REPORT ON PROCEEDINGS BEFORE

STANDING COMMITTEE ON STATE DEVELOPMENT

URANIUM MINING AND NUCLEAR FACILITIES (PROHIBITIONS) REPEAL BILL 2019

CORRECTED

At Macquarie Room, Parliament House, Sydney, on Monday 11 November 2019

The Committee met at 9:15

PRESENT

The Hon. Taylor Martin (Chair)

The Hon. Mark Banasiak
The Hon. Mark Buttigieg
The Hon. Wes Fang
The Hon. Scott Farlow
The Hon. Mark Latham
The Hon. Natasha Maclaren-Jones
The Hon. Mick Veitch (Deputy Chair)

The CHAIR: Welcome to the first hearing of the uranium mining. The inquiry has been established to inquire into the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019. The object of this bill is to repeal the ban on uranium mining in New South Wales, which has been in place since the enactment of the Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986. This inquiry is a fact-finding mission to consider if New South Wales should investigate the viability of nuclear power as an energy source.

Before I commence, I acknowledge the Gadigal people, who are the traditional custodians of this land. I also pay respect to the Elders, past and present, of the Eora nation and extend that respect to other Aboriginals present. Today we will hear from a panel of witnesses representing NuScale power, SMR Technology and the Energy Policy Institute of Australia. I do not believe that is accurate. That may apply to the previous hearing. Before we commence, I will make some brief comments about the procedures for today's hearing. Today's hearing is open to the public and is being broadcast live via Parliament's website. A transcript of today's hearing will be placed on the Committee's website when it becomes available.

In accordance with the broadcasting guidelines, while members of the media may film or record Committee members and witnesses, people in the public gallery should not be the primary focus of any filming or photography. I also remind media representatives that you must take responsibility for what you publish about the Committee's proceedings. It is important to remember that parliamentary privilege does not apply to what witnesses may say outside their evidence at the hearing here today. I urge witnesses to be careful about any comments you may make to the media or to others after you complete your evidence, as such comments would not be protected by parliamentary privilege if another person decided to take action for defamation, should that happen. Guidelines for the broadcast of proceedings are available from the secretariat.

There may be some questions that a witness could only answer if they had more time or with certain documents to hand. In these circumstances witnesses are advised that they can take a question on notice and provide an answer within 21 days. Witnesses are advised that any messages should be delivered to Committee members through the Committee staff. To aid the audibility of this hearing, I remind both Committee members and witnesses to speak into the microphones provided. The room is fitted with induction loops compatible with hearing aid systems that have telecoil receivers. In addition, several seats have been reserved near the loudspeakers for persons in the public gallery who have hearing difficulties. Finally, could everybody please turn their mobile phones to silent for the duration of the hearing today

ALEX KING, Executive Director, Resources Policy, Planning and Programs, Department of Planning, Industry and Environment, affirmed and examined

MICHAEL WRIGHT, Deputy Secretary, Resources and Geoscience, Department of Planning, Industry and Environment, affirmed and examined

The CHAIR: Thank you, Mr King and Mr Wright, for making yourselves available this morning. Would you like to begin with an opening statement?

Mr WRIGHT: I would just like to explain the role of the Division of Resources and Geoscience, which I head up within the department. It is focused on managing applications for mining exploration titles across New South Wales. This is a regulatory function. It is also responsible for setting the policy framework for mining and exploration across the State. In addition, it acquires geoscientific information to assist the industry in targeting exploration and to assist the community and the Government more generally around understanding better the geology of the State. I report to Gary Barnes, the Coordinator General, for Regions, Industry, Agriculture and Resources within the department.

We are able to answer questions today on the history behind the prohibition around uranium exploration and mining in New South Wales, possible occurrences of uranium across the State and the state of the market for uranium both within Australia and globally. We are not in a position to answer questions on nuclear energy per se, though.

The CHAIR: Thank you. Mr King, do you have anything to add?

Mr KING: Nothing to add.

The CHAIR: No problem. We will start with questions. The Deputy Chair would like to begin.

The Hon. MICK VEITCH: Good morning, gentlemen. Have you had a chance to read the submissions to the inquiries?

Mr KING: Some of them.

The Hon. MICK VEITCH: Some of them? Mr Wright?

Mr WRIGHT: Not I.

The Hon. MICK VEITCH: Probably the first lot of questions will be addressed to Mr Wright. Uranium mining currently is banned in New South Wales. I think the O'Farrell Government repealed the exploration ban in about 2012, from memory.

Mr WRIGHT: Correct.

The Hon. MICK VEITCH: Since the exploration ban was repealed or overturned, has there been much activity around exploration for uranium in New South Wales?

Mr WRIGHT: Very little. What happened, following the lifting of the prohibition on uranium exploration in 2012, was that the Government put out an expression of interest to companies who could potentially be interested in exploring for uranium. There were about 39 expressions of interest received at that time. The Government invited six of those applicants to apply for exploration licenses for uranium. Only one of those applicants responded at the end of the day and that applicant subsequently withdrew due to some controversy about one of its directors. So there has really been no active uranium exploration activity in New South Wales since the lifting of the prohibition in 2012.

The Hon. MICK VEITCH: There was one round of calls for expressions of interest.

Mr WRIGHT: That is correct.

The Hon. MICK VEITCH: We have not had a second round subsequent to that?

Mr WRIGHT: No second round.

The Hon. MICK VEITCH: Why is that?

