower overnight capital cost and annual operating costs on a dollar per MW-hour basis significantly better than the current U.S. nuclear fleet average, and can be constructed in considerably less time compared to large nuclear plants. That's in part because of fully factory-fabricated elements of the modular design that takes safety-related fabrication work out of the field, lessening the risk to both cost and schedule.<sup>66</sup>

### GenCost 2018 report's SMR costings

- 1.69 The GenCost 2018 report, jointly prepared by the CSIRO and the Australian Energy Market Operator (AEMO), forecast the future costs of

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63 Mr Ian Fischer, *Submission 8*, p. [2]; Mr Rob Watson-Smith, *Submission 19*, p. [3]; Mr Gerard Van Hees, *Submission 40*, p. [1]; Mr Allen Biggins, *Submission 42*, p. [1]; Mr Kevin F Chilman, *Submission 92*, p. [1]; Mr Henry Gillard, *Submission 102*, p. 8.

64 Mr Craig Tamlin, *Submission 125*, p. 4; Ms Rosumund Krivanek and Ms Noel Wauchope, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 40.

65 Mr Barrie Hill, *Submission 60*, p. [2].

66 NuScale Power, *Submission 71*, p. 2.

energy options. The report is available on the CSIRO's website.<sup>67</sup> The report stated that:

The updated projections indicate that solar photovoltaic (PV) capital costs continue to fall at a faster rate than most other technologies and solar PV is projected to represent one of the largest contributors to electricity generation by 2050. Wind, batteries, pumped hydro and CCS [carbon capture and storage] are also expected to feature more strongly in the global electricity generation mix and consequently achieve cost reduction through increased deployment.<sup>68</sup>

1.70 The report compared small modular reactors with solar options between 2020 and 2050:

- Small modular reactors are assessed to cost \$16,000 per kilowatt and this trend remains flat (unchanged) over the next thirty years to 2050.
- Solar thermal (with 8 hours storage) is shown to decrease from \$5,000-\$8,500 per kilowatt in 2020 to \$2,000-\$4,000 per kilowatt in 2050.
- Large scale solar photovoltaic is shown to decline from around \$2,000 per kilowatt in 2020 to \$600 per kilowatt in 2050.<sup>69</sup>

1.71 In relation to the flat trend predicted for nuclear generation technology capital cost, the GenCost 2018 report stated:

The flat trend arises because, while nuclear is assigned a learning rate to recognise the potential for further improvements in the technology, they do not experience significant changes in costs due to the limited scope to double global cumulative capacity. In this sense, nuclear power is caught between having the existing deployment scale of a mature technology, but with the technological potential of an immature technology in terms of optimal technology design not being completely settled. Another factor which partially constrains nuclear deployment is that, besides economic drivers, its uptake is significantly influenced by government policy.<sup>70</sup>

1.72 Dr Alex Wonhas from AEMO provided the Committee with further explanation of the projections in the GenCost 2018 report, in particular the future capital costs of solar energy and small modular reactors:

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67 CSIRO, 'Annual Update Finds Renewables are the Cheapest New-Build Power', at <https://www.csiro.au/en/News/News-releases/2018/Annual-update-finds-renewables-are-cheapest-new-build-power>.

68 GenCost 2018, p. v.

69 GenCost 2018, pp. 15-18.

70 GenCost 2018, p. 16.



What we endeavour to do is provide on an annual basis the best consensus view on capital cost. ...there is typically an observation of decreasing capital costs; this is actually referred to as the learning effect. Where the installed capacity doubles we typically observe in the market a reduction in the capital cost of the equipment. Obviously, with the significant deployment of renewable energy resources, there is learning, and, therefore, those resources become more cost-effective, which has been observed over many decades now...

The challenge at the moment with SMR reactor technology is that it is still very much in development. The actual deployment of the technology is relatively low, but once there is deployment I expect we will see some cost reduction based on that. But that's obviously an event that at the moment looks to be in the future.<sup>71</sup>

- 1.73 Dr Jim Green from Friends of the Earth Australia assessed that the estimates in the GenCost 2018 report are 'reasonable, but there's a wide degree of variance and a high degree of uncertainty'.<sup>72</sup>
- 1.74 Dr Jennifer Hayward from CSIRO told the Committee that the figure in the GenCost 2018 report was being reviewed:
- ...based on stakeholder feedback, we're revising the scenarios... the modelling assumptions, and we're also modifying our methodologies. What we're expecting to see is a bit more variety in terms of the outcomes for SMR. So, instead of having a flat cost trajectory going out to 2050, we think that, given the changes that we're making because of the stakeholder feedback...that will actually see some cost reductions. But, yes, we are sticking with that number, because it is a first-of-a-kind plant. That's the assumption that we're sticking with.<sup>73</sup>
- 1.75 Dr Hayward said the figure of \$16,000 had been sourced from the World Nuclear Association's website.<sup>74</sup>
- 1.76 Other submissions and witnesses did not agree with the costings published in the GenCost 2018 report.
- 1.77 Mr Ian Hore-Lacy from the Australasian Institute of Mining and Metallurgy said that some numbers in the GenCost 2018 report are 'astronomically high and unjustifiable'. He said:

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71 Dr Alex Wonhas, *Proof Committee Hansard*, 29 August 2019, p. 22.

72 Dr Jim Green, *Proof Committee Hansard*, 1 October 2019, p. 2.

73 Dr Jennifer Hayward, CSIRO, *Proof Committee Hansard*, 16 October 2019, p. 2.

74 Dr Jennifer Hayward, CSIRO, *Proof Committee Hansard*, 16 October 2019, p. 2.

They must have been pulled out [of] thin air. There are plenty of numbers available in terms of costs of generation and so forth – that is, capital cost per kilowatt of setting up a nuclear power plant and the levelised cost of the energy which comes from it. I simply make the point that if you're looking at the LCOE be careful not to compare apples to oranges. The LCOE from a reliable, continuous supply – a dispatchable source such as nuclear, coal or gas – cannot be compared with those costs from solar and wind, because your system costs need to be added... Even if you were getting solar and wind at zero cost, it would still be more expensive by the time the consumer got it because of the system costs that are involved.<sup>75</sup>

1.78 The World Nuclear Association submitted:

The joint AEMO CSIRO GenCost report which is apparently considered authoritative in Australia certainly cannot be considered as credible when it comes to nuclear costs. The latest edition excludes the technologically mature gigawatt-scale light-water and pressurized heavy water reactor designs – for which data are available – in order to focus on small modular reactors, for which prices are currently speculative. There is scant reasoning provided for this exclusion in the report and the supporting material. Australia has 13 major sites for coal electricity generation and those plants will have to [be] replaced sooner or later. Eleven of those sites house more than 1.3 gigawatts of power capacity and could be suitable for gigawatt-scale nuclear facilities.

The report then assigns a surprisingly high estimated cost to SMRs of \$16,000 AUD/kW, as well as assuming almost no learning rate. Confidence about the costs of as yet unbuilt reactor designs is naturally lower than in the (excluded) gigawatt-scale reactor segment. However, confidence is increasing as several prospective vendors undertake the necessary studies to advance through licensing processes and secure private investment. We can therefore say categorically that the figure of \$16,000 AUD/kW is not in concordance with current international expectations.<sup>76</sup>

1.79 In response to the CSIRO's advice on the source of this figure being from the World Nuclear Association, Mr David Hess from that organisation said:

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75 Ian Hore-Lacy, *Proof Committee Hansard*, 1 October 2019, pp. 21-22.

76 World Nuclear Association, *Submission 259*, p. 7.

The World Nuclear Association gets its cost data from other people who develop the projects – the vendors and the developers – so any data that we collect would be coming from there. But we can't be the ultimate authority for these kinds of projections. On our website we have an online information resource that is kept up to date as regularly as it can be with new information as it comes in. There is a possibility that the information used to be present as a data point in our extensive information collection, but it would have only been one value and, by the sound of things, it would have been an extreme value, because it's a very high capital cost estimate for nuclear projects.<sup>77</sup>

### **Friends of the Earth SMR and large reactor costings**

1.80 Based on publicly available information, Friends of the Earth Australia (FoE) submitted the following analysis:

A 2016 report by the South Australian Nuclear Fuel Cycle Royal Commission estimated levelized costs of electricity (LCOE) of US\$161/MWh based on the US NuScale SMR design. A 2015 NuScale report estimated a LCOE of \$98-\$108/MWh. And in June 2018, NuScale said it is targeting a cost of just US\$65/MWh for its first plant. No doubt NuScale's cost estimates will continue to drop precipitously ... unless and until it actually builds an SMR plant.<sup>78</sup>

1.81 The submission continued:

Lazard's most recent levelized-cost-of-energy analysis gives figures of US\$112–189/MWh for new, large reactors; \$29–56 for wind power; and \$36–46 for utility-scale solar. If figures of US\$60–65/MWh could be achieved with SMRs, the electricity they generate would be 2–3 times cheaper than that from large reactors but still more expensive than wind power and utility-scale solar.<sup>79</sup>

1.82 Dr Jim Green from FoE told the Committee that:

Given the absence of any operating SMRs and the unpromising nature of the two under construction, or the two relevant ones under construction, the argument that SMRs are leading to cleaner, safer and more efficient energy production could only possibly be justified with reference to paper designs until the unproven claim is promoted by the nuclear industry. It ought to be obvious, and I'm sure it is obvious... that paper designs and

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77 Mr David Hess, World Nuclear Association, *Proof Committee Hansard*, 22 October 2019, p. 2.

78 Friends of the Earth Australia, *Submission 36*, p. 16.

79 Friends of the Earth Australia, *Submission 36*, p. 17.

corporate claims are no basis for public policy, especially given the history of the past decade.<sup>80</sup>

1.83 Dr Green also said:

If SMRs were half as good as they're said to be, where is the private finance? It's not there. It's not there in the US or the UK or Canada. They're insisting on massive government subsidies, billions of dollars, and without that we won't even have any prototypes of these small reactors or these advanced reactors, let alone fleets of them generating vast amounts of low-carbon power. So we're in a holding pattern now where, unless governments are prepared to bet on these technologies...nothing is going to happen.<sup>81</sup>

### **Australian Nuclear Association and Nuclear for Climate Australia 1000MWe reactor costings**

1.84 The Australian Nuclear Association's submission provided an estimated cost of larger nuclear power plants in Australia (1000MWe/1GWe), using a model from Energy Power Consulting:

Costing for the nuclear power option was based on information provided by South Korean government agencies during an intensive study tour of that country's nuclear engineering industry. After adjusting the Korean costing information for the labour rates and general civil engineering costs currently seen on local major projects in Australia, the overnight cost of 1 GWe nuclear plant was A\$6200/kWe which was used in the EPC model.<sup>82</sup>

1.85 Nuclear for Climate Australia's submission provided the same information and included further information on how the costings were calculated.<sup>83</sup>

1.86 The model uses an approach based on system levelised cost of energy. Mr Robert Parker of Nuclear for Climate Australia said:

This model calculates the levelised cost of energy for each generation source, but, importantly, it then calculates the systemised levelised cost of energy for the whole NEM [National Energy Market] system. This incorporates costs from all generation sources, plus storage, devices and extra transmission

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80 Dr Jim Green, *Proof Committee Hansard*, 1 October 2019, p. 1.

81 Dr Jim Green, *Proof Committee Hansard*, 1 October 2019, p. 12.

82 Australian Nuclear Association, *Submission 155*, p. 10.

83 Nuclear for Climate Australia, *Submission 135*, pp. 18-19.

costs above and beyond those required to supply a current, more compact system. It also calculates the carbon abatement cost of a generation mix from a base reference cost. Models were run for a range of scenarios involving various amounts of nuclear energy, renewables and fossil fuels...In essence, we've found the systems based on renewables grew steadily more expensive than those incorporating nuclear energy as the emissions reductions intensified.<sup>84</sup>

1.87 Dr Alex Wonhas from AEMO said:

...the best metric to look at in the long run is what we call 'total system cost' that takes into account the capital investment and the operating cost of a plant, and that is actually the metric that we are looking at when we do the analysis for the integrated system plan.<sup>85</sup>

### **Assessing the economics and business case for nuclear energy**

1.88 The Committee heard many general views on the economics and business case relating to nuclear energy in Australia.

1.89 Dr Alex Wonhas from AEMO said that reliability and system security are two key considerations.

1.90 In relation to reliability, Dr Wonhas said:

Reliability is what you have referred to as keeping the lights on, which means we have enough power available when consumers actually demand it. As we all know, renewables have a variable output that depends on the influence of weather – at least, I should say that some renewables do – and, as a result, we need what we call dispatchable resources within the Australian energy market. That can be a whole range of different plants. It is obviously the existing coal generation fleet and it is gas generators, which have the advantage of being quite flexible in their approach, but it can also be technologies set up that are now growing, such as pumped hydro or battery storage.<sup>86</sup>

1.91 On system security, Dr Wonhas said:

The separate issue is what we call system security, which means that, at very short time scales, the system remains stable, in particular against potential disturbances. That is also an issue that

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84 Mr Robert Parker, *Proof Committee Hansard*, 9 October 2019, p. 18.

85 Dr Alex Wonhas, *Proof Committee Hansard*, 29 August 2019, p. 25.

86 Dr Alex Wonhas, *Proof Committee Hansard*, 29 August 2019, p. 20.

we look at very carefully when integrating renewables, because that requires a certain amount of what's called inertia, which basically keeps the frequency stable at 50 hertz, and maybe an additional injection of frequency through frequency ancillary services. What is also needed to integrate renewables is what is called a high short-circuit ratio and, in general, system strength.<sup>87</sup>

- 1.92 Dr Wonhas commented on the responsiveness of the energy system to changes in demand:

There is a certain amount of energy that we expect renewables to deliver, which is obviously driven by the statistics of weather, which we will be looking at, but we will need dispatchable resources in the market and we also need resources that can actually respond relatively quickly to changes, which is quite important. Some generators are more able to do that than others. Take existing coal generators. They are typically slower and have less flexibility to respond, whereas a gas generator or, say, a pumped hydro system or a battery is much faster to respond.<sup>88</sup>

- 1.93 The Minerals Council of Australia submitted that:

SMRs represent one of the cheapest new build 24/7 power supplies of any technology. In Australia, this would possibly make SMRs the cheapest zero emission power source capable of providing 24/7 energy. ... the capital cost attributed to SMRs of \$16,000/KW cannot be validated and appears to be at least 2-3 times that cited elsewhere. For example, NuScale estimates the capital cost of large-scale fabrication (which leads to lower costs) would be US\$3,600/KW or A\$5,140/KW.<sup>20</sup> The Canadian SMR Roadmap also provided a range of estimates, with the average just under C\$7,200/KW (A\$7,500/KW).<sup>89</sup>

- 1.94 Ms Chloe Munro from the Australian Academy of Technology and Engineering said:

In terms of the economics...the capital costs have been plummeting for both solar and wind. The calculation of the levelised costs of energy takes into account the capacity factor. Solar and wind may be generating only 30 or 40 per cent of the time, and that's taken into account in calculating the levelised cost of energy. In terms of reliability and security, yes, they need to be firmed – that is the technical term – in some other way. But again,

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87 Dr Alex Wonhas, *Proof Committee Hansard*, 29 August 2019, p. 21.

88 Dr Alex Wonhas, *Proof Committee Hansard*, 29 August 2019, p. 21.

89 Minerals Council of Australia, *Submission 266*, p. 9.

with the falling costs of storage and with potential deployment of large-scale storage like pumped hydro, renewables plus storage can deliver a much more reliable service. The question is whether that is then usefully backed up by other forms of generation – gas technology and potentially, in the future, nuclear. That's a relatively small residual piece that's left to be filled.<sup>90</sup>

- 1.95 The Australian Workers' Union supported trialling SMRs in Australia. The submission recommended:

...a pilot program to assess the viability of Small Modular Reactors in the Australian economy, with a focus on providing energy to the heavy industrial using businesses in the economy. This should involve liaising with the US Department of Energy to assess the outcomes of the US Government's pilot project.<sup>91</sup>

- 1.96 On the other hand, a submission from Professor Steve Thomas and Mr Paul Dorfman (University of Greenwich) advised against SMRs. Their submission stated:

SMRs have been widely promoted as potentially solving the problems associated with new large reactors, which have led to a sharp decline in the prospects for new large plant nuclear power orders. Their main somewhat implausible rationale is that building SMRs factories as modules, leaving just assembly on-site, will produce savings from use of production-line techniques that will more than counter-balance the lost scale economies of building large reactors.<sup>92</sup>

- 1.97 The submission continued:

...the first demonstration plants are unlikely to be online before 2030. Whilst SMR demonstration plants will show whether the designs are technologically viable, it will take a further decade or more (only if production lines have been set up and large numbers of reactors have been pre-ordered and produced) before their economic viability is tested. Based on past experience with new nuclear technology, there is a high probability that this line of technology development will fail. At most, SMRs are [a] distant and very costly experiment, and Australia should focus on the very wide range of fully mature and commercially viable

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90 Ms Chloe Munro, *Proof Committee Hansard*, 1 October 2019, p. 50.

91 Australian Workers' Union, *Submission 290*, p. 4.

92 Professor Thomas and Mr Dorfman, *Submission 277*, p. 1.

renewable, energy management, distribution and storage technologies for reducing emissions.<sup>93</sup>

1.98 The submission anticipated financial risks:

The poor record of existing designs and the unproven nature of SMRs means financing nuclear will be impossible via normal project finance and will require all major risks to fall on the public, either as tax-payers or electricity consumers.<sup>94</sup>

1.99 Environmental groups opposed the idea of introducing 1000MWe nuclear reactors in Australia:

For Australia, the Australian Nuclear Association suggests South Korea as a potential supplier of reactor technology. However...the South Korean nuclear industry suffers from sustained allegations of endemic corruption. South Korea's four-reactor project in the UAE is said to be a welcome contrast to the vastly over-budget and long-delayed projects in western Europe and the US, but the UAE project is at least three years behind schedule (partly because of the corruption scandal involving South Korean manufacturers) and costs are reported to have increased from A\$29.7 billion to A\$47.3 billion (US\$20 billion to US\$32 billion). Remarkably, the South Korea/UAE reactor contract was accompanied by a secret military side-agreement.<sup>95</sup>

1.100 Ms Noel Wauchope also cited research from Carnegie Mellon University, concluding that the SMR industry would not be viable without 'several hundred billion dollars of direct and indirect subsidies'.<sup>96</sup>

1.101 Prof John Quiggin said:

Having studied the subject extensively, I don't believe that nuclear power is economically feasible in the absence of a substantial carbon price...In this, I'm simply endorsing what the Switkowski inquiry concluded 12 years ago...if we are to proceed, the correct path is to implement a carbon price, starting at probably a level of \$25 a tonne and rising gradually to a level of \$50 a tonne, which in my view is the minimum necessary for nuclear power to compete against fossil based fuels. It will then be an open question whether nuclear power in fact succeeds in competition with renewables.<sup>97</sup>

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93 Professor Thomas and Mr Dorfman, *Submission 277*, p. 2.

94 Professor Thomas and Mr Dorfman, *Submission 277*, p. 2.

95 Nine environment groups and state conservation councils, *Submission 219*, pp. 4-5.

96 Ms Noel Wauchope, *Submission 72*, p. [3].

97 Prof John Quiggin, *Proof Committee Hansard*, 30 September 2019, p. 7.



1.102 Prof Quiggin said that small modular reactors may be feasible ‘on paper’ but added: ‘I’d be surprised if they got a cost below \$100 a megawatt hour.’<sup>98</sup>

1.103 Mr Tony Wood from the Grattan Institute assessed:

So what we've seen is economic models that prove that some particular view of the world in the future will be the cheapest. If you look at almost all of those results, you find that the results are consistent with those who paid for the modelling.<sup>99</sup>

### The mining industry

1.104 Processed uranium is a fuel source for nuclear energy. Some submissions and witnesses commented on the value of mining in Australia, in particular the extraction of uranium.