Mr WRIGHT: I think the poor uptake from that first round was probably influential. I would say that is largely due to the fact that there was a significant fall in the price of uranium globally following the Fukushima incident. Commodity prices dropped about 50 per cent. In addition, there was probably some policy uncertainty about whether, if a company did in fact identify an economically viable uranium resource, whether it would be able to extract that resource.

The Hon. MICK VEITCH: I guess we have lifted the prohibition on exploration but we have not on extraction.

Mr WRIGHT: That is correct.

The Hon. MICK VEITCH: Essentially, that is a disincentive in the process.

Mr WRIGHT: That is correct.

The Hon. MICK VEITCH: Would that be correct?

Mr WRIGHT: Indeed.

The Hon. MARK BUTTIGIEG: What was the rationale of the timing? If he knew that the market was not there as a result of a ban on extraction, why would you lift the ban on exploration?

Mr WRIGHT: I think the Government was keen to get a better understanding of the size and location of the resource. I was not in this role at the time. My understanding is that, by letting the exploration activity occur, that would fill what continues to be a bit of a knowledge gap around exactly how much uranium there is.

The Hon. MARK BUTTIGIEG: I know. I understand the rationale behind wanting to continue exploration. I just wondered why they would think people would be interested, given there was no market for it because there was a ban on extraction. It is interesting.

The Hon. MICK VEITCH: Like a one-arm approach. With regard to identifying where the uranium deposits are in New South Wales, what work has the department conducted around that?

Mr WRIGHT: Very little directed work in that sense because of the previous prohibition prior to 2012 and the fact that our Geological Survey NSW really focuses its activity on resources which are likely to be able to be extracted in the first instance. But we do have some general knowledge about where occurrences of uranium are likely to occur. There would need to be much more work about forming up a better view about the size and value of those resources.

The Hon. MICK VEITCH: So it is that really detailed work that needs to be done and that could be done by someone external—a private entity essentially taking up exploration licences.

Mr WRIGHT: That is one way of actually recording the data, but Geological Survey NSW also acquires significant amounts of data about the geology of New South Wales and the occurrence of resources. It has not put effort into uranium over the last decades because of the prohibition on exploration mining.

The Hon. MICK VEITCH: Can I talk about workforce capacity in New South Wales around both uranium mining but also nuclear facilities? You may have to take this question on notice, but has there been much work done around New South Wales' workforce capacity, if we were to move towards uranium extraction or nuclear facilities?

Mr WRIGHT: I would say that the mining sector in New South Wales, as you know, is very well developed. We have deep expertise within industry for both metal and coalmining generally. In so far as that skills set can be applied to uranium mining, we are probably well positioned. I would have to take on notice what some of the specifics might be around the skills required for uranium mining.

Mr KING: I do not think there would be any unique skills for uranium mining that differ from other forms of mining. Most of the additional hazards would be around inhalation of dust and gases, which are features of other forms of mining. There would not be any issue with the capacity of the workforce, I do not think. Nuclear facilities, we do not hold any information on that.

The Hon. MICK VEITCH: Has there been much work done in the department to look at nuclear facilities at all? Have you been instructed by government to maybe look at the potential for nuclear facilities or SMRs, the smaller modular reactors?

Mr WRIGHT: No, we have not. Certainly the division of resources and geoscience has not been requested.

The Hon. MICK VEITCH: Mr Latham's bill, which is the basis upon which we are here today, have you received any instruction on preparing information for government? I do not want the information. Have you been instructed to prepare information around Mr Latham's bill?

Mr WRIGHT: We have certainly provided information to the Deputy Premier John Barilaro on uranium exploration and prospects for uranium mining in New South Wales.

The Hon. MARK LATHAM: You have mentioned Chernobyl which coincides with the period where New South Wales introduced this ban on uranium mining and nuclear power. What is the history of that? Was the ban in 1986 a direct response to Chernobyl, was that the political framework?

Mr WRIGHT: That is before my time. That is my understanding. The Three Mile Island incident occurred at a similar time. That is my understanding of the impetus for that change.

The Hon. MARK LATHAM: We have this ban in New South Wales essentially because of accidents where a lot of the nuclear experts now say that technology is upgraded to a point where those incidents are literally last century events that would not be repeated?

Mr WRIGHT: The legislation certainly reflects the state of knowledge in 1986.

The Hon. MARK LATHAM: You mentioned earlier on a general impression about uranium deposits in New South Wales. What is that general impression you have got as to what might be under the ground?

Mr KING: As Mr Wright said earlier we do not have a huge amount of information but geologically speaking New South Wales does have good potential for uranium. There is information about occurrences principally in the Far West and Broken Hill region. Some in the Central West region and some in the north-east. The ones in the Far West, Broken Hill, are by some way the most viable for extraction.

The Hon. MARK LATHAM: It is the department's expectation that if there was exploration it would discover a viable industry into the future?

Mr WRIGHT: I would say there is further exploration activity that would need to be conducted to form up a better view about the value and size of the uranium occurrences in the State. It may well be that they are economically viable and could support a significant industry in New South Wales.

The Hon. MARK LATHAM: Is there something under the ground of an unknown quantity and we will not really know until the exploration is undertaken to see how extensive it is?

Mr WRIGHT: That is correct.

The Hon. MARK LATHAM: The Beverley mine is just on the other side of the border in South Australia. It is incomprehensible that the industry would stop at the State border?

Mr WRIGHT: It is interesting, if you look at the EOIs that were received in 2012-13 once that prohibition was lifted they have fundamentally focused around Broken Hill and the South Australian border, north and south of Broken Hill, moving across to the South Australian resource.