1.105 The Minerals Council of Australia submitted:

The Australian uranium sector directly and indirectly employs around 3000 Australians and delivers more than \$600 million in export income.<sup>100</sup>

1.106 The Australian Workers’ Union submitted that:

Australia is the largest global exporter of almost all raw materials and commodities for energy production yet perversely has the highest domestic electricity prices. Despite abundant reserves and large exports of coal, gas, uranium, and lithium, as well as natural endowments of wind, solar, hydro, thermal and wave technology – Australia is unable to satisfy its energy needs.<sup>101</sup>

1.107 Mr Ian Macfarlane from the Queensland Resources Council told the Committee that:

In 2013, a Queensland government review into the recommencement of uranium mining in Queensland indicated the value of Queensland's major uranium deposits to be approximately \$10 billion. Mining is a vital contributor to the economic growth of Queensland's regions. According to QRC's economic contribution survey in 2017-18, 77 per cent of direct employees of the Queensland resource industry live in regional Queensland, and 55 per cent of the direct and indirect jobs

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98 Prof John Quiggin, *Proof Committee Hansard*, 30 September 2019, p. 8.

99 Mr Tony Wood, *Proof Committee Hansard*, 1 October 2019, p. 31.

100 Minerals Council of Australia, *Submission 266*, p. 11.

101 Australian Workers’ Union, *Submission 290*, p. 5.

supported are in regional Queensland. Most importantly, mining jobs are typically highly skilled, high tech and high paying.

1.108 Mr Dave Sweeney of the Australian Conservation Foundation did not agree. He said:

We certainly do have considerable uranium reserves – a third of the world's uranium reserves – but we are actually mining and exporting less each year, and that's simply in relation to the market demand and commodity price. It is measured in US dollars a pound. It was US\$120 a pound pre Fukushima; it's US\$30 a pound now. The basic rule of thumb is that it takes US\$60 a pound for a greenfield mine site to be viable in Australia... We are seeing profit shrink, production shrink and value shrink, and the sector is being hit by external commodity forces. To say that the creation of some nuclear powered future in Australia will lead to a uranium renaissance and bonanza is simply fanciful.<sup>102</sup>

1.109 Associate Professor Gavin Mudd stated that:

...uranium is being left behind and is largely being overtaken by lithium. Lithium has now almost triple the value of uranium, and that has given a dynamic to current energy globally and to the shift to renewables and is increasing the use of batteries. I think that's unlikely to change at all, and in some ways that's a very good direction for Australia to be heading in. There are certainly opportunities for Australia in energy exports and so on, but I think those relate to things such as lithium.<sup>103</sup>

### **3. Legal and regulatory frameworks**

1.110 One essential element in considering any future nuclear energy industry in Australia is a suitable legal and regulatory framework.

1.111 The only Australian nuclear facility presently requiring regulation is the Commonwealth-owned research reactor at Lucas Heights, although states and territories have legislative and regulatory arrangements in place in relation to nuclear materials (such as medical supplies) and radiation within their jurisdictions. At the Commonwealth level, regulatory responsibilities and functions for aspects of nuclear security, safeguards and safety cut across the Health, Foreign Affairs and Trade, and Environment and Energy portfolios.

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102 Mr Dave Sweeney, *Proof Committee Hansard*, 1 October 2019, p. 13.

103 Associate Professor Gavin Mudd, *Proof Committee Hansard*, 1 October 2019, p. 15.

1.112 The 2006 UMPNER report stated:

Australia currently has several Commonwealth regulatory entities as well as state and territory authorities. Safeguards and security are regulated by the Australian Safeguards and Non-Proliferation Office (ASNO) while health and safety is regulated by state and territory radiation protection authorities or, in the case of Commonwealth entities, by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Some of these regulatory functions could be consolidated.

While the existing regulation of uranium mining, transportation, radioactive waste disposal and nuclear research facilities in Australia is of a high standard, significant overlaps in regulatory responsibility exist, and reform to streamline existing arrangements would improve regulatory efficiency and transparency.

For Australia to expand its role in the nuclear power industry it is essential that an appropriate and rigorous regulatory framework is established at an early stage. Adequate provision would need to be made for its implementation.<sup>104</sup>

1.113 CEO of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), Mr Carl-Magnus Larsson, advised the Committee on nuclear regulation in Australia:

The aim of the regulatory activities, as for all other activities that we carry out at ARPANSA, is the protection of the health and safety of the workers, the public and the environment independent of any promoting interests. Our focus is also on the safety and security of the regulated facilities, with the aim of reducing the likelihood of accidents and mitigating their consequences, should they occur. We apply international best practice in our regulatory decision-making and we participate in the development and implementation of the international framework for safety together with our international partners. We also fulfil Australia's reporting obligations under certain international instruments such as the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. We are also the national competent authority

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<sup>104</sup> Department of the Prime Minister and Cabinet, *Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia?*, 2006, p. 9.

on the assistance and early notification conventions for radiological and nuclear emergencies.<sup>105</sup>

- 1.114 Mr Larsson said that regulatory arrangements for nuclear energy could depend upon who is operating the facilities:

Looking at other countries with a federated constitution like Australia's, when they have embarked on a nuclear program they have made a choice to establish a federal regulator for all nuclear installations. So today we have federal regulation for all the nuclear installations, but all the nuclear installations are owned and operated by the Commonwealth, so that would be something that the regulator would have to consider. Changes would in that case have to be made to the ARPANS Act if we were to think about non-Commonwealth operated entities. Obviously, as the committee surely is fully aware, there are prohibitions in the ARPANS Act and in the EPBC Act but it is a much broader look at the regulatory structure that is needed in order to accommodate a nuclear power program.<sup>106</sup>

- 1.115 Mr Adriaan van der Merwe submitted that:

Prior to the inclusion of nuclear energy in a country's energy mix, consideration also needs to be had to the status of energy and nuclear legislation and regulations on a commonwealth and state level, as well as the required expansion thereof to bring same in line with required international benchmarks. In Australia the interplay between commonwealth and state legislation will be particularly important, especially in light of international treaty obligations and the level to which those obligations are backed down into domestic law.<sup>107</sup>

- 1.116 Ms Robyn Glindemann from the Law Council of Australia (LCA) elaborated on the complications of legal and regulatory arrangements for nuclear energy in Australia's federal system:

If you start from the point of the mining part of the energy, if we use our own uranium and actually have a secondary processing capability in this country to then put it into a nuclear energy reactor, the mineral resources themselves are the properties of the states; they're not the Commonwealth's, so the regime for getting the stuff out of the ground is governed by state law. There's a little overlay of Commonwealth law in terms of the EPBC Act and

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105 Mr Carl-Magnus Larsson, *Proof Committee Hansard*, 29 August 2019, p. 9.

106 Mr Carl-Magnus Larsson, *Proof Committee Hansard*, 29 August 2019, p. 12.

107 Adriaan van der Merwe, *Submission 175*, p. 1.

various other pieces of legislation, but the fundamental digging it out of the ground is governed by state mining legislation...So there are inherent differences in the regime from the very get-go. If we were to have a...legislative regime to cover the entire cycle from taking it out of the ground to processing to using it as fuel to waste, other than the boundaries with the current Commonwealth legislation...it is a patchwork quilt of state legislation that you'd have to manage. In terms of managing risk, it is simpler to have one legislative regime that is properly resourced in terms of compliance and enforcement to manage those risks rather than relying on the states to manage their own regimes in combination with the Commonwealth.<sup>108</sup>

- 1.117 ARPANSA advised the Committee that it hosted an International Atomic Energy Agency (IAEA) peer review of Australia's regulatory framework in 2018. The review noted that the legal framework for radiation and nuclear safety in Australia is 'complex' and suggested improvements, particularly to address inconsistencies in requirements and practices between jurisdictions. ARPANSA stated that:

The observations by the IRRS team provide strong incentives to review the legal framework for radiation and nuclear safety, and efforts are underway through jurisdictional collaboration to make changes.<sup>109</sup>

- 1.118 ARPANSA noted that the ARPANS Act 'was developed with research reactors in mind', and while its general provisions could provide a regulatory framework for nuclear power reactors, there are 'areas that need to be strengthened, either in the ARPANS Act or in other existing legislation – or, alternatively, in new legislation'.<sup>110</sup> These include waste management, emergency preparedness and nuclear liability.

- 1.119 Ms Helen Cook, a legal adviser on civilian nuclear energy, submitted that if Australia were to introduce nuclear energy, 'a comprehensive review of Australia's existing legal and regulatory infrastructure would be needed', focusing on the following:

- the underlying policy objectives for, and role of the Federal Government in, the development of nuclear energy;
- overturning the primary legal impediments to nuclear energy (legislated prohibitions);

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108 Ms Robyn Glindemann, *Proof Committee Hansard*, 18 October 2019, pp. 25-26.

109 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), *Submission 136*, p. 3.

110 ARPANSA, *Submission 136*, pp. 6-7.

- the need for any Federal actions to strengthen international and bilateral nuclear commitments, including in relation to third party liability for nuclear damage;
- the adequacy of the ‘domestic legal infrastructure’ including in relation to nuclear safeguards, security, safety, emergency preparedness, international obligations, and liability. This may result in the need to amend existing legislation, or promulgate ‘new, consolidated and comprehensive legislation’ for the civilian nuclear energy sector;
- ‘domestic regulatory infrastructure’ including licensing and information disclosure, and the suitability of the powers and responsibilities of the current regulatory agencies; and
- a roadmap for the implementation of all of the above.<sup>111</sup>

1.120 Resources Law International submitted that Australia is ‘already well down the track in implementing international best practice’ for a nuclear power program, but an ‘up-to-date audit’ on the efficacy of the current framework may be warranted.<sup>112</sup>

1.121 Ms Cook noted the need for ‘a legal and regulatory regime that is tailor-made to our particular policies and circumstances’.<sup>113</sup> ARPANSA said that ‘the building blocks already exist in Australia, but are not optimally linked or presented within a coherent framework’.<sup>114</sup> Dr Adi Patterson, CEO of ANSTO, said that Australia’s regulatory construct is both ‘robust and flexible, and that’s a prerequisite, I think, to being successful in expanding a nuclear footprint in any country’.<sup>115</sup>

1.122 ARPANSA submitted that:

It is ARPANSA’s view that a single piece of national legislation encompassing, as a minimum, radiation and nuclear safety (including waste safety, transport safety, environmental protection, emergency preparedness and response, and security) should be a vision for a review and revision of the legal framework, whether a decision is taken to pursue nuclear power or not. This should accommodate different ownership/operator options.<sup>116</sup>

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111 Ms Helen Cook, *Submission 158*, pp. 1-3.

112 Resources Law International, *Submission 156*, p. 4.

113 Ms Helen Cook, *Submission 158*, p. 3.

114 ARPANSA, *Submission 136*, p. 5.

115 Dr Adi Patterson, Chief Executive Officer (CEO), Australian Nuclear Science and Technology Organisation (ANSTO), *Committee Hansard*, Sydney, 29 August 2019, p. 15.

116 ARPANSA, *Submission 136*, p. 5.

- 1.123 Resources Law International noted that while the IAEA is not an international nuclear regulator, it does act as an advisory body and is mandated to help build capacity in its member states, including through publishing a number of ‘invaluable’ guidance documents to assist countries developing nuclear power for the first time.<sup>117</sup>
- 1.124 With regard to regulation arrangements, the LCA supported the UMPNER report’s recommendation for a single national regulator for radiation safety, nuclear safety, security safeguards and environmental impact, in relation to all nuclear fuel cycle activities.<sup>118</sup>
- 1.125 ARPANSA expressed the ‘firm view that, should nuclear power be introduced in Australia, it should be under Commonwealth regulation’. ARPANSA suggested that this would not entirely eliminate state and territory responsibilities, and that other nations with nuclear power in federal systems, such as Germany, Canada and the United States, could offer useful models for an appropriate framework for Australia.<sup>119</sup>
- 1.126 Resources Law International submitted that:
- ...ARPANSA is an effective, national and independent regulatory authority for the purposes of developing an Australian nuclear power programme subject to two important provisos: first that ARPANSA would need to build additional resourcing to cope with an expanded work load and, second, that there should be direct representation by the community on its board of directors.<sup>120</sup>
- 1.127 LCA also recommended:
- ...rationalisation of the uranium mining regulatory framework to ensure a consistent approach to environmental and radiation protection throughout the nuclear fuel cycle; and...a secure long-term commitment to compliance and enforcement of approvals issues for the energy cycle, and this includes a commitment by way of properly funded human resources within the relevant regulatory agencies.<sup>121</sup>
- 1.128 The Medical Association for the Prevention of War (MAPW) expressed concern that ‘Australia is likely to under regulate the industry, with a resulting loss of safety culture and increased risk to the community’.<sup>122</sup> MAPW submitted detailed concerns about ‘regulatory capture’ in the

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117 Resources Law International, *Submission 156*, pp. 3-4. See also ARPANSA, *Submission 136*, p. 5.

118 Law Council of Australia, *Submission 267*, p. 9.

119 ARPANSA, *Submission 136*, p. 6.

120 Resources Law International, *Submission 156*, p. 7.

121 Ms Robyn Glindemann, *Proof Committee Hansard*, 18 October 2019, p. 20.

122 Medical Association for the Prevention of War, *Submission 223*, p. 21.

nuclear industry internationally, citing the example of Japan, which it said ‘became captive to the government and industry’s goal of nuclear promotion at any cost, leading to a poor safety culture’.<sup>123</sup> It argued that the uranium mining industry in Australia was poorly regulated and subject to regulatory capture, suggesting that the same could be true of a nuclear power industry in this country.<sup>124</sup>

1.129 In this regard, Resources Law International submitted that:

The IAEA advocates the institutional separation of the regulatory authority from agencies concerned with the promotion and utilisation of nuclear energy. This is also one of the fundamental safety principles embodied in the [Convention on Nuclear Safety] CNS. Therefore, national legislation should provide for an effective separation between the functions of the regulatory body, and those of any other body or organization concerned with the promotion or utilisation of nuclear energy.<sup>125</sup>

## **Liability and insurance**

1.130 Matters relating to legal liability for nuclear incidents were also raised in some evidence given to the inquiry.

1.131 The Australia Institute commented that:

Nuclear power is...uninsurable. The low-probability but high-cost risk of a nuclear event means that private insurance won't cover the full costs. In the US and in many other countries, operator liability is capped, meaning taxpayers and individuals end up subsidising the risk. If the industry was required to cover the full risk in insurance, it would not even be up for discussion. Even in Australia, without a nuclear industry, when you or I get insurance for our car, home or contents, there are explicit exclusions for nuclear events.<sup>126</sup>

1.132 The Australia Institute submitted that ‘[i]f developers of nuclear power stations were forced to insure the full costs of nuclear accidents, nuclear power would be completely uncompetitive’.<sup>127</sup> The submission stated that in the absence of private insurance coverage either the Government would need to provide indemnity – as it has in the case of ANSTO’s Opal

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123 Medical Association for the Prevention of War, *Submission 223*, p. 12.

124 Medical Association for the Prevention of War, *Submission 223*, pp. 21-22.

125 Resources Law International, *Submission 156*, p. 6.

126 Mr Tom Swann, *Proof Committee Hansard*, 18 October 2019, p. 18.

127 The Australia Institute, *Submission 167*, p. 31.



- reactor – or the community would bear the risks of liability for nuclear incidents.<sup>128</sup>
- 1.133 Other submitters shared the view that the problem of insurance would either make nuclear energy economically unviable for operators, or place an unreasonable burden on taxpayers.<sup>129</sup>
- 1.134 The Australian Nuclear Science and Technology Organisation (ANSTO) stated that international law channels all liability for nuclear incidents to the operators of nuclear installations, and ‘there are large amounts of nuclear insurance (in the billions of dollars) available in the global market’, to cover this. ANSTO noted that there are gaps in commercial insurance coverage, and some governments therefore provide insurance to ensure the full coverage required by international Conventions.<sup>130</sup>
- 1.135 ANSTO noted that while the Government has provided a Deed of Indemnity to cover liability over its facilities, this may not be appropriate for private operators of nuclear energy facilities. Should such facilities be established in Australia, the Government may therefore need to enact nuclear liability legislation. ANSTO proposed that the Government may also consider ratifying the IAEA Convention on Supplementary Compensation,<sup>131</sup> ‘so as to provide a further level of reassurance to potential international partners’.<sup>132</sup>
- 1.136 In relation to international liability arrangements for a nuclear accident, Ms Robyn Glindemann from LCA advised that:
- In terms of the international legal framework for liability post disasters, there are general principles of international environmental law which unfortunately are not well embedded... To the extent that a disaster in one jurisdiction affects another, there are broad legal principles, but I’m not aware of a formal, internationally agreed legal regime for who is liable for what post a disaster. That should be addressed, but it is not something that Australia could address by itself.<sup>133</sup>

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128 Mr Tom Swann, *Proof Committee Hansard*, 18 October 2019, p. 25.

129 See PaYung Contracting, *Submission 91*, pp. 4-5; Citizens Climate Lobby Australia, *Submission 169*, pp. 3-4; Mr Ivan Quail, *Submission 253*, pp. 15-16; Mr Matthew Baird, *Submission 121*, p. 3.

130 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission 166*, pp. 31-33.

131 Convention on Supplementary Compensation for Nuclear Damage, done at Vienna on 12 September 1997 under the auspices of the International Atomic Energy Agency, entered into force 15 April 2015.

132 ANSTO, *Submission 166*, p. 35.

133 Ms Robyn Glindemann, *Proof Committee Hansard*, 18 October 2019, p. 24.

## 4. Workforce capability requirements

### Workforce capability requirements for a nuclear energy industry

1.137 Nuclear energy generation needs an adequately skilled workforce to develop, operate and regulate the industry.

1.138 In its submission, the Australian Nuclear Science and Technology Organisation (ANSTO) referred to the International Atomic Energy Agency's (IAEA) acknowledgement that 'it is unrealistic to expect that a Member State initiating a new nuclear power program would have sufficiently skilled personnel, with the required levels of competence, to implement that program.'<sup>134</sup> ANSTO further submitted that the IAEA would expect that in nations forming a nuclear workforce:

- a national system would be developed to build the human resource base;
- the first reactor project would be turnkey to leverage the knowledge and experience gained during the build from the provider;
- there will be recruitment of competent staff for the commissioning and operational phases of the program; and
- a loose partnership will be formed between the operator, vendor(s), regulatory bodies, established nuclear facilities, academic/educational institutions, and trade organisations.<sup>135</sup>

### The current nuclear workforce capability in Australia

#### Existing workforce

1.139 The current Australian workforce is largely supporting ANSTO's research reactor at Lucas Heights. A number of professionals are also working in related fields.

1.140 Evidence to the inquiry regarded this workforce as a basis for Australia's capability to operate potentially expanded nuclear operations in the future.

1.141 Australian Young Generation in Nuclear (AusYGN) submitted that despite the absence of a nuclear power industry, the current and former research reactors at ANSTO's Lucas Heights campus demonstrate Australia's proven ability to operate safe nuclear facilities.<sup>136</sup>

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<sup>134</sup> ANSTO, *Submission 166*, p. 27.

<sup>135</sup> ANSTO, *Submission 166*, p. 27.

<sup>136</sup> Australian Young Generation in Nuclear, *Submission 241*, p. 1.