The Hon. MARK LATHAM: You mentioned earlier on you had a look at market conditions for uranium mining. What is your conclusion there and how do you factor in this, by our standards, quite stunning news that China is going down the path of building 50 nuclear reactors as its response to the global warming issue?

Mr WRIGHT: My understanding is that we are likely to see an increase in demand for uranium globally in coming years. The price of uranium is still around $25 to $28 per pound. Indications are that could increase to about $40 per pound in the next couple of years. That is going to make, obviously, the economics of uranium exploration and mining more viable.

Mr KING: It does tend to be quite variable, in common with many minerals, because of the lag time. It takes 10 years or more to go from exploration to mining. Nuclear power similarly has a very long lag time so matching those up is very tricky and you do tend to get highly variable markets. That is one of the main barriers to the uranium market; the variability rather than the price itself.

The Hon. MARK LATHAM: If it is in the ground in New South Wales and China is going down the nuclear pathway, which is obviously the biggest player in the world other than the United States and potentially India, then this is of some potential, is it not?

Mr WRIGHT: Correct.

The Hon. MARK LATHAM: Can I just come back to the point about the decision in 2014 to lift the ban on exploration but not mining. Has not the industry at that point and consistently since said that there is no point whatsoever in looking for this stuff if they cannot make an economic return on it by mining? It was a policy change that inevitably was going to achieve nothing?

Mr WRIGHT: I am not privy to any firsthand narrative from the industry in response to those policy settings but you could speculate thus.

The Hon. MARK LATHAM: You have not had direct contact with the industry where they say, "Look, it is nice you have lifted the ban on exploration but why would we explore for a thing that we cannot mine?"

Mr WRIGHT: Certainly, some of the discussions we have had with some of the peak bodies like the Minerals Council would be along those lines.

Mr KING: My understanding, again I was not here at the time, was that when the exploration ban was lifted there was some narrative around that being a tentative first step with a potential for it to progress further. It was not intended to be lifting the exploration ban and that would be it. Some of those EOIs we received may have been on the expectation that the government would then carry on to lift the mining ban ultimately.

The Hon. MARK LATHAM: Finally, in terms of planning regulation and knowledge to ensure the industry is safe in all respects, is there anything special about this uranium industry that planning would be looking at in terms of development consents and safeguards? Are you treating it as any different to any other aspect of mining in New South Wales?

Mr KING: It would be subject to all the same safeguards including development consent, mining lease processes, exploration licences, environmental protection plans and so on. In the 2012 round we did add an extra requirement that every explorer develop a radiation management plan on top of those other existing permits and processes. I imagine we could do something similar if there was a similar process in the future. You also require a range of consents and permits from the EPA for handling of radioactive material, which you do not necessarily require for non-radioactive materials. It is possible. It is something that happens for medical research and so on and other states do it. There are no fundamental barriers there but there are some additional licensing requirements.

The Hon. MARK LATHAM: Has the department done any modelling about the potential investment and jobs impact? Certainly in terms of the drought in western New South Wales it is quite frustrating that this industry has not been able to develop to provide jobs and investment in a region that is doing it tough on other fronts.

Mr WRIGHT: Earlier this year the Government released the NSW Minerals Strategy, which commits to growing investment in exploration in the metals sector in New South Wales. We have not done any specific analysis of the potential of the uranium sector at this point in time. If uranium mining was to commence in New South Wales, should there be viable resources found, then it would obviously contribute to the Government's targets under the NSW Minerals Strategy.

The Hon. WES FANG: Just noting from your last answer that you have not done a lot of work in the uranium space but do you have a view as to potentially evaluating if we were to go down the path of mining instead of exporting yellowcake, if we did the processing here in New South Wales?

Mr WRIGHT: That is not something we have considered at this point.

The Hon. WES FANG: Is it something that could be considered into the future?

Mr WRIGHT: I think it is an issue more generally with our resources sector and the extent to which we value-add domestically rather than exporting the raw product.

The Hon. WES FANG: The 39 EOIs which led to six invites, which led to one response, which led to no exploration, as the Hon. Mark Latham has said, is the handbrake effectively that they could spend all this money with no guarantee of removing the resource from the ground because of the ban? Do you think that had the mining ban been lifted at the same time as the exploration ban that we would have seen an increase in EOIs and responses to the invites?

Mr WRIGHT: I will have to answer that question speculatively and answer; probably, yes. As is the case typically with mineral exploration you usually get a junior explorer company in with little capital behind it. The way it works is that if they do discover a resource they then seek to basically sell that potential upside to a larger mining company. You would imagine if there was a prohibition on mining those larger companies are not going to be particularly interested in buying such an offer from a junior explorer.

The Hon. MARK BUTTIGIEG: Just a quick one. From a planning perspective, has there been any research strategy documents prepared regarding the likely or projected direction of the market in this space? Let me elaborate. I mean, at an intuitive level it seems as though there is quite a big predisposition towards renewable energy, and that technology is bringing prices down hand over fist quite rapidly. Has there been any analysis done on the viability of a nuclear path vis-a-vis the likely trajectory of renewables and the technological advances in that area? I know that companies like BHP and major mining companies are actively out in the community saying, "We're going down the renewable path because we think that is the future of mining." Has the department got a view on that and where that might go in terms of a strategy for New South Wales?

Mr WRIGHT: Obviously the Government has a commitment to net zero emissions by 2050 and is doing a lot in the renewable space but I am not aware of that work being done within the department. I could take that on notice and refer perhaps to another part of the department to come back to you on that. But I am not aware of any specific work being done in that space.

The Hon. MICK VEITCH: Just following on from the question of my colleague, I think the next question would be: is the Government looking at diversifying its energy sources so that we are not reliant on one? If one falls over then the New South Wales economy falls over, essentially, because there is no power. Are we looking at modelling to make sure that we have a diversified source of energy for the State?

Mr WRIGHT: I cannot, with any expertise, respond to that question, given it is another part of the agency that deals with that matter.

The Hon. MICK VEITCH: Yes. Can you take it on notice?

Mr WRIGHT: Let me take it on notice.

The Hon. MICK VEITCH: I think that that sort of modelling is important, particularly as we move towards the aspirational goal, nil carbon emissions by 2050. What is that going to look like? What does that look like for us?

Mr WRIGHT: I am happy to take that on notice.

Mr KING: I am sure there is a range of modelling on things like gas, renewables, coal and so on. I doubt uranium or nuclear power has been included in any of those—largely, because, up until 12 months ago or so, it just was not even on the agenda. So historically we have not done a lot of work on that.

The CHAIR: Could I ask if the department has any opinion on how uranium mining could be legislated for, and what would be needed other than repealing the 1986 ban on mining itself? What would be required over and above repealing the ban?

Mr WRIGHT: My understanding is that repealing the ban is all that is required. The whole of the State remains a mineral allocation area, even though the exploration ban has been lifted, which means that you require ministerial consent to submit an application for a uranium exploration licence. You could choose to continue that arrangement, but my understanding—Alex might know more about this—is that it should be a relatively simple matter to lift that prohibition.

Mr KING: Yes, lifting the prohibition would suffice.

The CHAIR: I want to go a little bit further in asking how uranium mining differs from any of the mining that currently takes place in New South Wales, especially in regard to worker safety and whatnot.

Mr KING: I think we touched on this a little earlier. It is not significantly different. Hazards in uranium mining are the same as any form of mining—so, falls from height, heavy duty equipment operation and so on. Naturally occurring uranium is not very radioactive in its raw form. There are some additional dangers. I think I mentioned dust inhalation and gas inhalation, which can be managed through breathing equipment and ventilation. But largely it is not significantly more dangerous than other forms of mining and certainly could be managed easily within the existing regulatory framework and work safety.

The CHAIR: Is there a view from the department on what financial benefits the State might receive if we were to allow for uranium mining, and what the market might look like?

Mr WRIGHT: Given that we are not clear at this point in time around the size of the resources in the State and the extent to which they will be taken up by mining companies, it is difficult to speculate. Obviously, should uranium mining commence in New South Wales there would be a royalty stream to the State from the extraction of that resource.

The CHAIR: If I use the example of Olympic Dam mine in Australia, uranium is mined there and it is not the main product—it is not the reason for being. Are there any mines in New South Wales where the lifting of the uranium mining ban would almost instantly engage in such a process where uranium is quite a by-product from existing operations?

Mr KING: There are some existing operations in New South Wales that produce uranium, and it is treated as a waste product at the moment. There are at least two mineral sands mines—both south of the Broken Hill area—which currently treat it as waste and therefore bury it back at depth and could conceivably move that very quickly to be a viable product. There are additional constraints and licences you need to obtain, including that, if you wanted to export the product, you have to have additional licences from the Commonwealth relating

to the prohibitions around the use of nuclear materials and export of those—and customs and so on—but I think those are not particularly hard to overcome.

The CHAIR: Are there any further questions from the Committee?

The Hon. MARK BUTTIGIEG: Excuse my lack of research, if this has already been answered somewhere. Do we have any idea of the volume or the intensity of uranium as a source vis-a-vis other jurisdictions—not only within Australia but internationally? In other words, is there hard evidence that the source of uranium in Australia would give us a disproportionately high comparative advantage if we go down that path? You said that there had been some analysis on exploration, notwithstanding the fact that there is no market for it now because extraction is banned. Do we have any idea of how rich we are in uranium in New South Wales?

Mr KING: No, not in New South Wales. Australia is obviously already one of the largest exporters of uranium in the world, but in New South Wales it would be hard to tell at this stage. But the prospect is good so there is a good chance that we would have a reasonable market.

Mr WRIGHT: We do have a map of the likely occurrences of uranium across the State, which we are happy to provide to the Committee if that would be beneficial.

The CHAIR: That would be great. Thank you.

The Hon. MARK BUTTIGIEG: Likely, based on—

Mr WRIGHT: Based on the knowledge that we have at this point in time.

The Hon. MARK BUTTIGIEG: Was that done pre the ban era?

Mr KING: It is a combination of pre-existing exploration, but also geological modelling and extrapolation from what is known. For example it tends to occur in certain types of rocks and in certain types of places more than others.

The Hon. MARK LATHAM: I have a question which I am sure you will take on notice as it is not your area of expertise. You mentioned earlier on that you will take it on notice and get back to us with some material about energy security in New South Wales. This is our one contact with a government department and one of the key aspects of looking at nuclear power is the need for baseload dispatchable power into the future in our State to keep the lights on because of the obvious issues facing the coal-fired power stations and coal in general. Is it possible to draw out of your department—the energy section—a long-term projection about where nuclear could fit in in terms of providing dispatchable power, given all the challengers?