- 1.142 SMR Nuclear Technology submitted that the reactor at Lucas Heights is a ‘good example of how staff can be recruited, trained and become an efficient workforce.’ SMR submitted that the construction phase for ANSTO’s new OPAL reactor allowed for engineering graduates to be recruited and trained in nuclear operations, and that these graduates gained extensive operations experience during the commissioning process, resulting in ‘an expert cohort of nuclear engineers’ in Australia.<sup>137</sup>
- 1.143 Women in Nuclear Australia submitted that ANSTO, the Australian Safeguards and Non-Proliferation Office (ASNO) and the Australian Radiation Protection and Nuclear Safety Authority (ARPANSA) are well established bodies and could form a basis for a future regulatory body for a nuclear power industry.<sup>138</sup>

### **Current workforce training and development**

- 1.144 Dr Ziggy Switkowski told the Committee that Australia’s vocational and higher education sector is capable of quickly producing a trained workforce for a future Australian nuclear industry.<sup>139</sup> A number of universities in Australia currently offer relevant courses that may equip professionals for a future nuclear power industry:
- The Australian National University (ANU) offers a Masters course in nuclear physics,<sup>140</sup> established in 2007. The campus manages a particle accelerator facility with a strong experimental emphasis, and offers practical education in nuclear physics,<sup>141</sup> and includes nuclear reactors and the nuclear fuel cycle.<sup>142</sup>
  - The University of New South Wales offers a Masters course in nuclear engineering,<sup>143</sup> established in 2013.<sup>144</sup>
- 1.145 Women in Nuclear Australia submitted that these academic programs are already contributing technical skills and knowledge into the Australian nuclear workforce.<sup>145</sup>
- 1.146 The ANU program has produced graduates who have gone on to employment in ASNO, ARPANSA, ANSTO, and also at the headquarters of the IAEA.<sup>146</sup>

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137 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 12.

138 Women in Nuclear Australia Inc., *Submission 154*, pp. 11-12.

139 Dr Ziggy Switkowski AO, *Submission 41*, p. 2.

140 Women in Nuclear Australia Inc., *Submission 154*, p. 12.

141 ANU School of Physics, *Submission 151*, p. [2].

142 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 12.

143 Women in Nuclear Australia Inc., *Submission 154*, p. 12.

144 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 12.

145 Women in Nuclear Australia Inc., *Submission 154*, p. 12.

- 1.147 SMR Nuclear Technology submitted that a key workforce prerequisite for a nuclear power program in Australia is an increased number of nuclear engineering courses.<sup>147</sup>
- 1.148 The ANU School of Physics suggested that its courses could be expanded in the future to include undergraduate nuclear engineering programs and other necessary training including technical skills and research programs.<sup>148</sup>

### **Moving towards a workforce capability for nuclear power**

- 1.149 The Committee heard evidence nonetheless that the Australian nuclear workforce is not yet at a level that would be suitable to sustain a nuclear power industry.<sup>149</sup> A number of submissions observed that if Australia was to introduce nuclear power, there would be a need for more skilled workers to assist in developing the new industry.<sup>150</sup>
- 1.150 Mr Bernd Felsche said that the moratorium on nuclear energy meant that opportunities in Australia for employment in the nuclear sector are few, resulting in a lack of practicing nuclear engineers. He said some of the ‘immediate demand’ for nuclear engineers would likely need to be filled by skilled immigration or work-visas for short-term demand, particularly during plant construction.<sup>151</sup>
- 1.151 Resource Futures further noted that:
- There is clearly negligible current capacity to build or operate nuclear power in Australia beyond the non-nuclear components – site preparation, steam generation, transmission connection. Building these competencies would take many years and even then experienced middle and senior management would need to be sought from nuclear power capable countries until local capacity became available.<sup>152</sup>
- 1.152 SMR Nuclear Technology was optimistic about attracting a skilled workforce to Australia, and advised that:

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146 ANU School of Physics, *Submission 151*, p. [2].

147 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 12.

148 ANU School of Physics, *Submission 151*, p. [2].

149 Ms Julia Garside, President, Australian Young Generation in Nuclear, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 2; Dr Philip White, *Submission 119*, p. [9]; Mr Bernd Felsche, *Submission 129*, p. [3]; ANSTO, *Submission 166*, p. 27; Dr David Jones, *Submission 249*, p. 7.

150 Dr Philip White, *Submission 119*, p. [9]; Mr Bernd Felsche, *Submission 129*, p. [4]; Women in Nuclear Australia Inc., *Submission 154*, p. 12; Mr Tom Bammann, *Submission 178*, p. 4; Resource Futures Pty Ltd, *Submission 238*, p. [3]; Dr David Jones, *Submission 249*, p. 7.

151 Mr Bernd Felsche, *Submission 129*, pp. [3-4].

152 Resource Futures Pty Ltd, *Submission 238*, p. [3].

Australia is a very attractive place to live and there's no problem in attracting engineers from overseas to Australia. Our company is regularly contacted by people asking, 'Do you have any jobs for us?' We don't believe there's a problem in getting enough workforce for a nuclear power program.<sup>153</sup>

- 1.153 A submission from environmental groups noted the time needed to develop a specialised workforce as a disadvantage of nuclear power compared to alternative energy sources.<sup>154</sup>
- 1.154 The Committee heard that developing the workforce to a suitable level would be a lengthy process. Dr Philip White explained that 'the workforce issues associated with a nuclear power program would be of a different order of magnitude and level of complexity', and that it would take considerable time and investment for the required capability to be reached.<sup>155</sup> Similarly, Dr David Jones submitted that it would be 'unlikely' that a skilled nuclear workforce could be established in Australia in less than a decade.<sup>156</sup>
- 1.155 Dr White pointed to the example of the United Arab Emirates (UAE), submitting that despite placing orders for nuclear power plants in 2010, the UAE was only able to certify the first group of senior reactor operators in mid-2019, with 'additional training and procedural development' cited as necessary.<sup>157</sup>
- 1.156 ANSTO submitted that 'given the long lead times between any decision to introduce nuclear power in Australia and the commencement of operation of the first reactor, the current lack of a trained workforce should not be regarded as a constraint'.<sup>158</sup>
- 1.157 Similarly, AusYGN told the Committee that there is a current capability gap, but that one benefit of the lead times in enacting required legislative and regulatory changes, construction and commissioning of nuclear energy facilities would allow a window of opportunity to train up a capable workforce.<sup>159</sup>
- 1.158 Mr Tony Irwin from SMR Nuclear Technology said that the lead times present an opportunity to skill a workforce:

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153 Mr Tony Irwin, Technical Director, SMR Nuclear Technology Pty Ltd, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

154 Joint signatory of fifty civil society organisations, *Submission 172*, p. [1].

155 Dr Philip White, *Submission 119*, p. [9].

156 Dr David Jones, *Submission 249*, p. 7.

157 Dr Philip White, *Submission 119*, p. [9].

158 ANSTO, *Submission 166*, p. 27.

159 Ms Julia Garside, President, Australian Young Generation in Nuclear, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 2.

OPAL is a good example. I was reactor manager there, and what we would do with a nuclear power plant is appoint your operating staff at an early stage in the project so they can get involved with all the construction and commissioning. This is where you really gain all your experience. For OPAL what we did was employ young engineering graduates, obviously with no nuclear background at that time, and we trained them in nuclear during the time of the commissioning and early operation, which is where you really gain a huge amount of experience. Once a nuclear power plant is running, it's pretty boring. It sits there and just operates, so you get all your experience during its early operation.<sup>160</sup>

- 1.159 Mr Barrie Hill of Nuclear for Climate Australia told the Committee that in his experience, it takes around two years to suitably train qualified engineers to understand nuclear technology.<sup>161</sup> Mr Hill also pointed out that many of the required engineers for a nuclear workforce would not need specific nuclear experience:

Not every person needs to be a nuclear engineer. We would need, based on the OPAL experience, probably about 10 people with intimate nuclear engineering experience... The majority of the workforce is our normal engineering workforce – civil engineers, electrical engineers, mechanical engineers for most of the plants. The whole construction group does not need to be nuclear engineers.<sup>162</sup>

- 1.160 Women in Nuclear Australia also highlighted Australia's experience in large construction projects such as shipbuilding and related Defence industries, and indicated that nuclear power plant construction could draw on this workforce.<sup>163</sup>

- 1.161 Mr Hill said that a lack of workforce capability in Australia is 'a complete myth'<sup>164</sup>, and that examples such as liquid national gas and iron ore

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160 Mr Tony Irwin, Technical Director, SMR Nuclear Technology Pty Ltd, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

161 Mr Barrie Hill, Associate, Nuclear for Climate Australia, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

162 Mr Barrie Hill, Associate, Nuclear for Climate Australia, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

163 Women in Nuclear Australia Inc., *Submission 154*, p. 12.

164 Mr Barrie Hill, Associate, Nuclear for Climate Australia, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

projects point to Australia's ability to quickly mobilise a necessary workforce.<sup>165</sup> Mr Hill argued that a key barrier is finance:

If you put the money in the bank for me tomorrow, I'd have a 200-person team working on a nuclear power station within three months. We have experienced engineers, we have experienced scientists. Most of the engineers who worked for me at ANSTO, for instance, are nuclear trained and are now working on projects all over Australia. They could be easily pulled in.<sup>166</sup>

- 1.162 Mr Tony Irwin from SMR Nuclear Technology said that lifting the moratorium would likely result in an expansion of available university courses.<sup>167</sup> AusYGN agreed, submitting that the development of nuclear power in Australia would present 'significant opportunity for employment and education for young professionals.'<sup>168</sup>
- 1.163 AusYGN also noted the need for young entrants to the nuclear workforce in Australia to facilitate intergenerational knowledge transfer, as the industry consists of an ageing workforce.<sup>169</sup>
- 1.164 In her submission, Ms Noel Wauchope noted that around one third of nuclear professionals are over 55 years of age. The submission stated:
- The uncertainty about the industry's future means that there's a cloud over this industry as far as a career path is concerned. To develop a nuclear industry in Australia would require huge expenditure in training and tertiary education - large public investment would be needed.<sup>170</sup>
- 1.165 ANSTO told the Committee that if Australia was to opt to introduce nuclear power, the IAEA and the OECD Nuclear Energy Agency would be able to assist in the development and implementation of workforce training planning tools, the development of human resource plans and in the provision of guidance for long-term reactor operation.<sup>171</sup>

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165 Mr Barrie Hill, Associate, Nuclear for Climate Australia, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

166 Mr Barrie Hill, Associate, Nuclear for Climate Australia, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

167 Mr Tony Irwin, Technical Director, SMR Nuclear Technology Pty Ltd, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 20.

168 Australian Young Generation in Nuclear, *Submission 241*, p. 1.

169 Ms Julia Garside, President, Australian Young Generation in Nuclear, *Proof Committee Hansard*, Sydney, 9 October 2019, p. 2.

170 Ms Noel Wauchope, *Submission 72*, p. [4].

171 ANSTO, *Submission 166*, p. 27

- 1.166 ANSTO also noted that there would be a need to develop a framework to train the nuclear workforce for eventual decommissioning of plants; however, these skills would not be required for some time.<sup>172</sup>
- 1.167 Mr Bernd Felsche submitted that prospective nuclear engineers may be able to seek practical experience overseas.<sup>173</sup>
- 1.168 The Australian Academy of Technology and Engineering recommended pursuing international partnerships in nuclear education, research and development to further enhance workforce skills.<sup>174</sup>
- 1.169 With regard to regulation, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) advised the Committee that it is not currently able to provide of the all necessary skills and competencies to the scale required for a national nuclear power program.<sup>175</sup> The agency indicated that it would require a significant increase to its resourcing, involving two elements:
- establishment of a new resourcing and competence baseline to handle the establishment of a nuclear power program; and
  - a scalable element that is proportionate to the size of the nuclear power program.<sup>176</sup>
- 1.170 ARPANSA said it would need to recruit experts able to address the safety aspects across the nuclear supply chain, along with people to manage issues such as community engagement, communications and organisational psychology.<sup>177</sup> Additionally, a long-term education, training and research program would be required in order to support capability.<sup>178</sup>
- 1.171 ARPANSA's submission stated:
- Realistically, reaching the operational stage for the first nuclear power plant in Australia could not take much less than 15 years from the time a decision is taken to move in this direction; it is not unlikely that it would take longer time to complete construction and commence operations, possibly much longer.<sup>179</sup>

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172 ANSTO, *Submission 166*, p. 28.

173 Mr Bernd Felsche, *Submission 129*, p. [3].

174 Australian Academy of Technology and Engineering, *Submission 221*, p. 5.

175 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), *Submission 136*, p. 6.

176 ARPANSA, *Submission 136*, p. 6.

177 ARPANSA, *Submission 136*, p. 6.

178 ARPANSA, *Submission 136*, p. 6.

179 ARPANSA, *Submission 136*, p. 10.



## 5. Environmental considerations

- 1.172 The Committee heard that nuclear power may offer benefits in terms of assisting efforts to reduce emissions,<sup>180</sup> and may offer advantages in terms of air quality<sup>181</sup> and a smaller footprint.<sup>182</sup>
- 1.173 On the other hand, environmental concerns about nuclear energy raised in the evidence included radioactive waste,<sup>183</sup> mine site rehabilitation<sup>184</sup> and water usage.<sup>185</sup>
- 1.174 At present, there are no available impact statements to outline the likely effects of nuclear power on Australia’s environment. The Australian Nuclear Association submitted that the current moratorium in the *Environment Protection and Biodiversity Conservation Act 1999* prevents an Environmental Impact Statement from being prepared and assessed in Australia.<sup>186</sup>

### Nuclear as a potential method to reduce carbon emissions

- 1.175 Reducing emissions is a key aspect of the Australian Government’s climate change plan to achieve internationally agreed targets.<sup>187</sup>
- 1.176 The Australian Nuclear Association submitted that:
- The carbon emissions for the whole nuclear fuel cycle are very low and of the order of 40 g CO<sub>2</sub>/kWh. The low carbon emissions of nuclear power is similar to emissions from wind and hydro per unit of electricity produced [IPCC 2014] and slightly less than solar PV. This comparison assumes that methane from hydro is not significant and ignores the emissions from any storage or backup generators for wind and solar. In 2018, nuclear power plants around the world produced 50% more clean electricity than wind and solar combined. In the European Union and USA, nuclear produces more low carbon electricity than hydro. Countries with

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180 Bright New World, *Submission 168*, p. 5.

181 Nuclear for Climate Australia, *Submission 135*, p. 7.

182 World Nuclear Association, *Submission 259*, p. 3.

183 Sample of Friends of the Earth campaign submission (405 received), *Submission 306*, p. [1].

184 Associate Professor Gavin Mudd, *Submission 225*, p. [11].

185 Sample of the Australian Conservation Foundation campaign submission (5,104 received), *Submission 296*, p. 1.

186 Australian Nuclear Association Inc., *Submission 155*, p. 1.

187 Department of the Environment and Energy, ‘Government and international initiatives’, <https://www.environment.gov.au/climate-change/government>, accessed 8 November 2019.

nuclear energy are able to achieve very low carbon emissions from electricity generation.<sup>188</sup>

- 1.177 Mr Ian Hore-Lacy from the Australasian Institute of Mining and Metallurgy said that there is ‘no real realistic decarbonisation prospect for Australia which does not involve nuclear’.<sup>189</sup> He said:

You need a continuous, reliable supply on a considerable scale. If we also want decarbonisation then that points to nuclear rather than coal or gas. Building renewables at the rate we have been is simply saying that we're basically going to depend on gas to fill the gap, which has its own carbon footprint, especially if there's any methane leakage. You need only three per cent methane leakage and you have the same global warming potential as burning coal.<sup>190</sup>

- 1.178 Nuclear for Climate Australia also saw nuclear power as the only option to meet global emissions reduction targets:

Keeping the existing nuclear fleet in operation and adding new capacity can help the world reach its climate goal. Only by rapidly expanding nuclear energy together with renewables and other low carbon sources can we still deliver on the Paris agreement commitments.<sup>191</sup>

- 1.179 Nuclear for Climate added that nuclear nations in Europe had achieved rapid reductions in emissions from power generation. It highlighted that France, ‘which produces approximately three quarters of its electricity from nuclear, has the lowest per capita emissions of the seven largest industrialized countries (G7)’.<sup>192</sup>

- 1.180 Bright New World noted that the Intergovernmental Panel on Climate Change (IPCC) classifies nuclear as a ‘mitigation technology’, in terms of reducing greenhouse emissions, and said that nuclear power is ‘comparable to renewable energy technologies such as wind and solar PV’.<sup>193</sup>

- 1.181 Associate Professor Peter Speck and Dr Henry Askin were both supportive of nuclear power as a method to reduce emissions and as an alternative to coal:

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188 Australian Nuclear Association, *Submission 155*, p. 7.

189 Ian Hore-Lacy, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 21.

190 Ian Hore-Lacy, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 22.

191 Nuclear for Climate Australia, *Submission 135*, p. 5.

192 Nuclear for Climate Australia, *Submission 135*, p. 5.

193 Bright New World, *Submission 168*, p. 5.

With proper management, nuclear power will have little negative environmental impact, and potentially positive impact by reducing carbon emissions.<sup>194</sup>

Because coal is abundant and cheap it fuels the largest part of Australia's baseload electricity generating capacity. This is highly unsatisfactory as coal releases far more carbon dioxide than other fossil fuels per unit of useful energy...Nuclear generation is a zero emission option which could initially augment and eventually supplant combustion technology in providing base load generating capacity.<sup>195</sup>

1.182 Associate Professor Speck cautioned that as nuclear power carries a 'perception of adverse environmental impact', careful management would be required.<sup>196</sup>

1.183 Others were less convinced that nuclear energy offered a true low-carbon alternative. Dr Philip White submitted that:

There is a tendency for nuclear proponents to equate environmental impacts of nuclear power plants with CO<sub>2</sub> emissions during the electricity generation mode and to conclude that nuclear power is good for the environment because it has zero CO<sub>2</sub> emissions.

...it would take considerably more than a decade before the first nuclear power plant came on line. In the meantime, we would have obstructed the development of a reliable, affordable and low greenhouse gas emissions (GHG) electricity system based on renewable energy. Instead, we would have propped up a high GHG emissions system based on coal. So, even though nuclear power plants don't emit much CO<sub>2</sub> during the electricity generation phase...the delay in moving to a low GHG emission system makes them a very bad choice from an environmental perspective.<sup>197</sup>

1.184 The Medical Association for the Prevention of War said:

A critical consideration in relation to nuclear power is the carbon emissions generated by the whole nuclear fuel chain, which are repeatedly overlooked by nuclear proponents. The mining,

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194 Associate Professor Peter Speck, *Submission 108*, p. [1].

195 Dr Henry Askin, *Submission 113*, p. 2.

196 Associate Professor Peter Speck, *Submission 108*, p. [1].

197 Dr Philip White, *Submission 119*, pp. [6-7].

milling, fuel fabrication, enrichment, reactor construction, decommissioning and waste management all use fossil fuels.<sup>198</sup>

1.185 Ms Elizabeth Dangerfield submitted that:

- ...nuclear reactors, even modular ones, take [such] a long time to be approved and built that global warming is likely to be well over 1.5°C before the first reactors come online,
- this would only be an advantage if coal fired power stations in Australia were shut down soon,
- we need to contribute to a worldwide reduction in CO<sub>2</sub> emissions so we would still need to stop exporting our coal and natural gas to other countries,
- Mining, processing and transport of fuel for nuclear power stations produces CO<sub>2</sub> emissions as well as environmental and social impacts such as pollution, land degradation and erosion of Aboriginal customs and rights,
- we could achieve the same results with less cost through renewable energy.<sup>199</sup>

1.186 EcoEnviro submitted:

Whilst many nuclear power plants around the world have a strong safety record, there are a string of recorded incidents of failure of plants around the world... the impacts to the environment from the mining, transport and utilisation of uranium for nuclear generation are avoidable. Cheaper, cleaner options of generation are now available to us on utility-scale wind and solar projects. ... Perhaps a better idea would be to lead the world in renewable energy and new battery storage technologies, rather than heading back down a path that the rest of the world has decided to leave behind.<sup>200</sup>

## Air pollution

1.187 Evidence was also received regarding how nuclear power could result in less air pollution than other methods of electricity generation.

1.188 Nuclear for Climate Australia explained that uranium is an 'energy dense fuel', and that less uranium is required per unit of energy produced than the amount of coal that would be required for the same energy output:

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198 Medical Association for the Prevention of War, *Submission 223*, p. 16.

199 Ms Elizabeth Dangerfield, *Submission 185*, p. 5.

200 EcoEnviro, *Submission 6*, pp. 1-3.

...while a 1000 MWe coal plant would consume about 2.6 million tonnes of coal per year, the equivalent nuclear plant would consume only 25 tonnes of uranium.<sup>201</sup>

- 1.189 Nuclear for Climate added that less fuel usage results in less transport to supply fuel, and the refuelling needs of a nuclear plant keep pollution to a minimum:

Partial refuelling takes place every 18 to 24 months. This means that a nuclear power plant releases very little air pollution and there are very limited truck movements to supply fuel. Most nuclear plant has an operating lifetime of up to 60 years.<sup>202</sup>

- 1.190 The Australian Nuclear Science and Technology Organisation (ANSTO) submitted that regulations in the industry result in careful checks and balances to keep pollution levels as low as possible:

...the nuclear industry is subject to strict regulations and licensing conditions regarding emissions and discharges. Nuclear power plants, and, more broadly all nuclear facilities, are mandated to collect and analyse environmental samples and gaseous discharges to ensure that their environmental impacts are minimised.<sup>203</sup>

## Reduced environmental footprint

- 1.191 The Committee was told that nuclear energy has fewer impacts on the environment than other methods of energy generation, given that it requires less land and fuel per unit of energy produced.

- 1.192 The World Nuclear Association submitted that:

Nuclear plants leave more space for nature. They require far less fuel than their coal or gas equivalents, requiring less extraction and transport infrastructure. They also take up only a small fraction of the space needed for wind and solar farms. A 3.2 GW nuclear power plant on 430 acres produces the same amount of electricity as 130,000 acres of solar panels or 250,000 acres of onshore wind farms.<sup>204</sup>

- 1.193 Women in Nuclear submitted that small modular reactors and Generation IV reactors, in particular, provide:

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201 Nuclear for Climate Australia, *Submission 135*, p. 7.

202 Nuclear for Climate Australia, *Submission 135*, p. 7.

203 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission 166*, p. 19.

204 World Nuclear Association, *Submission 259*, p. 3.

highly capable, scalable power solutions...able to service cities through to small remote towns with a reliable power supply on a reduced footprint in comparison to other energy forms, therefore allowing precious land to be salvaged for agriculture, industry, population grown or for wildlife and green areas.<sup>205</sup>

- 1.194 StarCore Nuclear also compared the land area required to reach the same level of electrical output between different energy production methods, and concluded that the 'environmental risk of not using nuclear power is far greater than the use of nuclear power.' According to StarCore, despite there being over 439 reactors worldwide, they have had a 'largely benign effect on the environment'.<sup>206</sup>

### **Radioactive waste**

- 1.195 ANSTO submitted that waste is an 'important consideration' in discussing the environmental impacts of nuclear energy generation.<sup>207</sup>
- 1.196 In terms of waste impacting the environment, the Australian Academy of Science pointed out that nuclear waste is stored in containers and not released into the air, unlike 'gaseous emissions'.<sup>208</sup>
- 1.197 However, the Committee also received evidence from many concerned individuals saying that hazardous waste would 'pose a direct human and environmental threat for many thousands of years and impose a profound inter-generational burden.'<sup>209</sup>
- 1.198 Radioactive waste is discussed further below.

### **Mining sites**

- 1.199 Mr Dave Sweeney from the Australian Conservation Foundation told the Committee that mine rehabilitation was costly and, to date, largely unsuccessful:

If we look at this country's fledgling engagement with the nuclear industry, we have profound and adverse environmental impacts at existing and former uranium mine sites. Rio Tinto are currently spending in the order of \$1 billion and facing enormous challenges to rehabilitate the Ranger mine site in Kakadu. The public purse will be hit with a new cost – the figures spoken about are in the range of \$200 million to \$250 million extra – in public dollars to

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205 Women in Nuclear Australia Inc., *Submission 154*, p. 4.

206 StarCore Nuclear, *Submission 128*, p. [10].

207 ANSTO, *Submission 166*, p. 19.

208 Australian Academy of Science, *Submission 304*, p. [2].

209 Sample of Friends of the Earth campaign submission (405 received), *Submission 306*, p. [1].

clean up the former Rum Jungle site in the Northern Territory. There is a legacy of leaking tailings dams, underperforming mines and badly or non-remediated sites at every uranium operation.<sup>210</sup>

- 1.200 Associate Professor Gavin Mudd also commented on the rehabilitation efforts at uranium mine sites in Australia:

Australia has not demonstrated successful long-term uranium mine rehabilitation at any site. In other words, all sites still exhibit various problems ranging from local impacts or risks to severe risks to adjacent streams and land use restrictions. Perhaps most alarmingly, there remains a complete lack of agreed standards as to define an acceptable standard of rehabilitation – such as gamma radiation, radon & progeny, water quality, ecosystem re-establishment, erosion – but most critically the time frame over which site monitoring and maintenance needs to occur.<sup>211</sup>

- 1.201 The Queensland Resources Council’s view was that Australia is a world leader in mine rehabilitation. Mr Ian Macfarlane, Chief Executive, told the Committee:

Australia has the ability to supply uranium that is mined under the most stringent environmental standards in the world, where the land is repatriated or rehabilitated under the strictest laws in the world.<sup>212</sup>

- 1.202 Women in Nuclear Australia submitted that the ‘environmental impact of uranium mining is no different to the environmental impact of mining other heavy metals, such as rare earths and other elements used in solar panels or wind turbines.’<sup>213</sup>

- 1.203 Its submission cited research that found solar and wind facilities require up to 15 times more concrete, 90 times more aluminium, and 50 times more iron, copper and glass than fossil fuels or nuclear energy. The submission concluded that ‘the environmental consequences from mining for nuclear energy, therefore, are substantially less than other forms of energy generation.’<sup>214</sup>

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210 Mr Dave Sweeney, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 10.

211 Associate Professor Gavin Mudd, *Submission 225*, p. [11].

212 Mr Ian Macfarlane, *Proof Committee Hansard*, Brisbane, 30 September 2019, p. 4.

213 Women in Nuclear Inc., *Submission 154*, p. 7.

214 Women in Nuclear Inc., *Submission 154*, p. 7.

## Water usage

1.204 More than 5,000 submissions received from individuals via the Australian Conservation Foundation expressed concern that nuclear power consumes too much water.<sup>215</sup>

1.205 Women in Nuclear Australia commented on water usage:

While large amounts of water are used for cooling, 99% of this water is returned to the environment, only a few degrees warmer and free of contaminants as the cooling water is circulated through heat exchanges and is never exposed to radioactive material.<sup>216</sup>

1.206 Its submission suggested that reactors located in coastal regions could desalinate seawater for both their own use and to provide drinking water to populations:

The freshwater usage requirements of a nuclear plant are slightly larger than that of a conventional fossil fuel plant but are not large enough to discount nuclear energy due to this factor alone. In addition, due to the small amounts of fuel used for nuclear energy compared to gas or coal, there is greater flexibility in the location of nuclear reactors. Hence reactors on the coast could desalinate water to cool themselves (or provide drinking water to communities) whilst at the same time generating electricity.<sup>217</sup>

1.207 Nevertheless, the Australian Academy of Science suggested that the water needs of nuclear energy generation may make it an unsuitable technology given the Australian environment. It further submitted that extreme weather events pose 'significant threats'<sup>218</sup>, and noted a number of resultant issues:

Nuclear power can also be disrupted by water scarcity and rising water temperatures, resulting in safety issues including flooding, loss of power, loss of communication, blockage of evacuation routes, and equipment malfunction.<sup>219</sup>

1.208 The Australia Institute submitted:

All thermal generation uses water, but the water requirements of nuclear power stations are 20-83% higher compared to fossil fuel-based power stations. Open loop nuclear power stations withdraw water from an inland water body and circulate it, discharging the

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215 Sample of the Australian Conservation Foundation campaign submission (5, 104 received), *Submission 296*, p. 1.

216 Women in Nuclear Australia Inc., *Submission 154*, p. 7.

217 Women in Nuclear Australia Inc., *Submission 154*, p. 9.

218 Australian Academy of Science, *Submission 304*, pp. [5-6].

219 Australian Academy of Science, *Submission 304*, p. [5].



warmer circulated water back into the original water body. This can lead to thermal pollution by overheating the local ecosystem, affecting fish and aquatic life. Other nuclear power stations are more water efficient but still require vast quantities of water.

Reliance on water for cooling increases vulnerability to extreme heat. Multiple heatwave-related nuclear power plant shut downs occurred in France in the 2019 summer, as the waters surrounding the plants become too warm to provide a cooling function.<sup>220</sup>

- 1.209 ANSTO provided the following comments on nuclear reactors and water usage:

Water usage by nuclear power plants is high, and second only to that required by the agricultural sector. Water is a requirement for cooling; however, the majority of water used in power reactors around the world is derived from the sea, which is returned to the environment only a few degrees warmer and with minimal loss due to evaporation.<sup>221</sup>

- 1.210 ANSTO advised that ‘as an average, water use for the OPAL Cooling Towers with the reactor operating at 20 MWth is 30 m<sup>3</sup> per hour’.<sup>222</sup>

## Comparison with other energy sources

- 1.211 Many submissions and witnesses compared nuclear power to other energy sources, in terms of environmental outcomes.

## Renewables

- 1.212 Mr Terry Vanden Bergh was concerned about the land area needed for large scale solar farms, along with the environmental cost of producing panels and batteries:

...few people consider the implications of solar on a mass scale if it was widely adopted. When the sun is not shining they are not producing. Large surfaces areas will need to be covered to support our growing population, not to mention the environmental impact producing and recycling of these systems will have on the environment. Now that’s before even considering all the mining of rare earth elements that will need to occur to produce the batteries required to store surplus energy for use at night. If we then take

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220 Australia Institute, *Submission 167*, p. 33.

221 ANSTO, *Submission 166*, p. 18.

222 ANSTO, *Submission 166*, p. 40.

into account the lifespan of the batteries and panels then it becomes a very wasteful alternative and environmentally costly.<sup>223</sup>

1.213 Mr Dallas Lane submitted that:

The environmental impact of solar panel and battery manufacture is a problem where toxic waste generally ends up in land fill forever... There is the further short lifetime of batteries and solar panels and the problem of recycling, whereas existing nuclear reactors have demonstrated they can operate for more than 50 years with little maintenance.<sup>224</sup>

1.214 StarCore Nuclear also indicated that there are environmental costs in pursuing renewable energy:

...environmental groups conveniently ignore the cost of mining the minerals needed to make PV panels, including rare elements such as gallium, indium and germanium as a necessary component of the PV technology. These elements are very rare and at this stage there is no commercial method for their recycling. Recycling of PV panels is a looming issue that has yet to be addressed and heavy metals such as cadmium are known to leach into the environment from them.<sup>225</sup>

1.215 SMR Nuclear Technology further submitted that an additional impact, in the form of noise, pointed to nuclear as a better option, stating that 'wind turbines produce significant noise which has an environmental impact and limits their siting. The noise of nuclear cannot generally be heard outside the plant boundary'.<sup>226</sup>

1.216 Not all submissions and witnesses agreed with the above views. For example, the Electrical Trades Union submitted:

Rather than fuel higher carbon emissions and unnecessary radioactive risk, the Australia Government can and should do better. Our shared energy future is renewable, not radioactive and our Government must plan for and support a fair and just transition for energy workers, their communities and the Australian people. The Government needs to focus its efforts on establishing and implementing an actual energy policy based on the science, technical and engineering expertise available to it. Australia needs to embrace the fastest growing global energy sector and become a driver of clean energy thinking and

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223 Mr Terry Vanden Bergh, *Submission 187*, p. [4].

224 Mr Dallas Lane, *Submission 138*, p. [3].

225 StarCore Nuclear, *Submission 128*, pp. [6-7].

226 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 8.

technology. Renewable energy is affordable, low risk, clean, and popular. Nuclear is simply not.<sup>227</sup>

## Coal

- 1.217 Some evidence received commented that nuclear energy is preferable to coal-fired energy due to reduced environmental impacts.
- 1.218 The Australian Academy of Science pointed out that burning coal to produce electricity releases radioactive elements into the environment, as opposed to nuclear power, where waste products are contained. These materials include uranium, thorium and radium; as well as cadmium, lead, mercury, selenium and thallium.<sup>228</sup>
- 1.219 The Academy further submitted that some 10-21 million tonnes of coal ash are produced each year in Australia and around 400 million tonnes are stored in unprotected sites. These sites ‘do not adhere to regulations’, management standards fall ‘below global best practices’, and a number of contamination events have occurred.<sup>229</sup>
- 1.220 StarCore Nuclear mentioned that air pollution from coal fired power plants is not limited to carbon emissions:
- ...despite the technology to contain other fine particulates they emit heavy metals such as cadmium and mercury. Mercury is of particular concern because there is no lower threshold limit below which mercury does not cause damage to human health. Similarly, there are few controls on the ash dumps from coal fired power stations which collectively contain more uranium than has ever been mined as fuel for nuclear power.<sup>230</sup>

## 6. Waste management

- 1.221 According to the Australian Nuclear Science and Technology Organisation (ANSTO), radioactive waste ‘encompasses any material that either is intrinsically radioactive or that has been contaminated by radioactivity, and that is identified as having no further use.’<sup>231</sup>
- 1.222 Around 90 per cent of radioactive waste is classified as low-level waste, and comprises items such as paper, rags, tools, clothing and filters, mostly

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227 Electrical Trades Union, *Submission 164*, p. 3.

228 Australian Academy of Science, *Submission 304*, p. [2].

229 Australian Academy of Science, *Submission 304*, p. [2].

230 StarCore Nuclear, *Submission 128*, p. [8].

231 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission 166*, p. 9.

generated in medical and industrial settings. Despite its large volume, only around one per cent of the radioactivity of all radioactive waste is generated by low-level waste.<sup>232</sup>

- 1.223 Intermediate-level waste has a higher radioactivity, accounting for seven per cent of the volume and four per cent of the radioactivity of all radioactive waste. This waste usually consists of resins, chemical sludges, metal fuel cladding and contaminated materials left behind following the decommissioning of a nuclear reactor. Intermediate-level waste requires a level of shielding.<sup>233</sup>
- 1.224 High-level waste results from nuclear energy generation within a reactor, and generally comprises used fuel and other waste products. Only three per cent of the volume of worldwide radioactive waste is high-level waste, however it comprises 95 per cent of total radioactivity of this waste.<sup>234</sup>
- 1.225 Australia produces and stores both low and intermediate-level waste, but at present neither stores nor produces high-level nuclear waste.<sup>235</sup>

### **Current radioactive waste management in Australia**

- 1.226 Australian Government policy in relation to radioactive waste is set out in the Australian Radioactive Waste Management Framework. The Framework provides principles and long-term goals to form the basis of Australia's national approach to radioactive waste policy making, and ensures that Australia's domestic arrangements align with its international obligations.<sup>236</sup>
- 1.227 Ms Samantha Chard from the Department of Industry, Innovation and Science advised that Australia produces around 40 cubic metres of low-level waste and five cubic metres of intermediate-level waste annually. Most is stored at the ANSTO facility at Lucas Heights, but there are over 100 locations around Australia holding waste.<sup>237</sup>
- 1.228 ANSTO CEO Dr Adi Patterson said that nuclear waste 'is rightly a public concern and rightly something that has to be done correctly'. He noted

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232 ANSTO, *Submission 166*, p. 9.

233 ANSTO, *Submission 166*, p. 9.

234 ANSTO, *Submission 166*, p. 9.

235 ANSTO, *Submission 166*, pp. 9-10.

236 Department of Industry, Innovation and Science, 'Australian Radioactive Waste Management Framework', [https://www.industry.gov.au/sites/default/files/2019-04/australian\\_radioactive\\_waste\\_management\\_framework.pdf](https://www.industry.gov.au/sites/default/files/2019-04/australian_radioactive_waste_management_framework.pdf), April 2018, p. 2, accessed 8 November 2019.

237 Ms Samantha Chard, General Manager, National Radioactive Waste Management Facility Task Force, Department of Industry, Innovation and Science, *Proof Committee Hansard*, Sydney, 20 September 2019, p. 3.

that spent fuel from its research reactor is currently sent to France for reprocessing, with the re-usable elements recycled into French fuel. The residual waste is returned to Australia and stored in special containers at Lucas Heights.<sup>238</sup>

- 1.229 Ms Chard explained that introducing nuclear power to Australia would lead to additional amounts and types of waste:

Australia currently doesn't produce any high-level radioactive waste. So approximately two energy reactors operating over 50 years would double Australia's inventory of radioactive waste and produce a new type of radioactive waste that we currently don't have any arrangements to store.<sup>239</sup>

- 1.230 Dr Henry Askin told the Committee that compared to fossil fuels, nuclear power generation produces only small quantities of waste. He did, however, point out that a 'credible' permanent waste solution would need to be implemented in order for nuclear power to be accepted by the general public.<sup>240</sup>

## Views about radioactive waste

- 1.231 Mr David Sweeney of the Australian Conservation Foundation voiced concerns that nuclear energy is not 'clean' energy because of long-lived radioactive waste:

There is also this talk of nuclear being clean. It is absolutely unacceptable, not proper and actually inconceivably to say that about an energy source that generates three years of reliable electricity – low carbon, granted – in a reactor and then, when those fuel rods are no longer reliable, has them taken out, because they're then spent nuclear fuel, and they're a radioactive waste management issue for up to 100,000 years. Now, that's not a good rate of return – three years of cold drinks, cool beers and warm showers and 100,000 years of needing to be isolated. That's a massive impost on the future. So it's not clean, cheap and safe, and it's not necessary.<sup>241</sup>

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238 Dr Adi Patterson, *Proof Committee Hansard*, 29 August 2019, p. 16.

239 Ms Samantha Chard, General Manager, National Radioactive Waste Management Facility Task Force, Department of Industry, Innovation and Science, *Proof Committee Hansard*, Sydney, 20 September 2019, p. 4.

240 Dr Henry Askin, *Submission 113*, p. 3.

241 Mr Dave Sweeney, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 10.

- 1.232 However, StarCore Nuclear explained that public focus on the length of time these substances remain radioactive may be misplaced, as the more hazardous wastes are those with shorter half-lives:

Central to the nuclear waste debate is that there is a focus on products produced in the fission process that are long lived (have long half-lives). In reality those nuclides with long half-life have less of an effect on human health than those with short half-lives, since they release a small number of radioactive particles. Those with short half-lives such as iodine and caesium which decay quickly, produce a relatively higher number of particles and exit the environment quickly, are of more concern but for periods of about 3 months (not 3,000 years!).<sup>242</sup>

- 1.233 Women in Nuclear agreed, submitting that:

Unlike other toxic wastes, the principle [*sic*] hazard associated with nuclear waste is radioactivity, which diminishes over time. Used nuclear fuel loses 99.9% of its radioactivity in the first 40 years, making it easier to handle and manage.<sup>243</sup>

- 1.234 The Maritime Union of Australia submitted that public anxiety about nuclear waste continues to hinder efforts to find storage solutions for Australia's current needs, and that a nuclear power industry would increase this waste concern. The union pointed out that '[t]he attempts of successive federal governments to construct a nuclear waste facility have been thwarted by persistent community campaigns and legal actions'.<sup>244</sup>

## **Required waste management for a future nuclear power industry**

- 1.235 The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) submitted that if Australia established a nuclear power industry, new arrangements would need to be considered for the treatment of spent fuel and permanent storage of waste.<sup>245</sup> This would include reconsidering the framework for radioactive waste management in Australia; and consideration of a disposal facility for spent nuclear fuel.<sup>246</sup>

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242 StarCore Nuclear, *Submission 128*, p. [7].