We have the Australian Energy Market Operator [AEMO] that said there is a heightened risk of black-outs in New South Wales unless we do something about increasing supply of dispatchable power. There is the interconnector that is being built into Queensland to draw on their relatively young coal fired power stations and some other issues—whether it is viable to get these gas peaking plants up and running, given they rely on private investment. There is no guarantee for Government; it is all private speculation and funding, and also some issues about curtailment problems with renewables. I know it is a complex areas but I have seen some graphs that are quite disturbing. After the closure of Liddell in 2023, the lines of demand and supply of electricity in New South Wales start to separate and continue to separate through the longer term. Obviously you need something to fill that gap, otherwise we have mass blackouts. So if it is possible for the department to provide us with a report on those longer term projections and where nuclear could fit in to fill the gap I think that would be very useful for the Committee's deliberations.

Mr WRIGHT: I will take that on notice and take it back to the department.

The Hon. MARK LATHAM: If it is possible, please.

The CHAIR: Thank you for your time here this morning. The Committee has resolved that answers to questions taken on notice be returned within 21 days. To my recollection there might have been a few. The secretariat will be in contact with you in relation to the questions you have taken on notice. Thank you very much for your time this morning.

(The witnesses withdrew.)

(Short adjournment)

LYNDON EDWARDS, National Director, Australian Generation IV International Forum Research, Australian Nuclear Science and Technology Organisation, affirmed and examined

ADRIAN PATERSON, Chief Executive Officer, Australian Nuclear Science and Technology Organisation, affirmed and examined

STEVEN McINTOSH, Senior Manager, Government and International Affairs, Australian Nuclear Science and Technology Organisation, affirmed and examined

ROBERT GEE, General Manager, ANSTO Materials, Australian Nuclear Science and Technology Organisation, sworn and examined

The CHAIR: Would anybody like to begin by making an opening statement?

Dr PATERSON: Thank you. I have an opening statement on behalf of the Australian Nuclear Science and Technology Organisation [ANSTO]. I thank the members of the Committee for the invitation to appear today. I was pleased to meet with many of you on 24 July during your visit to the ANSTO Lucas Heights campus. I trust you found the visit valuable and enlightening. As a custodian of Australia's nuclear science, technology and engineering capabilities and expertise, ANSTO has made a submission to your inquiry into the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019. As we noted in our submission, ANSTO's support for, and involvement with, the Australian uranium industry spans multiple decades. ANSTO Minerals, a business unit of our organisation, is playing a leading role in minerals process and product development related to nuclear materials, rare earths and lithium resources through consultancy services and pilot plant operations.

The unit's work has been, and continues to be, instrumental in the minimisation of environmental impacts of uranium mining and extraction, and in efficiency and cost-effectiveness of production. ANSTO is agnostic about whether New South Wales or Australia might in future adopt or consider the adoption of nuclear power and other nuclear fuel cycle activities currently prohibited by State and Federal legislation. ANSTO plays a critical and strategic role as an intelligent observer of international developments in nuclear power and other peaceful uses of nuclear science and nuclear technology. This knowledge and expertise is gained through our staff, representation in various International Atomic Energy Agency and Organisation for Economic Co-operation and Development Nuclear Energy Agency forums, and our engagement with bilateral and multilateral partners. These include the Generation IV International Forum collaboration on research and development for Generation IV nuclear energy systems.

As mandated by the ANSTO Act, we play a vital role in providing expertise and technical advice on all matters related to nuclear science, technology and engineering, and play a critical role in contributing to, and informing, policymaking in these areas. I am joined today by my colleagues Prof Lyndon Edwards, who has just introduced himself, Dr Robert Gee and Mr Steven McIntosh. ANSTO's capabilities and expertise extend across the nuclear fuel cycle and we welcome your questions on any aspects related to our expertise in our submission. Thank you.

The Hon. MARK LATHAM: Dr Paterson, congratulations to ANSTO on the work that it has done at Lucas Heights over a long period of time, particularly medical science benefits around the nation. One of the concerns obviously that exists in the public arena is when you ask people about nuclear power in Australia, they refer to Three Mile Island or Chernobyl. Could you inform the Committee of progress that has been made in the technological safety of the nuclear industry?

Dr PATERSON: Thank you very much. One is always keenly aware when talking about nuclear energy that these single-point events have a very strong influence on public understanding and public sentiment in relation to nuclear. In relation to each of those events, we have seen the developments, subsequent to that, improvements in safety. This includes improvements in the safety margin of facilities so that the possibility of accidents is dramatically reduced, but also there are improvements in the underlying technological capacity to operate facilities in modes where the accidents are very much less likely and, in some cases where very passive safety systems—systems that operate only according to the laws of physics—may be applicable in reducing the possibility of accidents down to the level of the underlying science and physics.

These developments have led to ongoing investment by countries around the world in developing those nuclear systems. As part of a process of continuous improvements for existing plants and the potential for a better, much bigger and inherently safe margin in the future for new plants, there is continued interest globally in using nuclear energy I think both from an economic perspective—in many nations it remains a very cost-effective way of producing electricity. It also has the capacity—and this is demonstrated by facts and figures produced for example by the International Energy Agency and by individual nations that the capacity of nuclear energy to

mitigate carbon is disproportionate relative to its level of activity within the global setting and, indeed, in some country settings. The attractiveness for many countries and for many actors who have adopted or are adopting nuclear power is both in relation to the provision of reliable base load power but also the capacity to mitigate carbon dioxide production, which impacts the long-term impacts of climate change. Certainly in my mind as a scientist, they are highly correlated.