243 Women in Nuclear Australia, *Submission 154*, p. 4.

244 Maritime Union of Australia, *Submission 237*, p. 7.

245 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), *Submission 136*, p. 8.

246 ARPANSA, *Submission 136*, p. 8.

1.236 ARPANSA explained that:

Changed arrangements including final management and disposal of spent fuel in Australia would require new facilities and a separate site selection process; it is not within scope for the ongoing site selection process for a NRWMF [National Radioactive Waste Management Framework].<sup>247</sup>

1.237 Dr Ziggy Switkowski described current arrangements for high-level nuclear waste storage in some detail, concluding that:

In effect, that is your high-level waste repository: concrete silos queued up on an open field, where people walk and mow the grass. If you touch the silos they feel vaguely warm, so you know there's something going on. You don't want to linger there for hours or days, but you can certainly walk around. It's been like that for decades, awaiting a more permanent subterranean storage. In the meantime, it's not mysterious and it's not dangerous. You'd have to make a very, very big effort to somehow or other penetrate or compromise the storage. It's inefficient and it's probably not a good use of real estate, but that's what happens around the industry, around the world. So, although communities are easily unsettled at the notion of very long-lived radioactive waste, the way in which it is managed and prepared for subterranean storage is in fact quite simple and, thus far, has proven to be very effective.<sup>248</sup>

1.238 ARPANSA also explained that alternate policies for the transport of waste would need to be considered:

A nuclear power program will see a substantial shift to the status quo of transported radioactive waste with increased transportation over potentially new transport routes, and introduction of new types of wastes not currently transported. Transport of radioactive material is a matter of considerable public concern.<sup>249</sup>

1.239 Nuclear for Climate Australia did not see it as difficult for Australia to change its processes to accommodate waste from nuclear energy generation. The group believed that the current regulatory rules covering radioactive waste disposal in Australia could be easily adapted to include high-level waste:

An Australian Code for Disposal Facilities for Solid Radioactive Waste, ARPANSA 2018] is for low and intermediate level waste.

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247 ARPANSA, *Submission 136*, p. 8.

248 Dr Ziggy Switkowski AO, *Proof Committee Hansard*, Sydney, 20 September 2019, p. 31.

249 ARPANSA, *Submission 136*, p. 8.

This Code could readily be modified to cover disposal facilities for high level waste. The Australian Code is based on the International Atomic Energy Agency General Safety Guide No. GSG-1 Classification of Radioactive Waste (IAEA 2009) which itself covers high level waste.<sup>250</sup>

- 1.240 Women in Nuclear highlighted that the nuclear industry is not waste-heavy:

The volume of waste generated from nuclear energy is significantly less than the volumes generated from other forms of energy. More than 95% of a used fuel assembly is recyclable, which also greatly reduces the lifetime of the waste.<sup>251</sup>

- 1.241 Mr Ian Hore-Lacy from the Australasian Institute of Mining and Metallurgy commented on nuclear waste storage abroad, stating that 'nuclear waste is the most boring aspect of the industry, bar none. The waste is handled. It's well funded. It's extremely safe. It's small in volume.'<sup>252</sup>

## **Permanent storage facilities for radioactive waste**

### **The National Radioactive Waste Management Facility**

- 1.242 The Australian Government has been working for some years to establish a 'single, safe, purpose-built radioactive waste management facility' in this country.<sup>253</sup>

- 1.243 The ANU Energy Change Institute submitted that Australia's current arrangements are unsuitable in the long-term and that the facility must be established:

The current national radioactive waste arrangements are unsustainable in the long term, and the need for a national low-level waste disposal and intermediate-level waste storage facility is clear. Australia has the capability to construct and operate in the long term, a national facility for its own radioactive waste.<sup>254</sup>

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250 Nuclear for Climate Australia, *Submission 135*, p. 11.

251 Women in Nuclear Australia, *Submission 154*, p. 4.

252 Mr Ian Hore-Lacy, Senior Adviser Nuclear, Australasian Institute of Mining and Metallurgy, *Proof Committee Hansard*, Sydney, 20 September 2019, p. 31.

253 Department of Industry, Innovation and Science, 'Managing radioactive waste', <<https://www.industry.gov.au/strategies-for-the-future/managing-radioactive-waste>>, accessed 7 November 2019.

254 ANU Energy Change Institute, *Submission 160*, p. [2].



- 1.244 The Government’s National Radioactive Waste Management Facility Taskforce is considering sites in South Australia,<sup>255</sup> but the planned facility is only intended for low- and intermediate-level radioactive waste, and would not be suitable for high-level waste from nuclear power generation.<sup>256</sup>
- 1.245 ARPANSA explained that under the legislative framework for this facility:  
...any site for establishing a National Radioactive Waste Management Facility (NRWMF) must be volunteered and subject to a comprehensive process of community consultation. A NRWMF cannot be established unless it meets environmental and regulatory approvals under the ARPANS Act, the EPBC Act and the Safeguards Act.<sup>257</sup>
- 1.246 The Australian Government is negotiating with communities in South Australia about siting the proposed National Radioactive Waste Management Facility. The Department of Industry, Innovation and Science submitted that:  
Consultations with the communities have been based on the premise that the proposed facility would primarily support the Australian nuclear medicine industry – not a nuclear energy industry. The facility has not been designed for the disposal or temporary storage of high level waste that would result from the nuclear energy cycle. A different type of facility, likely a deep geological one, will be needed for permanent disposal of high level waste.’<sup>258</sup>
- 1.247 The Committee heard evidence that the negotiations were difficult, and that the communities may not be in favour of the facility. Mr Dave Sweeney from the Australian Conservation Foundation said that:  
Right now, communities in South Australia are taking legal action because they feel disenfranchised about consultation about waste siting.<sup>259</sup>
- 1.248 A joint submission to the inquiry made by a number of environmental groups and conservation councils said of the plans in South Australia:

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255 Department of Industry, Innovation and Science, ‘Managing radioactive waste’, <<https://www.industry.gov.au/strategies-for-the-future/managing-radioactive-waste>>, accessed 7 November 2019.

256 Department of Industry, Innovation and Science, *Submission 211*, p. 1

257 ARPANSA, *Submission 136*, p. 7.

258 Department of Industry, Innovation and Science, *Submission 211*, p. 1.

259 Mr Dave Sweeney, *Proof Committee Hansard*, 1 October 2019, p. 10.

The current push to establish a national radioactive waste repository and store in SA is strongly contested and aspects of the proposal are currently subject to legal challenges and a Human Rights Commission complaint, initiated by Traditional Owners of the targeted sites.<sup>260</sup>

1.249 Prior consultation undertaken by the South Australian Nuclear Fuel Cycle Royal Commission had also showed that community acceptance was not high, with a 'citizens' jury' convened in 2016 rejecting the construction of a high-level waste repository in the state.<sup>261</sup>

1.250 With regard to the site selection in South Australia, the Committee heard that Indigenous groups may have particular concerns. Mr Dwayne Coulthard from the South Australian Conservation Council told the Committee:

...we are currently in discussion with the federal government in regard to a nuclear waste facility here in South Australia. There were two preferred nominated sites, those being Kimba and Hawker – Wallerberdina and Barndioota. In the midst of this discussion about nuclear energy, Adnyamathanha people, and Aboriginal people in South Australia, are very much afraid that we're going to be left with a dump site for our next generation.<sup>262</sup>

1.251 Mr Coulthard added:

We, the people, feel like any destruction to our land is a destruction to our culture, because you can't separate the two. You can't say, 'This little patch of land here is not going to be impacted.' It will have an impact.<sup>263</sup>

1.252 The Australian Human Rights Commission also noted that different parts of the community have alternate views about radioactive waste management:

Agreement on selecting a site for a waste management facility has proven to be contentious in Australia. This is often due to the divergent positions of many groups, including Indigenous peoples.<sup>264</sup>

1.253 The Commission advised that Article 29(2) of the United Nations Declaration on the Rights of Indigenous Peoples states that 'no storage of

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260 Submission by nine national environment groups and state conservation councils, *Submission 219*, p. 36.

261 The Australia Institute, *Submission 167*, p. 35.

262 Mr Dwayne Coulthard, *Proof Committee Hansard*, 2 October 2019, p. 2.

263 Mr Dwayne Coulthard, *Proof Committee Hansard*, 2 October 2019, p. 4.

264 Australian Human Rights Commission, *Submission 161*, p. 3.

hazardous materials shall take place on Indigenous lands without their free, prior and informed consent.’<sup>265</sup>

1.254 The Commission added:

Furthermore, beyond the phases involved for site selection, radioactive waste management facilities will have a long-term impact on the surrounding community, potentially over generations, due to the long half-life of radioactive material. The social, environmental, economic and political context will change over this time which is likely to impact on the nature of Indigenous people’s consent. As the site selection process and advanced stages progress, there is potential for Indigenous peoples’ consent to change during each phase.<sup>266</sup>

1.255 The Commission submitted that in order for Indigenous people to make informed consent, adequate resourcing to representative groups needs to be provided to ensure appropriate and informed consultation.<sup>267</sup>

1.256 Nuclear for Climate Australia did not consider that completion of the national facility was a necessary prerequisite for commencing a nuclear energy industry:

Such a central facility for managing and disposing of low and intermediate level waste would be beneficial to the operation of a nuclear power plant but is not essential. If in the unlikely event that the national radioactive waste management facility is not operational by the time a nuclear power plant is operational, then waste from the nuclear power plant would be stored in an interim storage facility like the other radioactive waste already existing in Australia.<sup>268</sup>

### **A future high-level waste repository**

1.257 The Australia Institute commented that worldwide, there are not yet any operating high-level radioactive waste facilities:

No country has successfully built a deep repository for high-level radioactive waste. Many countries have plans to develop such a repository and one is under construction in Finland. But there is no current example of an operating HLW [high-level waste] repository.<sup>269</sup>

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265 Australian Human Rights Commission, *Submission 161*, p. 4.

266 Australian Human Rights Commission, *Submission 161*, p. 9.

267 Australian Human Rights Commission, *Submission 161*, p. 9.

268 Nuclear for Climate Australia, *Submission 135*, p. 11.

269 The Australia Institute, *Submission 167*, p. 35.

- 1.258 The World Nuclear Association advised that the Finnish facility is due to start accepting high-level waste in 2023.<sup>270</sup>
- 1.259 Dr Philip White submitted:
- Much is made of Finland's SNF [spent nuclear fuel] disposal program. Of all nuclear nations, its program is the furthest advanced for the disposal of SNF from nuclear power plants. Nevertheless, although a licence has been issued for a repository, no spent fuel has been disposed of yet. It is important to realise that obtaining approval for a geological repository does not prove that SNF and HLW high-level waste can be safely disposed of. It just proves that certain procedural hurdles have been cleared. Given the very long half-lives of some of the radionuclides involved, we will not know whether the project was successful for thousands of years.<sup>271</sup>
- 1.260 StarCore Nuclear, however, submitted that the Finnish facility would be safe, stating that the project:
- ...has had its safety aspects studied very intensely over many years by experts and peer reviewed and even in the most pessimistic scenario, the most highly exposed person would receive an annual radiation dose equivalent to eating several bananas.<sup>272</sup>
- 1.261 The Committee heard that Australia is suited to hosting an appropriate high-level waste storage repository, owing to stable geology and hydrological conditions.<sup>273</sup>
- 1.262 Despite this, a number of conservation councils and environmental groups submitted that the high costs of such a repository would be of concern:
- Estimated construction costs for high-level nuclear waste repositories are in the tens of billions of dollars and cost estimates have increased dramatically.<sup>274</sup>
- 1.263 Their joint submission further stated that:
- Operation of waste repositories adds many billions more to the costs. The US government estimates that to build a high-level
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270 World Nuclear Association, *Submission 259*, p. 1.

271 Dr Philip White, *Submission 119*, p. [1].

272 StarCore Nuclear, *Submission 128*, p. [7]. See also section 7 for information about the Banana Equivalent Dose index for understanding radiation exposure.

273 Nuclear for Climate Australia, *Submission 135*, p. 12; Women in Nuclear Australia, *Submission 154*, p. 4; ANU Energy Change Institute, *Submission 160*, p. [2].

274 Submission by nine national environment groups and state conservation councils, *Submission 219*, p. 38.

nuclear waste repository and operate it for 150 years would cost US\$96.2 billion (in 2007 dollars) (A\$143 billion), a 67% increase on the 2001 estimate.

The South Australian Nuclear Fuel Royal Commission estimated a similar figure: A\$145 billion over 120 years for construction, operation and decommissioning of a high-level nuclear waste repository.<sup>275</sup>

1.264 Nevertheless, waste storage could represent a potential economic benefit for Australia. Dr Ziggy Switkowski AO told the Committee that ‘stewardship of the world’s nuclear waste may yet prove to be a significant commercial opportunity for Australia’.<sup>276</sup>

1.265 Similarly, the ANU Energy Change institute said:

...the greatest economic impact of participation in the NFC [nuclear fuel cycle] would be from the storage and disposal of international nuclear waste.<sup>277</sup>

1.266 ANU Energy Change Institute submitted that in addition:

...waste storage would have significant non-proliferation benefits, by removing the rationale for national reprocessing programs for used fuel management reasons, and by removing national accumulations of used fuel which would otherwise be available for reprocessing in the future.<sup>278</sup>

1.267 Regardless of perceived or actual economic benefit and the suitability of the Australian geography for a repository, some submitters argued that previous experience pointed to likely ongoing resistance to a high-level waste repository in Australia.

1.268 Dr White shared his concerns that gaining public acceptance of disposal sites for spent nuclear fuel (SNF) and high-level waste (HLW) would be difficult:

In Australia, the history of attempts to gain approval for storage and disposal sites for low and intermediate level radioactive waste has been traumatic and unsuccessful to date, while attempts to persuade the public to accept international SNF and HLW have been a total failure. There is no reason to believe finding a site for disposal of Australian SNF and HLW would be any easier.<sup>279</sup>

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275 Submission by nine national environment groups and state conservation councils, *Submission 219*, p. 39.

276 Dr Ziggy Switkowski AO, *Submission 41*, p. 2.

277 ANU Energy Change Institute, *Submission 160*, p. [2].

278 ANU Energy Change Institute, *Submission 160*, p. [2].

279 Dr Philip White, *Submission 119*, p. [2].

- 1.269 Similarly, The Australia Institute highlighted the difficulties in establishing such a facility:

There have been many proposals and considerable controversy in Australia over the issue of nuclear waste dumps, for various levels of waste, including HLW, resulting in bitter political fights between and within jurisdictions, and staunch community and legal opposition.<sup>280</sup>

## **Emerging nuclear technologies and waste**

- 1.270 The Committee received some evidence that emerging reactor technologies offer benefits including reduced waste when compared with older models.
- 1.271 ANSTO said that Generation IV reactors are more fuel efficient and produce less waste than previous designs.<sup>281</sup>
- 1.272 Similarly, the Australian Academy of Science advised that some small modular reactors produce less waste due to their higher burn rates, and that SMRs running on thorium as a fuel source produce waste of lower radioactivity.<sup>282</sup>
- 1.273 Mr James Fleay from Down Under Nuclear Energy (DUNE) commented that waste from the nuclear power industry is comparatively small. He drew comparisons between the volumes of waste produced in nuclear energy generation, with the volumes produced by renewables such as wind or solar:

I'm not sure how many solar panels there are in Australia, but I would suggest that it's probably in the tens of millions. Globally, it would be more than that. There is a well-known issue that is coming at nations with renewable energy – and it's not insurmountable, but it is being ignored by industry presently – on what to do with solar panels when they get to the end of their 20-year life. At the moment there is no viable recycling pathway for that. Any viable recycling pathway, not only for solar panels but also for wind turbines, requires an enormous amount of energy to reconstitute those components. It may be worth it in time, but the energy needs to come from somewhere. The point is that solar panels and wind turbines currently go into landfill and the cost of that waste stream is not thoroughly acknowledged. We would say

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280 The Australia Institute, *Submission 167*, p. 35.

281 ANSTO, *Submission 166*, p. 4.

282 Australian Academy of Science, *Submission 304*, p. [1].

that on a comparative basis the waste streams from nuclear are quite small compared to zero-emissions alternatives.<sup>283</sup>

## 7. Public health and safety

1.274 The Committee received evidence from many submitters and witnesses opposed to nuclear energy expressing concern about health risks from radiation exposure, and the safety risks posed by nuclear power including potentially catastrophic accidents.

### Understanding radiation

1.275 Radiation is energy, travelling as waves or particles.<sup>284</sup> Radiation occurs naturally in the atmosphere and soil, in building materials and in food and drink. People also receive radiation exposure from sources such as X-rays and medical treatments, industrial processes and items such as smoke detectors and digital devices.

1.276 Nuclear energy generation involves the use of radioactive substances throughout the fuel cycle. When discussing nuclear energy, concern about radiation usually refers to ionising radiation, which has the potential to affect normal biological processes.<sup>285</sup>

1.277 Mr Terry Ryan submitted that a useful way to understand different levels of radiation exposure is to consider the Banana Equivalent Dose (BED) measure, developed by the University of California. Bananas contain a small amount of radiation (due to their potassium content), and Mr Ryan provided the table at Figure 1 below comparing various background, medical and nuclear power related exposure levels.<sup>286</sup>

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283 Mr James Fleay, Chief Executive Officer, *Down Under Nuclear Energy*, *Proof Committee Hansard*, Perth, 3 October 2019, p. 6.

284 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 'Glossary of terms', <<https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/radiation/glossary>>, accessed 31 October 2019.

285 International Atomic Energy Agency (IAEA), 'Radiation in Everyday Life', <<https://www.iaea.org/Publications/Factsheets/English/radlife>>, accessed 31 October 2019.

286 Mr Terry Ryan, *Submission 14*, p. 3.

**Figure 1 Banana Equivalent Doses (BED) of various forms of radiation exposure**

<b>Radiation source</b>	<b>B.E.D</b>
<b><i>Background radiation in everyday life</i></b>	
Living one day	100
Flying from Brisbane to Perth	400
Living in a concrete, stone or brick building for one year	700
Six months of an average food intake (or twenty-two bananas per day)	4,000
<b><i>Modern technology exposures to radiation</i></b>	
Airport security scan	2.5
Dental x-ray	50
Mammogram	400
Full body CT scan	100,000
<b><i>Radiation exposures from nuclear power</i></b>	
Living within 80 km of a nuclear power station	0.9
Average radiation dose within 16 km of the 3 Mile Island accident	800
Visiting Fukushima for 1 hour, 3 km from the reactors 2 months after the accident	1,000
Average dose of Chernobyl residents after 1986 accident	3,500,000
Non-fatal dose for temporary radiation sickness	10,000,000
Fatal dose of radiation leading to death within two weeks	100,000,000

Source Mr Terry Ryan, *Submission 14*, p. 3.

1.278 Mr Ryan advised that the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) estimates that the average annual Australian radiation exposure is equivalent to around 15,000 BEDs.<sup>287</sup>

### **Public health risks of nuclear power**

1.279 Mr Martin Jane submitted that public health was improved by the use of nuclear power, due to reduced reliance on fossil fuels and avoiding their associated health burdens. Mr Jane pointed to over 3,000 deaths per year in Australia that result from the burning of fossil fuels and associated respiratory illnesses, and stated that:

Nuclear power plants produce no pollution or release any radiation during normal operation... It is estimated by NASA's Goddard Institute that nuclear power plants have saved over 2 million lives by displacing fossil fuel pollution that would have been used instead. If we were to replace fossil fuel generators and

287 Mr Terry Ryan, *Submission 14*, p. 3.



automation with electricity produced from nuclear power, we would decrease negative health outcomes in Australia.<sup>288</sup>

1.280 However, Dr Peter Tait from the Public Health Association of Australia (PHAA) told the Committee that the use of nuclear power is ‘not acceptable from a health perspective’, given alternative energy sources that avoid the risks associated with nuclear power.<sup>289</sup>

1.281 Associate Professor Gavin Mudd spoke about the health aspects of uranium mining, and said that renewables are a safer option:

If you look at the work that has been done internationally through UNSCEAR, the United Nations Scientific Committee on the Effects of Atomic Radiation, when they've looked at these sorts of global dose estimates of the nuclear chain, uranium mining is always very significant in those calculations. That is dominated by the fact that they are assuming exposure only from tailing, so they're not even accounting for waste rock or open cuts and things like that. In terms of relative risk... we also have to look at the different choices of power, and the more I look at these things... I choose renewables any day. I believe they're much safer. The overall public safety, public health costs are much lower. That's even accounting for the radioactivity involved with rare earth mining, which I'm happy to go into if you want me to. But overall I see renewables as much safer.<sup>290</sup>

1.282 Dr Ingrid Johnston from PHAA commented on the health impacts of nuclear accidents:

Along with the immediate and longer-term physical health issues, psychological and social effects are found. Severe healthcare problems are created by evacuation and long-term displacement, especially for the most vulnerable people such as the elderly and those in hospital. Public health responses required after the Fukushima disaster included the evacuation of 150,000 people; stable iodine prophylaxis to reduce the uptake of radioactive iodine by the thyroid; morgue management for radioactive dead bodies; protection of food and drinking water supply, including monitoring intake of contaminated food and water; monitoring of radioactivity and estimations of exposure; a massive

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288 Mr Martin Jane, *Submission 88*, p. [2]. See also *Down Under Nuclear Energy (DUNE)*, *Submission 159*, p. 12.

289 Dr Peter Tait, Public Health Association of Australia, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 24.

290 Associate Professor Gavin Mudd, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 19.

decontamination exercise through disposal of contaminated soil and wastes; and public communication around risks.<sup>291</sup>

- 1.283 SMR Nuclear Technology cited a statement from the UK Tyndall Centre for Climate Change, suggesting that safety risks for nuclear power and renewables are within a similar range:

In 2013, the UK Tyndall Centre for Climate Change, in a report for Friends of the Earth, found that:

"... overall the safety risks associated with nuclear power appear to be more in line with lifecycle impacts from renewable energy technologies and significantly lower than for coal and natural gas per MWh of supplied energy".<sup>292</sup>

- 1.284 Professor M V Ramana noted the ongoing problem of radiation exposure, as it relates to waste products from the nuclear industry. In his review of the technical and social problems of nuclear waste, he emphasised that waste remains harmful for as long as it remains radioactive, and that in storing this waste, humans are contending with an unprecedented issue:

Since radiation is hazardous to health, even at low levels, exposure to these wastes will be harmful to people and other living organisms as long as the wastes remain radioactive. Thus, they have to be isolated from human contact for periods of time that are longer than anatomically modern *Homo sapiens* have been around on the planet.<sup>293</sup>

- 1.285 Environmental groups submitted:

The Committee will likely receive submissions stating or implying that there is a threshold below which exposure to ionizing radiation is harmless. Such views are at odds with expert scientific opinion, including:

- The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) states in a 2010 report that "the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."
- The 2006 report of the US National Academy of Sciences' Committee on the Biological Effects of Ionising Radiation (BEIR) states that "the risk of cancer proceeds in a linear fashion

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291 Dr Ingrid Johnston, Public Health Association of Australia, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 19.

292 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 5.

293 MV Ramana, *Submission 95*, Attachment 1, p. 3.

at lower doses without a threshold and ... the smallest dose has the potential to cause a small increase in risk to humans."<sup>294</sup>

- 1.286 The Australian Nuclear Science and Technology Organisation (ANSTO) submitted that experience has shown that managing waste and spent fuel can be done safely, highlighting its 60 years of efficient waste management<sup>295</sup> and the 25,000 international shipments of used fuel moved without incident.<sup>296</sup>

### Health risks for the nuclear workforce

- 1.287 Some submitters raised concerns about health impacts for workers in the nuclear industry.
- 1.288 Dr Margaret Beavis from the Medical Association for the Prevention of War (MPAW) said that 'nuclear industry workers also have higher rates of leukaemia and solid cancers'. She also remarked that there had been inadequate monitoring of affected populations following the accidents at Chernobyl and Fukushima, which resulted in significantly understated health impacts.<sup>297</sup>
- 1.289 Dr Tilman Ruff from the International Campaign to Abolish Nuclear Weapons Australia (ICAN) told the Committee that it is not possible to separate nuclear power from the associated health risk of contamination.<sup>298</sup> Dr Ruff said:
- ...there is very clear evidence, from the normal operation of nuclear facilities and from every stage of the nuclear chain along the way, that there are routine emissions and that there are health and environmental costs involved for the workers and for downwind and nearby communities.<sup>299</sup>
- 1.290 However, the 2016 South Australian Royal Commission into the Nuclear Fuel Cycle concluded that any radiation exposure for workers would be within acceptable limits:

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294 Environment groups and state conservation councils, *Submission 219*, p. 52.

295 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission 166*, p. 12.

296 ANSTO, *Submission 166*, p. 13.

297 Dr Margaret Beavis, Vice-President, Medical Association for the Prevention of War, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 6.

298 Dr Tilman Ruff, International Campaign to Abolish Nuclear Weapons, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 13.

299 Dr Tilman Ruff, International Campaign to Abolish Nuclear Weapons, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 13.

Data from modern nuclear fuel cycle facilities demonstrates they operate well within the applicable regulatory limits for workers, the public and the environment.<sup>300</sup>

- 1.291 The Minerals Council of Australia submitted that according to the 2019 Australian National Radiation Dose Register (ANRDR), those working with uranium receive relatively low annual doses of radiation, less than the doses received by airline crews and significantly below the recommended maximum dosages.<sup>301</sup>

### **Health risks for nearby communities**

- 1.292 The Committee also heard evidence that some studies show increased health risks for people in communities near nuclear power stations.
- 1.293 The Medical Association for the Prevention of War (MAPW) explained that:
- a German study conducted over 25 years demonstrated that children faced double the risk of leukaemia if living within five kilometres of a nuclear power station, and that their risks remained elevated extending beyond 50 kilometres from a plant.<sup>302</sup>
  - A further study conducted in France found similarly increased levels of risk.<sup>303</sup>
  - A Swiss study examined the risks of cancer for children living in areas of the nation with higher radiation levels and found 64 per cent more cancers and more than double the risk of leukaemia.<sup>304</sup>
- 1.294 MAPW also advised that a 2007 analysis supported by the US Department of Energy considered all available, reliable data worldwide, and concluded that there is a 'statistically significant increase in leukaemia for children living near nuclear power plants.'<sup>305</sup>
- 1.295 Dr Philip White submitted that it is not possible to directly attribute a person's cancer to radiation exposure, but pointed out that studies show that cancer is more likely in those who have been exposed.<sup>306</sup>
- 1.296 ANSTO, however, did not share this level of concern about the health risks to the community. ANSTO submitted that nuclear power is safe,

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300 Report of the South Australian Nuclear Fuel Cycle Royal Commission, 2016, p. 135.

301 Minerals Council of Australia, *Submission 266*, p. 14.

302 Medical Association for the Prevention of War, *Submission 223*, p. 8.

303 Medical Association for the Prevention of War, *Submission 223*, p. 8.

304 Dr Margaret Beavis, Vice-President, Medical Association for the Prevention of War, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 6.

305 Medical Association for the Prevention of War, *Submission 223*, p. 8.

306 Dr Philip White, *Submission 119*, pp. [4-5].

‘outperforming other established electricity generation technologies in human health outcomes.’<sup>307</sup>

- 1.297 Regarding the incidence of cancer resulting from exposure during nuclear accidents, ANSTO cited the example of Chernobyl and stated that increased cancer incidence in the community, related to the accident, had not been established.<sup>308</sup> It submitted that UNSCEAR believed that the effects of the accident on nearby populations were psychosocial rather than negative physical health outcomes.<sup>309</sup>
- 1.298 Similarly, the Committee was advised that no radiation related illness or deaths have been attributed to the accident in 2011 at Fukushima.<sup>310</sup>

### **Safety risks of nuclear power**

- 1.299 With regard to nuclear safety, proponents of nuclear power pointed to the low rate of incident compared to the output in terms of energy, while those against nuclear power were generally concerned with the significant consequences should an accident occur.
- 1.300 The Minerals Council of Australia discussed the historical safety of nuclear power:
- With more than 17,000 cumulative reactor years over the past six decades, nuclear energy generation has resulted in fewer accidents and many fewer deaths and worker injuries than other energy generation sources.<sup>311</sup>
- 1.301 Down Under Nuclear Energy (DUNE) concurred, highlighting that nuclear power is the safest form of energy generation in terms of the number of deaths per unit produced.<sup>312</sup>
- 1.302 ARPANSA CEO Mr Carl-Magnus Larsson said that safety ‘begins with understanding that accidents can occur’ and depends upon technological and human factors.<sup>313</sup>
- 1.303 Professor Lyndon Edwards from ANSTO further contended that historic accidents and the acceptance of risk has resulted in a safer nuclear industry:

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307 ANSTO, *Submission 166*, p. 14.

308 ANSTO, *Submission 166*, p. 15.

309 ANSTO, *Submission 166*, p. 15.

310 ANSTO, *Submission 166*, p. 15.

311 Minerals Council of Australia, *Submission 266*, p. 13.

312 Down Under Nuclear Energy (DUNE), *Submission 159*, p. 12.

313 Mr Carl-Magnus Larsson, Chief Executive Officer (CEO), Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), *Committee Hansard*, Sydney, 29 August 2019, p. 13.

...we all accept that in the aviation industry accidents happen. We accept that risk all of the time when we fly. We also accept that every accident makes the industry safer. That means that, when we fly, we accept the risk. Incidents have gone down. Deaths have gone down. It's got better and better. Philosophically, for the nuclear industry, it's presented the other way around: every accident seems to make nuclear less safe, when actually it makes it safer. This is how continuous improvement happens.<sup>314</sup>

- 1.304 Mr Logan Smith explained to the Committee he saw the common opinion of 'nuclear is dangerous' as an invalid argument, comparing safety within the nuclear industry to safety regulations in other sectors of the economy:

One of the things that comes up – and it's come up a few times today – is that nuclear is dangerous, and I don't consider this a valid argument. I've worked in mining, I've worked in gas and I'm currently working in construction, and, I can tell you right now, in all of those industries every day there are hazards that, if left unchecked, will kill you – hazards like arc flash, confined space, pressurised equipment, BLEVE, suspended loads falling from heights...hydrofluoric acid... However, such risks in industry are managed. We have engineering controls, preventative maintenance, isolation procedures, safe work method statements, barricading and exclusion zones. Radiation protection is just one facet of the overall ethos of working safely in the workplace.<sup>315</sup>

- 1.305 Mr Michael Wright (Electrical Trades Union) said:

Inherently electricity itself is dangerous. You can't see it, you can't smell it and you can't touch it...when all is going well in nuclear, as it usually does, the risks are lower than for comparable generation...The risk of catastrophic damage in which, ordinarily, there will be no survivors in a power plant is the risk that we talk about when we talk about the risk. It is true that there is risk involved in all areas of electricity generation, but again we see the catastrophic risk as being too great in nuclear energy.<sup>316</sup>

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314 Professor Lyndon Edwards, National Director, Australian Generation IV International Forum Research, Australian Nuclear Science and Technology Organisation (ANSTO), *Committee Hansard*, Sydney, 29 August 2019, p. 14.

315 Mr Logan Smith, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 41.

316 Mr Michael Wright, Electrical Trades Union, *Proof Committee Hansard*, 9 October 2019, p. 36.

1.306 PHAA submitted that:

The nuclear fuel process is unsafe - there are direct health and environmental consequences from radioactive leaks, and there is potential contamination at all stages of the process.<sup>317</sup>

1.307 Dr Margaret Beavis from the Medical Association for the Prevention of War said that safety issues are relevant at all stages of the nuclear fuel cycle, not only during power generation at reactor sites. She told the Committee:

...uranium is a key component of nuclear power generation. BHP's Olympic Dam mine in South Australia is exempt from many legislative and regulatory controls. BHP has a record of mine tailings dam failures – most notably, their mine in Brazil in 2015, which destroyed a village and killed 19 people... In June this year, after pressure from investor stakeholders after the dam failures, BHP released a global assessment of all its tailings facilities – where all its mining waste is piled up... five are listed as 'extreme risk'. Extreme risk – and this is an estimate from BHP's own engineers – is a potential loss of life of at least 100 workers. It also means that environmental rehabilitation of the site would be impossible.

Of these five extreme risk sites, one is in the USA, and that mine has been closed. The remaining four extreme risk tailings facilities...are all in Australia. Three out of four are at Olympic Dam. These extreme risk tailings facilities represent a complete failure of regulation of worker safety and also of environmental safety. Yet this year BHP applied to build another tailings facility, and it is highly likely that they will be able to build another one.<sup>318</sup>

## Nuclear accidents

1.308 Many critics of nuclear power pointed to three major reactor accidents as evidence of the risks to public health and safety: those at Three Mile Island (1979, USA), Chernobyl (1986, Ukraine, former USSR) and Fukushima (2011, Japan).

1.309 Dr Philip White, for example, submitted that:

In the Japanese case, a myth of nuclear safety was deliberately propagated by nuclear proponents. Indeed, the belief in absolute safety permeated the nuclear industry itself, including the

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317 Public Health Association of Australia, *Submission 141*, p. [2].

318 Dr Margaret Beavis, Vice-President, Medical Association for the Prevention of War, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 6.

regulators. Anything that challenged this myth was covered up. This included failing to acknowledge or take measures to address known safety risks for fear that to do so would frighten the public and give ammunition to nuclear critics. That is, of course, in addition to the desire to avoid additional expense. This safety myth and this reluctance to address safety problems was one of the root causes of the 2011 Fukushima Daiichi nuclear accident. ... The 1986 Chernobyl disaster was dismissed by the nuclear establishment as a problem specific to Soviet type reactors, but the Fukushima Daiichi nuclear accident proved that optimism to be misplaced.<sup>319</sup>

- 1.310 Others, however, disputed the relevance of these examples when considering a nuclear energy industry in Australia. Bright New World submitted that radiation exposure to the community from the Three Mile Island accident was 'equivalent to a chest x-ray'.<sup>320</sup> ANSTO submitted that there had been no established increase in cancer risk in communities surrounding Chernobyl,<sup>321</sup> and it was noted that there were no recorded deaths from radiation in the Fukushima disaster.<sup>322</sup>
- 1.311 ANSTO submitted that in all three accidents, poor safety culture, operational, design and emergency response flaws were contributing factors.<sup>323</sup>

### **New technology and passive safety**

- 1.312 The Committee heard evidence that new reactor technologies would include design aspects that make them safer than the current fleet of reactors used throughout the world.
- 1.313 SMR Nuclear Technology asserted that emerging small modular reactors would be much safer than traditional nuclear reactors:

Modern SMR designs have now become a game-changer for nuclear safety. Although traditional reactors are safe, SMRs take safety to a new level of "walk-away safety". For example, the NuScale SMR does not require any operator action, backup electrical supplies or water supplies and would have survived even the Fukushima accident. The passive safety systems enable

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319 Dr Philip White, *Submission 119*, pp. [3]-[4].

320 Bright New World, *Submission 168*, p. 15.

321 ANSTO, *Submission 166*, p. 15. However see Dr Donald Higson, *Submission 139*, Attachment 1, p. [2], stating that around 4,000 cases of thyroid cancer are attributed to the accident.

322 Ian Hore-Lacy, 'Nuclear Energy in the 21<sup>st</sup> Century', 4<sup>th</sup> edition, 2018, p. 99.

323 ANSTO, *Submission 166*, p. 16.



the reactor to be cooled indefinitely without attention - “indefinite cooling time”.<sup>324</sup>

- 1.314 Emeritus Professor Erich Weighold agreed, advising that advances in technology make modern reactors ‘extremely safe’:

The probability of core damage or the loss of structural integrity (CDF) for modern nuclear reactors is close to one in a million years. Small Modular Reactors (SMR) are even safer, with a CDF of only 5 in a billion years.<sup>325</sup>

- 1.315 Down Under Nuclear Energy (DUNE) submitted that critics of nuclear energy are erring by comparing historical accidents to current and emerging reactor technologies:

If we are serious, we need to discuss risk of accidents with current generation reactors or what is known as Gen III and Gen IV. These include small modular reactors. It is as silly to look at risk in terms of problems with second generation reactors designed in the 1960’s as it is to look at airline safety with reference to the Hindenburg zeppelin disaster.

In essence, current and coming reactors are completely contained and have passive safety systems. This means that in case of an accident such as an earthquake or monster tsunami the reactors [*sic*] cooling system functions without any external intervention or the need for external power.

In the case of more advanced designs and small modular reactors a meltdown is virtually impossible. Most of these achieve the nuclear triple crown – no power, no additional water and no operator action required to achieve indefinite cooling.<sup>326</sup>

- 1.316 Mr Tristan Prasser pointed out that the older technologies that have suffered accidents in the past are no longer available for would-be nuclear nations to purchase:

The reality is that designs connected to previous nuclear power plant accidents are no longer on the market and thus out-of-scope for consideration. Newer advanced reactor designs (such as Small Modular Reactors (SMRs)) that are coming online or in development are inherently safe as they are designed to operate on the laws of physics rather than use ‘active’ safety mechanisms.

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324 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 5.

325 Emeritus Professor Erich Weighold, *Submission 123*, p. [2].

326 Down Under Nuclear Energy (DUNE), *Submission 159*, p. 12.

This makes the possibility of a Chernobyl-style meltdown significantly reduced or simply physically impossible.<sup>327</sup>

- 1.317 ANSTO, discussing new Generation IV technology reactors, agreed that the designs are 'inherently safe' and could be considered 'walk-away safe' by nuclear regulators.<sup>328</sup> CEO Dr Adi Paterson told the Committee that new technology was resulting in safer reactors:

There's a subset of small modular reactors that are under development around the world which are based on a more rigorous safety case, which is called passive safety. It's an oversimplification, and I really don't want to oversimplify a complex matter, but the principle of passive safety is that, basically, the laws of physics and how fluids move and how cooling can be effected are the primary drivers of the safety case. You are not dependent on human intervention in order to achieve the safety objective and the safety envelope of passively safe small modular reactors.<sup>329</sup>

## The role of the regulator

- 1.318 The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is the Australian Government's nuclear safety regulator and chief authority on radiation protection.<sup>330</sup> As discussed above, ARPANSA told the Committee that it would need further resourcing to achieve the necessary competencies and programs to regulate a national nuclear power industry.
- 1.319 Dr Margaret Beavis of the Medical Association for the Prevention of War was concerned that safety culture was deficient in Australia:

Here in Australia it is self-evident that there is an enormous problem with the safety culture at ANSTO. For many years, there have been repeated accidents and worker exposures, with repeated reprimands and breaches from the regulator, ARPANSA. There have been repeated allegations of management bullying and blaming individual workers.

There have also been numerous near misses. An independent inquiry last year made 85 recommendations to improve safety. Clearly, at ANSTO a safety culture is missing. One has to ask if the

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327 Mr Tristan Prasser, *Submission 274*, p. 2,

328 ANSTO, *Submission 166*, pp. 4-5.

329 Dr Adi Paterson, Chief Executive Officer, ANSTO, *Committee Hansard*, Sydney, 29 August 2019, p. 10.

330 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), *Submission 136*, p. 1.