The Hon. MARK LATHAM: When we were at Lucas Heights, you mentioned the development of self-closing down reactors, where basically the safety zone is the perimeter of the facility. Could you give us some more information about that technology and when it is coming online?

Dr PATERSON: Certainly. At the research reactor level, the OPAL reactor at Lucas Heights is an example of that where the safety of the Lucas Heights reactor is based on the laws of physics and the period until the fuel is completely safe is enveloped by the capacity of the laws of physics to maintain cooling during that period. A very similar philosophy is being applied in a number of developments of reactors. It might be possible for Professor Edwards to take some of this thinking forward as well. But, for example, the safety case for the NuScale reactor, which is being developed in the United States in Oregon and Idaho, is based on convincing the Nuclear Regulatory Commission in the United States that the safety zone can be limited to the site because of the improbability of an accident that would have impacts beyond the site. This is a big change because most of the nuclear power systems that are operating in the world today have emergency planning zones of the order of 10 miles and, in some cases, more than that. As a result of that, communities are directly impacted in things like emergency planning. This next generation of reactors, should they be adopted, have the capacity, subject to regulatory decision-making, to not require that. That will be a big change both in public perception of the risk but also in the inherent risk, which is faced by society from these reactors.

Professor EDWARDS: If I can perhaps use an analogy, which might apply to the public—in all technology, as we get accidents and incidents, we learn about it and it gets safer. We are all about technological learning. Like, for instance, in aerospace or even, say, the family car, even though the reactor today might look like the reactor of 30 years or 40 years ago, it is entirely different. The analogy of safety is exactly the same. The first and second generation reactors relied on safety systems operated by skilled operators. That is not unusual—we like skilled operators at the front of our aircraft and in front of the car. We have not gone to automatic systems there. The three and three-plus are going to what is called passive safety and they have automatic systems. They are like the sort of automatic car—they do not need the skilled operators to operate anything in the case of an accident or incident; it happens automatically. It is particularly interesting when we come to small modular reactors [SMRs], which are driven by the laws of physics.

If you make the reactor small enough you can cool it using air. The problem you have with a large reactor is that you have so much residual heat after you shut it down that you need water, which is the best way to cool anything, including the tragic fires we are seeing today in New South Wales. If you make the reactor small then you can use another cooling medium, air, which is freely available everywhere. That means that you can have an air-cooled reactor. That means it can be what we might call "inherently safe" or "walkaway safe". In other words, you do not have to do anything. There is always enough cooling power in the air and the structures so that it can never melt down. Those reactors are not available commercially yet. But there is $1 billion being invested in North America alone to work on this. We expect them to be available some time—depending on which country—in the next 10 to 20 years. There is a lot of commercial work working towards that system. What we have seen is that move towards, if you like, automation, driven by, in the case of size, inherent physics, which means we can make a reactor that is inherently safe.

The Hon. MARK LATHAM: What you are saying is that there is a very clear expectation among nuclear scientists and those working on the technology that it would be possible in New South Wales to lift the ban on nuclear power and that if the Commonwealth did the same we could have regulations in the place, in the medium-term future, to legalise inherently safe or walkaway reactors and that we would not have to have any sensible and rational public speculation about a Chernobyl or Three Mile Island event?

Professor EDWARDS: I can only comment on the technology. I can provide the technology. Then it is up to society to decide whether to use it. My job is to make sure that that capability is there and to drive science and engineering to progress mankind. I would leave it to others to make those—

The Hon. MARK LATHAM: But you are certain that that technology is coming online?

Professor EDWARDS: Yes, I am certain that that will develop. I will give you some background. As you know, I am the Director of the Australian Generation IV International Forum. That forum has a series of meetings, including the top meeting, which includes the policy and expert group. That is held every six months. The last one was held in Wuhan in China. I went to see HTR-PM, the Chinese very-high temperature reactor that is based on those principles. It is probably not all the way there—it is passively safe, but not inherently safe. It

was started 10 years ago and it does take time to develop. But that is clearly coming online. They are in the commissioning phase now, which will develop. I am confident that there is enough investment there, both in the Western world and in Asia, that the next step will be made.

The Hon. MARK LATHAM: Dr Paterson, mention was just made of China. One of the big advantages of nuclear power is the way in which it effectively addresses the climate change issues. At Lucas Heights you gave us a very useful briefing on what China—the world's largest carbon emitter—is doing to meet its Paris obligations by way of extra nuclear power. Could you put that on the record please?

Dr PATERSON: China has got a very strong nuclear build program. All the indications are that they are currently at about 3.5 per cent overall, depending on which ones are on or off. That is less that a twentieth of their power. But their policy intention is to find a pathway to 20 per cent. There are some indications that they might want to go north of that as well. If you take the amount of nuclear energy that is produced globally at the moment, it makes up around 20 per cent of global electricity production. Depending on how you calculate it, the indication is that that is responsible for between 40 and 60 per cent of global mitigation in electricity production. There is a three-times multiplier based on the capacity of nuclear to operate all the time and the fact that it is essentially zero carbon after the fuel cycle is taken into account. There is no doubt in my mind that the global proportion of nuclear power production is the major contributor to carbon mitigation in electricity production. I think that is incontrovertible.

The Hon. MARK LATHAM: To move to 20 per cent nuclear, how many new nuclear power plants does China need to build?