ANSTO board and senior management understand the critical need for a safety culture. If a small government funded research reactor can't operate safely, what hope is there for the safe operation of a large reactor?<sup>331</sup>

- 1.320 ARPANSA's view was that increased numbers of radiation incidents reflected increased reporting rather than more occurrences.<sup>332</sup> ARPANSA and ANSTO advised the Committee that they were working to address the recommendations made in the 2018 safety review referred to by Dr Beavis.<sup>333</sup> Further, ANSTO submitted that over the past twenty years, only five safety incidents had been reported where a person received a radiation dose in excess of the statutory limit, and that only one of those persons displayed physical symptoms.<sup>334</sup>

## 8. Security and non-proliferation

- 1.321 The Committee was told that there are a number of security implications associated with operating nuclear power reactors in Australia. These implications include:
- risks of sabotage on facilities;
  - risks of theft of nuclear materials from facilities; and
  - wider implications for possible nuclear weapons proliferation.<sup>335</sup>

### Current safeguards in Australia

- 1.322 The key agency governing nuclear security in Australia is the Australian Safeguards and Non-Proliferation Office (ASNO). 'Safeguards' refers to the 'total system for accounting for nuclear materials', and constitutes the measures taken to ensure non-proliferation commitments are fulfilled.<sup>336</sup>
- 1.323 ASNO's responsibilities include:
- the application of nuclear safeguards in Australia;

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331 Dr Margaret Beavis, Vice-President, Medical Association for the Prevention of War, *Proof Committee Hansard*, Melbourne, 1 October 2019, p. 6.

332 ARPANSA press release, 'Radiation safety incidents in Australia', 1 August 2019, <<https://www.arpansa.gov.au/news/radiation-safety-incidents-australia>>, accessed 5 November 2019.

333 Mr Carl-Magnus Larsson, CEO, ARPANSA, *Committee Hansard*, Sydney, 29 August 2019, p. 9; ANSTO, *Supplementary Submission 166.1*, Answer to Questions on Notice, p. [1].

334 ANSTO, *Supplementary Submission 166.1*, Answer to Questions on Notice, p. [2].

335 Australian Safeguards and Non-Proliferation Office (ASNO), *Submission 153*, p. [1].

336 SMR Nuclear Technology Pty Ltd, *Submission 39*, p. 12.

- the physical protection and security of nuclear items in Australia;
  - the operation of Australia's bilateral safeguards agreements; and
  - contribution to the operation and development of International Atomic Energy Agency (IAEA) safeguards and the strengthening of the international nuclear non-proliferation regime.<sup>337</sup>
- 1.324 The *Nuclear Non-Proliferation (Safeguards) Act 1987* (Cth) (Safeguards Act), administered by ASNO, applies to 'all nuclear facilities and all nuclear material in Australia'. The Act provides the framework for ASNO to prevent 'acts of theft or sabotage', and also gives effect to Australia's obligations under various treaties and agreements.<sup>338</sup>
- 1.325 Within Australia, ASNO is responsible for issuing various permits to industry in respect of nuclear materials. While the legislative moratorium would need to be lifted to permit a nuclear power industry to be established in Australia, ASNO noted that the Safeguards Act does not prohibit the granting of a permit to establish or operate a nuclear power reactor.<sup>339</sup>
- 1.326 ASNO further advised that the construction of nuclear power reactors in Australia would not 'substantially affect the application of IAEA safeguards in Australia' but would increase IAEA inspections and reporting. ASNO stated that if Australia were to establish a nuclear energy industry, further responsibilities for the regulator would need to be determined.<sup>340</sup>
- 1.327 The International Campaign to Abolish Nuclear Weapons Australia (ICAN) listed a number of problems it had identified with the current safeguards regime:
- under-resourcing;
  - national sovereignty, commercial confidentiality and secrecy;
  - accounting discrepancies due to conflicting assumptions and measurement issues surrounding fissile materials; and

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337 Department of Foreign Affairs, Defence and Trade, 'About the Australian Safeguards and Non-Proliferation Office', <<https://dfat.gov.au/international-relations/security/asno/Pages/about-the-australian-safeguards-and-non-proliferation-office.aspx>>, accessed 12 November 2019.

338 ASNO, *Submission 153*, p. [1].

339 ASNO, *Submission 153*, p. [1].

340 ASNO, *Submission 153*, p. [2].

- breakdown of safeguards in time of conflict.<sup>341</sup>

1.328 Additionally ICAN explained that the IAEA safeguards only begin at the stage of uranium enrichment, that the IAEA has ‘no mandate’ to prevent the misuse of nuclear facilities and materials, and countries may invoke their right to pull out of the Nuclear Non-Proliferation Treaty and develop a weapons capability, as North Korea has done.<sup>342</sup>

## Security and proliferation considerations for a future Australian nuclear power industry

### Risk of nuclear sabotage

- 1.329 Some evidence received described nuclear power plants as targets<sup>343</sup>, posing a major threat to Australian security.<sup>344</sup> Examples included physical attacks on infrastructure<sup>345</sup>, the possibility of insider attacks<sup>346</sup>, and cyber attacks.<sup>347</sup>
- 1.330 The Medical Association for the Prevention of War (MAPW) submitted that ‘a major coolant loss caused by accident or malice could cause a massive release of radioactive isotopes into the surrounding environment, with profound consequences in terms of morbidity, mortality, social disruption, tourism and agriculture...’.<sup>348</sup>
- 1.331 MAPW noted the importance of proper planning and risk assessment to mitigate the threat of ‘deliberate attacks on infrastructure’. The submission added:
- ...to date there have been no major incidents involving terrorism at nuclear facilities but multiple attempts and minor incursions, including involving the research reactor in Sydney.<sup>349</sup>
- 1.332 The MAPW submission noted reports that nuclear facilities face near-daily cyber-attacks.<sup>350</sup> Dr Philip White also discussed cyber security, explaining

341 International Campaign to Abolish Nuclear Weapons Australia (ICAN), *Submission 157*, pp. 7-8.

342 ICAN, *Submission 157*, pp. 7-8.

343 Sample of Friends of the Earth campaign submission (405) received, *Submission 306*, p. [1].

344 Ms Julia Greenhill, *Submission 124*, p. [1]; Electrical Trades Union, *Submission 164*, p. 7; Sample of the Australian Conservation Foundation campaign submission (5,104 received), *Submission 296*, p. [1].

345 Medical Association for the Prevention of War, *Submission 223*, p. 14.

346 Medical Association for the Prevention of War, *Submission 223*, p. 15.

347 Dr Philip White, *Submission 119*, p. [9].

348 Medical Association for the Prevention of War, *Submission 223*, p. 14.

349 Medical Association for the Prevention of War, *Submission 223*, p. 14.

350 Medical Association for the Prevention of War, *Submission 223*, p. 15.

that it can be 'compromised by the use of third-party contractors who conduct maintenance activities, as well as contractors who update software and hardware and conduct monitoring.'<sup>351</sup>

1.333 Dr White also submitted that nuclear facilities are 'not failsafe against cyber-intrusions'<sup>352</sup>, and went on to warn that:

...a conventional military attack or a cyber attack would result in a direct cost to the nuclear facility due to physical damage and loss of output, but the greater concern is the potential for such an attack to precipitate a catastrophic accident.<sup>353</sup>

1.334 The 2006 Switkowski Review found that:

While proliferation of nuclear weapons remains a critical global issue, increased Australian involvement in the nuclear fuel cycle would not change the risks; nor would Australia's energy grid become more vulnerable to terrorist attack.<sup>354</sup>

1.335 MAPW noted that the US Nuclear Regulatory Commission (NRC) considers nuclear power plants as 'difficult targets due to them being low lying and the reactor core being a small target'.<sup>355</sup>

1.336 ASNO noted that the IAEA provides advice and assistance to states to establish appropriate security infrastructure and to respond to cyber threats.<sup>356</sup>

### **Risk of nuclear theft**

1.337 Dr John Kalish from ASNO said that one of the main threats associated with nuclear security is the potential theft of nuclear material.<sup>357</sup>

1.338 Dr Kalish assured the Committee that ASNO uses a risk-based approach to 'prevent and mitigate' such threats. He said that Australia's arrangements are based on the current 'nuclear footprint' and would need to be amended if Australia introduced nuclear power.<sup>358</sup>

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351 Dr Philip White, *Submission 119*, p. [10].

352 Dr Philip White, *Submission 119*, p. [9].

353 Dr Philip White, *Submission 119*, p. [10].

354 Department of the Prime Minister and Cabinet, *Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia?*, 2006, p. 2.

355 Medical Association for the Prevention of War, *Submission 223*, p. 14.

356 ASNO, *Submission 153*, p. [2]. See also Medical Association for the Prevention of War, *Submission 223*, p. 15.

357 Dr John Kalish, Assistant Secretary, Australian Safeguards and Non-Proliferation Office, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 40.

358 Dr John Kalish, Assistant Secretary, Australian Safeguards and Non-Proliferation Office, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 40.

- 1.339 Dr Kalish suggested that locating a nuclear reactor underground provides ‘additional capacity to safeguard material and reduces the likelihood of theft’.<sup>359</sup>
- 1.340 A joint submission by a number of environment groups and conservation councils highlighted IAEA reporting that showed a total of 424 confirmed incidents of ‘unauthorised possession and related criminal activities’ in the period from January 1993 to December 2013.<sup>360</sup>
- 1.341 Fuelling a nuclear power industry would require the movement of significant amounts of nuclear materials, both new and used. ASNO submitted that nuclear material is ‘most vulnerable during transport’.<sup>361</sup> In his submission, Mr David Jones noted that a nuclear power industry would result in more fuel in transit, and warned of a ‘consequent risk of domestic or international terrorist groups obtaining access to radioactive nuclear material and using it in attacks on the Australian population’.<sup>362</sup>

### Proliferation issues

- 1.342 Some evidence to the inquiry noted a link between nuclear power and nuclear weapons.<sup>363</sup>
- 1.343 The Nuclear Non-Proliferation Treaty (NPT)<sup>364</sup> is the key international agreement regulating the use of nuclear technology. Under the NPT, non-nuclear-weapon States parties commit themselves not to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices, while nuclear-weapon States parties commit not to assist, encourage or induce others to manufacture or acquire them.<sup>365</sup>
- 1.344 The IAEA is entrusted with verifying states’ compliance with the NPT and other non-proliferation agreements, including through its inspection system.<sup>366</sup>

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359 Dr John Kalish, Assistant Secretary, Australian Safeguards and Non-Proliferation Office, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 41.

360 Submission by nine national environment groups and state conservation councils, *Submission 219*, p. 57.

361 ASNO, *Submission 153*, p. [2].

362 Mr David Jones, *Submission 249*, p. 7.

363 International Campaign to Abolish Nuclear Weapons Australia (ICAN), *Submission 157*, p. 2; Medical Association for the Prevention of War, *Submission 223*, p. [1].

364 Treaty on the Non-proliferation of Nuclear Weapons, 729 UNTS 161 (entered into force generally 5 March 1970; entered into force for Australia 23 January 1973).

365 International Atomic Energy Agency, ‘Non-Proliferation Treaty’, <<https://www.iaea.org/topics/non-proliferation-treaty>>, accessed 11 November 2019.

366 International Atomic Energy Agency, ‘Safeguards legal framework’, <<https://www.iaea.org/topics/safeguards-legal-framework>>, accessed 11 November 2019.

1.345 The International Campaign to Abolish Nuclear Weapons Australia (ICAN) outlined its concern about the linkages between nuclear power and nuclear weapons:

The basic technologies for power and weapons are the same:

- Uranium enrichment plants can produce low-enriched uranium for reactor fuel, or highly-enriched uranium for weapons.
- Reactors produce both electricity and fissile (weapons-usable) plutonium...
- Reactors can be operated on a short irradiation cycle to produce plutonium that is ideal for weapons production.
- Reprocessing plants can be used to separate uranium and/or plutonium for re-use as reactor fuel, and they can be used to separate plutonium for weapons.<sup>367</sup>

1.346 Further, ICAN submitted:

...any moves towards nuclear power could be read as a proliferative signal to our neighbours. In other words, if Australia were to adopt nuclear power, other states in our region might seek this technology to lower the barriers to a weapons capability – even if there was no such agenda in Australia.<sup>368</sup>

1.347 The Medical Association for the Prevention of War submitted that:

There are clear historical and current links between the nuclear power industry and nuclear weapons proliferation. Any proposal for Australia to acquire nuclear power is likely to fuel suspicion as to our motives ... and this could in turn promote regional nuclear weapons proliferation.<sup>369</sup>

1.348 The Electrical Trades Union submitted that 'nations in our region may view Australian nuclear aspirations with suspicion and concern'.<sup>370</sup>

1.349 ICAN provided a list of nations aligning nuclear energy and weapons programs:

There is a long history of nation-states using civil nuclear programs as cover for weapons programs – five of the ten countries that have produced nuclear weapons did so under cover of a civil program (South Africa, Pakistan, India, Israel and North Korea) and power reactors have been used to produce plutonium for weapons in most or all of the other five nation-states.<sup>371</sup>

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367 ICAN, *Submission 157*, p. 2.

368 ICAN, *Submission 157*, p. 2.

369 Medical Association for the Prevention of War, *Submission 223*, p. [1].

370 Electrical Trades Union, *Submission 164*, p. 7.

371 ICAN, *Submission 157*, p. 1.



- 1.350 MAPW added France and the UK to this list, stating these nations ‘have used civilian reactors to supply plutonium for their nuclear weapons.’<sup>372</sup>
- 1.351 MAPW also noted a German survey regarding the driving force behind acquiring nuclear energy:
- The German Institute for Economic Research recently surveyed the 674 nuclear power plants that have ever been built. They found that an examination of economic history confirmed that electricity has primarily been used as a coproduct of nuclear power generation. The driving force was military developments and interests, primarily generating weapons-grade plutonium and, especially in the U.S. in the 1950s, developing pressurized water reactor technology to drive submarines.<sup>373</sup>
- 1.352 Dr Donald Higson disagreed with the described link between nuclear energy and nuclear weapons, stating ‘there would be no proliferation risk from a domestic nuclear industry’ and that ‘nuclear power bears no greater relationship to nuclear weapons than petrol fuel does to napalm’.<sup>374</sup>
- 1.353 SMR Nuclear Technology submitted that:
- Australia was one of the first countries to sign and ratify the 1970 *Treaty on the Non-Proliferation of Nuclear Weapons (NPT)* confirming Australia’s position as a nation that will not acquire nuclear weapons. In addition to the safeguards agreement required by the NPT, in 1997 Australia was the first country to sign the *IAEA Safeguards Additional Protocol* giving inspectors rights of access to any site.<sup>375</sup>

### **Emerging nuclear technologies and required safeguards**

- 1.354 The Committee was told that new reactor technologies, including small modular reactors (SMR), have design features that may lower their security and proliferation risks.<sup>376</sup> ASNO submitted that ‘establishing the appropriate security and safeguards arrangements in Australia to meet international standards is readily achievable’.<sup>377</sup>

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372 Medical Association for the Prevention of War, *Submission 223*, p. 4.

373 Medical Association for the Prevention of War, *Submission 223*, pp. 4-5.

374 Dr Donald Higson, *Submission 139*, p. [4].

375 SMR Nuclear Technology Pty Ltd, *Submission 39*, pp. 2-3.

376 ASNO, *Submission 153*, p. [3].

377 ASNO, *Submission 153*, p. [3].

- 1.355 Dr John Kalish from ASNO said that small modular reactors offer a level of ‘proliferation resistance.’<sup>378</sup> He advised that SMRs would use smaller quantities of fuel making theft less attractive. He added:

If the fuel assemblies are modular and they are put into the system and maintained there for many years, there is less movement and exchange of material, so again proliferation sensitivity is reduced and in fact nuclear security is also potentially increased in that situation...

There are a range of other aspects. There is also a suggestion that the small modular reactors would involve what's called high burn-up. So the fuel would remain in the reactor for a long period of time. That reduces the utility of that spent fuel for reprocessing in the production of a plutonium 239 device, because more of the material within the reactor forms a non-fissile form of plutonium, plutonium 240.<sup>379</sup>

- 1.356 Thorium fuel reactors are another example of an emerging technology which may reduce the risk of proliferation. A number of submitters explained that the thorium process does not produce fissile material suitable for nuclear weapons production.<sup>380</sup>

- 1.357 On the other hand, ANSTO cautioned that the production of uranium-233 during the thorium fuel cycle ‘presents a potential proliferation risk that would require similar safeguards to those that are established for the current uranium fuel cycle’.<sup>381</sup> ICAN submitted that:

...the proliferation risks associated with thorium are comparable to the risks associated with conventional uranium reactor technology.<sup>382</sup>

- 1.358 Further, ICAN claimed that other emerging technologies, such as ‘integral fast reactors’, ‘molten salt reactors’ and other small modular reactors, were also able to produce fissile material for nuclear weapons.<sup>383</sup>
- 1.359 Dr Kalish said that locating facilities in remote areas posed challenges for security, as the ability for appropriate armed or police forces to intervene

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378 Dr John Kalish, Assistant Secretary, Australian Safeguards and Non-Proliferation Office, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 41.

379 Dr John Kalish, Assistant Secretary, Australian Safeguards and Non-Proliferation Office, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 41.

380 See for example: Mr James Graham, *Submission 104*, p. [5], Mr Craig Tamlin, *Submission 125*, p. 3; Mr Tony Hine, *Submission 214*, p. [3]; Mr Ian Liley, *Submission 232*, p. [4], Mr Clem Grieger, *Submission 302*, p. 26.

381 ANSTO, *Submission 166*, p. 7.

382 ICAN, *Submission 157*, p. 3.

383 ICAN, *Submission 157*, pp. 4-5.

in the event of an incident may be reduced, and as remote locations may present opportunities for easier intrusions.<sup>384</sup>

## 9. National consensus and community engagement

1.360 Many submitters to the inquiry discussed the importance of community acceptance to any successful establishment of nuclear energy in Australia. One submission summarised that ‘the single biggest challenge for this inquiry will be to gain public support’.<sup>385</sup>

1.361 Dr Ziggy Switkowski said:

As I'm sure the committee is aware, currently there is no bipartisan support for a nuclear energy strategy. The community sentiment is mixed, and the topic of nuclear energy produces strong, often emotional opposition from some quarters and is readily undermined by scare campaigns. There is no social licence at this time.<sup>386</sup>

1.362 During the inquiry, the Committee’s attention was drawn to a number of surveys of public opinion in relation to nuclear power, with varying results. A Roy Morgan survey on Australian Attitudes to Global Warming was conducted in September 2019. Key findings published on 7 October 2019 included that:

- 51% of respondents believed Australia should develop nuclear power to reduce Australia’s carbon dioxide emissions, a rise of 16% since 2011. 34% opposed nuclear power in Australia and 15% were undecided.
- When the question was asked without the reference to reducing carbon emissions, 45% were in favour of nuclear power and 40% against.
- 58% of respondents would oppose a nuclear power plant being built in their area (down 17% since 2011).
- Support for nuclear power in Australia was distinguished by gender, with 65% of men and 38% of women in favour.<sup>387</sup>

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384 Dr John Kalish, Assistant Secretary, Australian Safeguards and Non-Proliferation Office, *Proof Committee Hansard*, Canberra, 18 October 2019, p. 41.

385 Mr Ronald James, *Submission 89*, p. 3.

386 Dr Ziggy Switkowski, *Proof Committee Hansard*, 29 August 2019, p. 2.

387 Roy Morgan, ‘A narrow majority of Australians want to develop nuclear power to reduce carbon dioxide emissions’, *Finding No.8144*, 7 October 2019, <https://www.roymorgan.com/findings/8144-nuclear-power-in-australia-september-2019-201910070349>.