Dr PATERSON: I am uncertain of the exact numbers that are required. I understand that there will be a presentation from some other groups and they may well have those detailed figures for you. We can provide that as a written submission if necessary.

The Hon. MARK LATHAM: One of the countries that Australia often compares itself to in size, values and political framework is Canada. You gave us some examples at Lucas Heights of how they are using the smaller modular reactors to power up towns in the Tundra instead of helicoptering in diesel, which sounds pretty bizarre. Could you elaborate on that? Canada is obviously directly relevant to Australia.

Dr PATERSON: Canada is very interesting because they developed the Canada Deuterium Uranium [CANDU] reactor, which is a reactor system that uses natural uranium. That means they do not have to enrich the uranium. Canada has got a long tradition of and experience with nuclear power. For example, a State like Ontario, with its hydro plus nuclear, produces almost no carbon emissions and is a very, very successful example of the combination of those two energy sources to completely mitigate carbon in electricity production. As a result of their history, they have developed a program—which, as I understand it, has bipartisan support—to develop small modular reactors and smaller reactors that they sometimes term "nuclear batteries".

These are small plants that you could transport relatively easily into a rural area, install in for a period of time, operate and then remove and replace immediately with a replacement reactor. They literally are like batteries. They are a plug and play-type reactor. These reactors have been conceptual designs for a considerable period of time but the Canadian Government has provided a regulatory environment where it is attractive for entrepreneurial firms to approach the regulator to see if they can bring forward a number of these designs. Canada is a cold place and Australia is a hot place, but there are large parts of Canada and Australia that have low-population density. Where the population density goes down very often rural electricity supply is challenging and is often reliant on gas or diesel. The intention for the Canadian program is to try to replace diesel-burning electricity facilities next to small communities in the cold areas of Canada. At the moment as those areas warm the ability to transport by road goes down because the roads become of very poor quality both in the late spring and in the Autumn periods and so on.

As a result people are flying in diesel with helicopters in order to provide the diesel that those communities require, which is obviously very, very expensive. A similar case can be made for small island states where they bring in gas or diesel for their power provision. For example, in the Caribbean and in our own setting in the Pacific the cost of electricity is a very high multiple of what we pay in Australia because of that need to supply those low-density communities with fuel. Professor Edwards may want to comment on some of those designs.

Professor EDWARDS: At the very, very lowest level, the people who are furthest ahead at the moment are NASA, which has commissioned and built the first stage of a very small—it is the hundreds of kilowatts—one for future missions to Mars. They have kickstarted that. There has been a change—I do not want to get too technical—in the small reactors to use something called a heat pipe, which is bit like a siphon that you would use in an old-fashioned central heating system in the UK—I am Welsh originally—but that you do not have here so

much because you have air conditioning. This new technology can only be used for very small reactors. NASA has built the first stage of a reactor. I think people have now seen that drive and that work and said, "We can start to use this heat pipe technology", which is for micro reactors. There are several small firms that are now taking this technology—which was always around but has been kickstarted by NASA—to push it up the line. I think Canada is very clear that they need this technology.

I do not think they know how much they need, to be honest, or how much it would cost. However, if they had it, it would solve a problem that is worsening. They cannot deliver the diesel any longer because the ice roads are melting for too long. That is the latest thing. There is also a very great interest in Canada in putting energy up there, because the North-West Passage is becoming more navigable.

The Hon. MARK LATHAM: You mentioned Ontario, Dr Paterson. One of the arguments that the anti-nuclear movement presents is about cost, but I was looking up some of the unit costs of electricity in Ontario. Hydro and nuclear are the cheapest by far, ahead of wind, natural gas and solar. It sounds like they have got affordable electricity. But it is also true that the main cost of nuclear power generation is the upfront construction cost. Once you have got it constructed, looking at these kilowatt-per-hour costs, they are quite low in nuclear.

Dr PATERSON: Yes.

The Hon. MARK LATHAM: How do you respond to that question of upfront construction costs? Are these small modular reactors going to solve that problem as well?

Dr PATERSON: The first thing that I would say is that electricity is a long-term plan, whichever nation you start with. I think Australia falls firmly into the category of the costs of electricity being highly correlated to the ability to plan for the long term, rather than to react to the short term. Therefore, we need to reflect on the fact that energy options sometimes have a high initial cost and a low incremental cost and others have a very low initial installation cost but might have a high operating cost. One can consider the uncertainty with economics means that one should look firmly in the rear-view mirror.

All of the countries that made sustained, systems-level, competent investments in nuclear power have the lowest costs of electricity in the world today. You can say the same thing for hydro. If you look at the history, France is a very good example. It is absolutely clear that strategic investment in long-term, low-operating-cost electricity facilities is smart. People can be quite scary about the cost of these things, but, in general, most economies that are building fleets have demonstrated fleet effects from this—South Korea is a really good example.

If you have fleets of small modular reactors you also are based on the lower cost of factory production of the facilities. You get a fleet effect and a multiples effect. A combination of the fleet effect and the multiples effect, I believe, will provide the economics that are sometimes questioned when people look at the quite large numbers of nuclear build costs. If I was to give advice, which I cannot really do on a national level, but if I am asked in the international setting, if you look at the long-range economics it is fleet plus multiples equals lowest cost of electricity in the global setting.