1.363 The Australia Institute submitted the findings of its 2019 *Climate of the Nation* report:

nuclear power remains greatly divisive in Australia. Asked about their preferred source of energy, 22% placed nuclear in their top three and 11% placed it first, a small increase over the previous year. Yet even more placed it last (34%) and most (59%) placed it in their bottom three, making nuclear about as unpopular as coal.<sup>388</sup>

1.364 Dr Switkowski and others believed the 2011 Fukushima disaster had reversed a previously growing level of support for nuclear power in the Australian community.<sup>389</sup>

1.365 The Committee received evidence that public sentiment had shifted on this issue, and that the majority of the Australian community today was unlikely to oppose the introduction of nuclear energy. Mr James Graham, for example, submitted:

Most Australians understand Australia's narrowing energy options and the challenge these present. They would be accepting of nuclear energy provided it is safely and responsibly implemented, with any potential for proliferation eliminated.<sup>390</sup>

1.366 Nuclear for Climate Australia submitted that community presentations conducted by the Australian Nuclear Association were hearing a change:

The issues being raised by the public at these presentations are evolving. Two or three years ago they were reactor safety, radiation and cancer. These days a level of real interest exists in actually how nuclear energy can meet both our economic and environmental needs. Positivity is replacing anxiety.<sup>391</sup>

1.367 The Minerals Council of Australia submitted that:

Nuclear power's safety record demolishes the argument that nuclear energy should be banned because it is dangerous. Its public acceptance in communities around the world where it has operated for decades negates the argument that it should be banned because communities do not accept it. Despite two decades of legal prohibition, nuclear energy commands net

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388 The Australia Institute, *Submission 167*, p. 36 (footnote omitted).

389 Dr Ziggy Switkowski, *Proof Committee Hansard*, 29 August 2019, p. 3. See also Mr Gershon Nimbalkar, *Submission 109*, p.[1]; Dr Phillip White, *Submission 119*, p. [2]; Dr Donald Higson, *Submission 139*, p. [3].

390 Mr James Graham, *Submission 104*, p. 10.

391 Nuclear for Climate Australia, *Submission 135*, p. 29. See also VIMY Resources, *Submission 251*, p. 4; Australian Taxpayers' Alliance, *Submission 263*, p. 11.

positive support in Australia in the most recent polls, shattering the argument that the public is not ready for it to be legal.<sup>392</sup>

- 1.368 However, the Committee also received many expressions of strong continued opposition to nuclear energy in Australia. These included a ‘Civil Society Statement on Domestic Nuclear Power’ opposing nuclear energy, endorsed by 55 non-governmental organisations including environmental, union, church-based and professional groups.<sup>393</sup>
- 1.369 In addition, campaigns conducted by two non-government organisations generated 5636 form letters and short submissions from individuals to the inquiry.<sup>394</sup> These comprised:
- 4535 identical letters from supporters of the Australian Conservation Foundation (ACF);
  - 569 copies of the ACF letter with additional or amended text included by the submitters;
  - 337 identical letters from supporters of Friends of the Earth (FoE);
  - 68 copies of the FoE letter with additional or amended text included by the submitters; and
  - 127 short submissions received via the ‘DoGooder’ campaign website. All but a handful of these expressed opposition to the introduction of nuclear energy in Australia.
- 1.370 One point repeatedly made to the Committee by those both for and against nuclear power was that bipartisan political support would be necessary to gain community acceptance.<sup>395</sup> Mr Anthony Wood emphasised the importance of meeting ‘as fellow Australians seeking solutions to our perceived problems and willing to judge proposals on their merits’, rather than ‘as antagonists trying to overwhelm opposition to some preconceived solution developed in the party room’.<sup>396</sup>
- 1.371 Nuclear for Climate Australia believed that ‘[t]he chances for a bi-partisan approach may be enhanced by the use of community forums where short term political opportunism can be defused’.<sup>397</sup>

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392 Minerals Council of Australia, *Submission 266*, p. 5.

393 *Submission 172*.

394 See *Submission 282*, *Submission 296* and *Submission 306*.

395 See, for example, Mr Michael Angwin, *Submission 50*, p. [6]; Mr Ronald James, *Submission 89*, p. 11; Dr Phillip White, *Submission 119*, pp. [8-9]; Nuclear for Climate Australia, *Submission 135*, p. 31; Dr Ian Burston, *Submission 215*, p. 1; 1Medical Association for the Prevention of War, *Submission 223*, p. 18; Mr Trevor Robotham, *Proof Committee Hansard*, 1 October 2019, p.46; Mr Barry Murphy, *Proof Committee Hansard*, 9 October 2019, p. 55.

396 Mr Anthony Wood, *Submission 116*, p. [3].

397 Nuclear for Climate Australia, *Submission 135*, p. 30.

## Public education and community consultation

- 1.372 The Committee received evidence recommending public education and further discussion of the issues related to energy.
- 1.373 For example, Mr Anthony Wood submitted that '[o]n global warming we heed the advice of the experts. On reactor accidents we listen to anecdotal evidence often by the media which is usually designed to impress rather than inform'. He recommended more public education about radiation and nuclear issues, including in schools.<sup>398</sup> Mr Geoff Russell argued that once modern science was understood, '[p]ublic angst will drop to a realistic level and risks associated with nuclear power will be seen for what they are; far lower than those of air travel or bacon, for example'.<sup>399</sup>
- 1.374 Dr John Patterson commented on the citizen jury sessions held following the South Australian Royal Commission. He said:
- I attended as an observer two of the citizen jury sessions. ...afterwards I spoke to a few of the delegates, and the message that came back from the general public was that they were confused. I spoke to, in particular, a couple of ladies there who said, 'For every argument that the experts put on one side, there's a counterargument on the other side, and we don't know who to believe.' So I leave that to you regarding the discussions on social licence, which are very important, I understand. Somehow we need to communicate to the general public and try to remove some of this confusion that I experienced after those citizen juries.<sup>400</sup>
- 1.375 Nuclear for Climate Australia submitted that:
- The lessons learned from the South Australian Nuclear Fuel Cycle Royal Commission with community engagement must not be repeated. Rushing to a "Citizens Jury" that lasted over a few weekends was a mistake. Understanding and assimilating the benefits of nuclear energy takes time and people need to become familiar with the issues.<sup>401</sup>
- 1.376 Nuclear for Climate Australia recommended that community consultations needed to focus on the key issues of environmental impact, reprocessing and disposal of waste, electricity prices, training and employment opportunities, and safety concerns.<sup>402</sup>
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398 Mr Anthony Wood, *Submission 116*, pp. [4-5].

399 Mr Geoff Russell, *Submission 93*, p. 3.

400 Dr John Patterson, *Proof Committee Hansard*, 2 October 2019, p. 6.

401 Nuclear for Climate Australia, *Submission 135*, p. 30.

402 Nuclear for Climate Australia, *Submission 135*, p. 31.

1.377 The ANU Energy Change Institute submitted the findings of a national symposium of around 70 participants held in 2017 to discuss the outcomes of the South Australian Royal Commission. The symposium assessed that ‘a social licence to operate will not be achieved quickly. It will take time, transparency and extensive consultation’. The symposium concluded that ‘distributed fairness and procedural fairness were critical to building trust and acceptance’, as was confidence in government to be able to manage the personal and environmental risks associated with nuclear energy.<sup>403</sup>

1.378 The symposium recommended:

that expertise in the humanities and social sciences be engaged to study the evolution and determining factors for public opinion on nuclear issues in Australia. This could be facilitated by engaging the Australian Academy of the Humanities (AAH) and the Academy of Social Sciences in Australia (ASSA) to propose jointly with the cosponsors of the Symposium, an [Australian Council of Learned Academies] ACOLA research project on the [nuclear fuel cycle] social license to operate...<sup>404</sup>

1.379 Mr Ronald James offered a recommendation to ‘develop and deliver extensive Australia-wide community awareness and consultative programs to “bring the community” on the journey.’<sup>405</sup> Mr James expanded on his views in this regard at a public hearing of the Committee:

A major public awareness program will be the deciding factor to enable the successful introduction of nuclear energy into Australia...I believe the first things that need to be done, assuming those prerequisites are acknowledged, are to undertake a comprehensive public education and awareness program about the benefits of nuclear energy in the 21st century and to amend the *Australian Radiation Protection and Nuclear Safety Act 1998* and the *Environment Protection and Biodiversity Conservation Act 1999* to permit the development of nuclear power. Since these acts were proclaimed the issue of climate change has gained massive momentum, and this legislation is now grossly out of date and counterproductive. We need to develop a plan for long-term sustainability of energy supply that identifies where we are now, where we want to be in 2050 and how we get there.<sup>406</sup>

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403 ANU Energy Change Institute, *Submission 160*, p. [3].

404 ANU Energy Change Institute, *Submission 160*, p. [3].

405 Mr Ronald James, *Submission 89*, p. 18.

406 Mr Ronald James, *Proof Committee Hansard*, 30 September 2019, p. 22.

- 1.380 Some views advised caution or expressed scepticism about public education. For example, Ms Noel Wauchope offered a view on public education programs:

...those who are pro-nuclear believe that the only experts we need to listen to are engineers, nuclear engineers, chemists that relate to the nuclear industry – people who are already involved in the nuclear industry...I feel that if there were an education program it would happen the way it's happening in America. The nuclear lobby would set up little groups in universities, give the universities plenty of funding and promote the story that only nuclear engineers know what it's all about.<sup>407</sup>

- 1.381 Mr David Jones argued that both in Australia and globally, the nuclear industry has 'a poor record of community engagement', and added that:

The nuclear power industry and its protagonists typically characterise opposition to nuclear power generation as "uninformed", "emotional" and "ideological".

The reality is that community opposition to nuclear power generation is generally both well-informed and based on sound rational objections.<sup>408</sup>

- 1.382 Mr Michael Angwin noted the importance of focusing on trust, stating that '[t]here is a rational basis for nuclear fear and it cannot be overcome by the wider and wiser collection and dissemination of facts...Nuclear fear can only be addressed by building trust and then nurturing it'.<sup>409</sup> Mr Angwin added that a trust-based strategy must be based on behaviour rather than narrative, respect people's fears and concerns, and acknowledge that sufficient community support may or may not be forthcoming.<sup>410</sup>

- 1.383 The South Australian Government reflected on its experience:

The Royal Commission emphasised the critical importance of social consent to the adoption of any new nuclear activity (including nuclear power) finding that:

Efforts over recent decades internationally to develop nuclear projects by focusing on technical considerations without an equal or even greater emphasis on systematic engagement with the community have commonly failed.

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407 Ms Noel Wauchope, *Proof Committee Hansard*, 1 October 2019, p. 38.

408 Mr David Jones, *Submission 249*, p. 6.

409 Mr Michael Angwin, *Submission 50*, p. [1].

410 Mr Michael Angwin, *Submission 50*, pp. [5], [7-8].



Further, the Royal Commission's report identified several key characteristics of successful processes that had sought community consent for new types of nuclear facilities. These characteristics included:

- Transparency of decision making;
- Willingness to accept long community engagement timeframes;
- Early and deep engagement with local communities to build knowledge and understanding; and
- Availability of scientific evidence and where necessary, multiple corroborating bodies of evidence to demonstrate the effectiveness of steps taken to address risks.<sup>411</sup>

1.384 Ms Chloe Munro from the Australian Academy of Technology and Engineering suggested that the Government's approach to wind farms could provide a useful model for community consultation:

As a part of the package for settling the review of the Renewable Energy Target, the Australian government established the National Wind Farm Commission. I think that has been very successful in terms of the quality of community engagement that the commissioner has embarked on. There were a number of communities that had concerns or some open complaints. The commissioner was very diligent in visiting those communities and resolving those issues. He was very firm in his findings and also reported on the quality of engagement by the industry and made recommendations on how that could be improved. I think that's had enormous benefit for the acceptability of wind generation in the communities. Not all communities are necessarily going to be settled in that view, but the intensity of that process, I think, has been very helpful. It strikes me that, if Australia were to pursue nuclear power, some equivalent function of a nuclear power commissioner who could lead that community engagement and deal very directly with local concerns would be a very helpful approach.<sup>412</sup>

1.385 Mr Gershon Nimbalker submitted, however, that 'marketing spin and government sponsored efforts' would be counter-productive, and instead proposed that governments '[w]ork with effective grassroots campaigners to get the message across', and focus on 'authentic and credible stories' from people who live with or near nuclear power.<sup>413</sup>

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411 Government of South Australia, *Submission 297*, p. 5.

412 Ms Chloe Munro, *Proof Committee Hansard*, 1 October 2019, p. 48.

413 Mr Gershon Nimbalker, *Submission 109*, p. [1].

- 1.386 Although opposed to the introduction of nuclear energy in Australia and believing it would be divisive, Dr Phillip White offered the following view:

One tool... could be to foster deliberative forums which enable ordinary citizens to objectively consider Australia's climate and energy options. The process could begin at the local level and build on these local discussions towards state-based and/or national forums. Politicians should listen carefully and respectfully to the considered opinions that emerge and studiously resist the temptation to use them for partisan purposes.

Nuclear energy could be one of the options that is discussed. Participants need to be given the opportunity to weigh up the merits and demerits of all the alternatives. The concern is not that ordinary citizens would not make sound judgements in a free and open deliberative process. Rather, it is that politicians and bureaucrats would try to rig the process to achieve a predetermined outcome.<sup>414</sup>

- 1.387 Professor John Quiggin submitted that the only way to achieve national consensus in support of nuclear power is to achieve 'unequivocal acceptance of mainstream climate science', and the adoption by government of 'radically more ambitious goals' to reduce CO2 emissions.<sup>415</sup>
- 1.388 Dr Heiko Timmers proposed that Australia may in the next twenty years focus on nuclear measures other than establishing a nuclear power capacity, such as sustained export of yellowcake (uranium), contributing to international research and establishing a successful spent fuel repository, as part of 'taking ethical and environmental responsibility for the planet and helping to limit carbon-dioxide emissions'. Such measures 'may generate an increased confidence among Australia's citizens that nuclear technologies can be managed safely and that they can be good for the nation'.<sup>416</sup>

## Indigenous land

- 1.389 The Committee received evidence relating to Indigenous Australians' relationship with the land, and the importance of their consent in relation to decisions about nuclear facilities. This mainly focused on proposals to establish nuclear waste disposal facilities, as discussed above.

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414 Dr Phillip White, *Submission 119*, pp. [8-9].

415 Professor John Quiggin, *Submission 16*, p. 3.

416 Dr Heiko Timmers, *Submission 63*, p. 3.

1.390 Associate Professor Peter Speck said:

Indigenous Australians... are... not terribly trusting of governments, and, given that a lot of nuclear assets are likely to be sited in out-of-the-way places, the Indigenous Australian view is one that I believe should be carefully considered, and there should be a great deal of respectful consultation undergone with Indigenous Australians and the broader population.<sup>417</sup>

1.391 The Australian Human Rights Commission (AHRC) provided a submission about Australia's obligations under international human rights law to ensure the consent of Indigenous peoples for radioactive waste management facilities. In this context, the AHRC elaborated on the meaning of the human rights principle of 'free, prior and informed consent':

It is much stronger than an obligation simply to provide information or 'consult' with Indigenous peoples. Obtaining free, prior and informed consent entails a process of ongoing discussion and engagement with Indigenous peoples. Furthermore, processes of engagement must be able to accommodate the complexities and inter-relatedness of Indigenous societies and a wide range of issues and players. The process must therefore be managed on a case-by-case basis and not through a 'one-size-fits-all' model of consultation.<sup>418</sup>

1.392 More generally, Mr Dwayne Coulthard from the South Australian Conservation Council told the Committee that:

A lot of these uranium deposits and a lot of the stuff that you find in uranium are very much associated with sacred stories and sacred sites. A lot of the minerals and such that you would find associated with sacred sites are very much connected with the stories that the old people would tell...So any discussion about creating a nuclear energy reactor, small or large – it would obviously happen on Aboriginal land, so that would obviously have to be taken into consideration, because it's a long legacy to leave.<sup>419</sup>

1.393 Councillor Dominic Wy Kanak requested that:

...the Committee apply an Aboriginal First Nations Indigenous 'Sovereignty' lens to all the Committee's Terms of Reference for this Inquiry...and seek as a fundamental prerequisite the views

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417 Professor Peter Speck, *Proof Committee Hansard*, 2 October 2019, p. 26.

418 Australian Human Rights Commission, *Submission 161*, p. 6 (footnote omitted).

419 Mr Dwayne Coulthard, *Proof Committee Hansard*, 2 October 2019, pp. 1-2.

and Approval of the First Nations Peoples of Australia. As Custodians, Descendants of Our Commonwealth's First Nations Peoples should decide if there should be any change to the moratoriums currently preventing an expansion of the nuclear industry in Australia.<sup>420</sup>

1.394 Cr Wy Kanak expressed the view that without First Nations consensus, the national consensus required for nuclear energy 'is void'.<sup>421</sup> He noted the long history of opposition to nuclear facilities by Australia's Aboriginal people, and inadequate consultation in relation to past nuclear testing and activities on Indigenous land, and requested that the Government dispense with proposals for nuclear energy and instead focus on how to move to a 100 per cent renewable energy market.<sup>422</sup>

1.395 The Committee heard from Aboriginal women representing the Australian Nuclear Free Alliance, including Ms Shelly Haseldine, who said:

I was fortunate enough to grow up on my father and grandmother's country, on the far west coast of South Australia, in Ceduna...My grandmother's strong desire to keep the land as it is has inspired me to follow in her footsteps and protect our beautiful country and our cultural way of life. Through my grandmother's experiences I have grown up witnessing the after-effects of the nuclear bomb test at Maralinga and Emu Field. I am currently undergoing tests for thyroid issues, and so is my nanna. As a young Aboriginal woman, I have seen and familiarised myself with how the government has continuously ignored Indigenous and wider community calls to stop uranium mining and nuclear usage, which both threaten all of our futures.<sup>423</sup>

1.396 Mr Coulthard also spoke about the shadow cast by past nuclear activities on Australia's Indigenous communities:

The atomic testing was back in the fifties, and they're still talking about it today in regard to the impacts it had. It remains very much a contentious issue for the communities, especially as the interface that we've dealt with it through is mining. There hasn't been any real discussion within Aboriginal communities, and what this actually means would need to be explained quite clearly. But, like I said, the previous history certainly left a bad taste...

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420 Cr Dominic Wy Kanak, *Submission 22*, p. [1].

421 Cr Dominic Wy Kanak, *Submission 22*, p. [1].

422 Cr Dominic Wy Kanak, *Submission 22*, p. [3].

423 Ms Shelly Haseldine, *Proof Committee Hansard*, 18 October 2019, p. 21.

especially in South Australia, which, as I hear, is one of the leaders in renewable energy. Yet here we are talking about a nuclear reactor or creating nuclear energy here in Australia.<sup>424</sup>

- 1.397 Mr Coulthard commented on how nuclear energy should be discussed with Indigenous communities:

I can't speak on behalf of all Aboriginal people here in South Australia. I'll only speak on behalf of, I guess, my own experience engaging with communities where English could be a second, third or even fourth language for some people in our state...

One of our biggest things is that you have to find a way to explain the process without being so verbal. So I would strongly encourage that a lot of visual presentations are used and diagrams to take it away from these technical terms... That language won't necessarily be accessible or won't be readily understood by certain communities... It's actually quite technical and quite scientific. So my suggestion would be to contact the local community. Get a community spokesperson or engagement officer that can help you facilitate any kind of discussions, because, like I said, this is a very technical aspect that can really just fly over a community's head if they're not given their own opportunity to engage with that information in a way that's done by them, for them. So empowering community to be part a of this process rather than just participants and actually being engaged in a way that really makes them feel like they're being spoken with, not to or on behalf of. They're actually leading the conversation.<sup>425</sup>

- 1.398 Professor Hans Bachor from the Australian Academy of Science said:

The Indigenous communities must be engaged respectfully and any form of tension must be avoided. This includes ensuring Indigenous communities are involved in the decision-making process, avoiding tactics that result in division between Indigenous communities and avoiding exerting pressure on traditional owners, including legal threats.<sup>426</sup>

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424 Mr Dwayne Coulthard, *Proof Committee Hansard*, 2 October 2019, p. 2.

425 Mr Dwayne Coulthard, *Proof Committee Hansard*, 2 October 2019, p. 2.

426 Professor Hans Bachor, *Proof Committee Hansard*, 18 October 2019, p. 33.