The Hon. WES FANG: Thank you very much for coming in today. I am going to crystal ball-gaze for a little bit here and make the assumption that the bill or a bill like it passes in the future and we do allow mining for uranium and we do allow nuclear facilities in this State. Do you think that there is a possibility that not only could we utilise uranium and utilise nuclear facilities to generate power but that New South Wales could potentially be a leader in this field? Is there the expertise and the experience within organisations such as yours to become, say, a producer of small modular reactors and refining uranium to not only produce yellowcake but actually the refined product that can be used inside a reactor?

Dr PATERSON: Thank you for that question. I think if I start with the fuel cycle, certainly in terms of the mining of uranium that Australia, across the rather small number of mines that are present and the newer ones that are coming on stream, has looked at both the ability to extract from conventional mining techniques as well as using in situ leaching. This technique means when you have finished with the deposit the land is returned essentially to its initial state because you have taken the uranium out and processed it in a water management facility and put the residues back underground. I think Australia has demonstrated good capacity in the uranium mining side.

As we move down the fuel cycle to the area of enrichment, that would be a long debate as to whether Australia seeks to undertake that. Certainly, Australia is already involved in understanding next-generation nuclear fuels. Making fuels safer and more accident-tolerant is a massive area of global research and ANSTO is very pleased to be involved in some of that research. Accident-tolerant fuels and the associated materials engineering developments is very important, both for research reactors and for this. I think that the capacity to be involved in that sort of work through the Generation IV International Forum and also to understand future designs

puts us in a good position to be an engineering player in appropriate parts of reactor construction and fabrication, for example.

The best way to do that is to build fleets. If you are building one-off you do not get a fleet effect. If you are involved in building fleets there is a tendency then to crowd in people who are involved in that part of the fuel cycle. I believe that has been seen in a number of countries, where you can see a fleet effect quite clearly from the figures. Further down at the back end of the fuel cycle, we at ANSTO are for example working on Synroc—synthetic rock—which will deal with particularly difficult and intractable nuclear wastes and make them safe. As we speak today we are building the first commercial-scale Synroc processing facility on our site for the waste that comes from our nuclear medicine production. Instead of producing a significant volume that actually increases when you go from the liquid to cement, which is the old technology, you will go from the liquid to a smaller volume of waste using Synroc.

We are demonstrating capacity to play at the back end of the fuel cycle in order to mitigate some of those issues. I think with the relatively small nuclear footprint that we have we are a respected global player. Should those decisions be taken politically I see no reason why we could not utilise, in the same way we have done with medical research, for example, to become a strong actor in an appropriate and effective use of uranium in the nuclear fuel cycle, for example.

Professor EDWARDS: Just to add to that, if you are looking for evidence of this then I would look to the Generation IV International Forum itself. In order to be accepted, we had to be accepted unanimously by all the present members. We are the only member of the Generation IV International Forum that does not actually utilise nuclear power. I think the commentary at the time was, yes, we could—and remember, what we are trying to do in the Generation IV Forum is actually work to reduce the time of deployment of these new technologies. Everybody was clear that Australia could make a significant contribution. I think part of that was our general scientific, technical, geological and engineering competence in Australia, a significant part of which, of course, is located in New South Wales.

The Hon. WES FANG: Looking at the current state of the world demand and projecting forward—which again is part of the crystal ball gazing—do you see sufficient demand for this sort of technology and uranium fuel, whether it be unprocessed or in a processed form, that it could potentially be an economic driver for New South Wales?

Dr PATERSON: I believe that if you look at the prospects for the adoption of nuclear power by existing nuclear countries and by the countries which have identified themselves to the International Atomic Energy Agency as being interested in or pursuing the development of capability to do that, I think there will be long-term and ongoing demand for uranium as a source of fuel. There are a small number of countries that are also looking at the thorium fuel cycle, and both those resources are available in the Australian setting. My sense is that the politics of nuclear may move over time, and this is very much a speculative discussion that happens in various places around the world.

Just like the airline industry seemed in the past to depend on national capabilities, and we all had our own regulatory authorities, we now have a global setting for that. I believe that the rate at which a global setting in which nuclear can be adopted by countries, as that global setting becomes clearer the rate of adoption will increase. I think it is prudent to retain national control over that for at least a few decades, but one can see over the longer term that people become sufficiently familiar and reactors and the associated processes sufficiently traceable and safe, that you would get a globalisation of international capabilities.

The Hon. WES FANG: In that you think it is important that we as a country and New South Wales as a State has a footprint now in order to be able to influence that potential decades down the track globalisation of the approval process?

Dr PATERSON: I think for New South Wales there are political elements of that question that I am not competent to answer. But my sense would be that if there are restraints, which with the benefit of hindsight do not need to be there, and that if people applied their minds to that, one would look for an environment in which one could be a global actor, as opposed to a global observer.

The Hon. WES FANG: My last bit of crystal ball gazing; if the predictions are true that small modular reactors can be built inherently safe, that waste products can be mitigated such as the work that you are doing, and that the energy produced is effectively zero carbon, the world demand for cleaner energy sources could potentially mean that if New South Wales has a nuclear industry we would be in a very good position to take advantage of that into the future?

Dr PATERSON: I believe it is important for all pathways to be considered from a policy perspective, because good policy is based on the broadest approach that you can do to the science and engineering. My sense

at the moment is that we should not forgo the opportunity to review where we are. My sense, if you look at the historical structure of power supply in New South Wales, New South Wales, in principle, could be a good place to study the application of small modular reactors from an academic point of view. My sense is that the structure of that power distribution and the likely demographic changes would favour high energy density sources that can be placed appropriately distant[1] from communities.

The Hon. SCOTT FARLOW: Thank you for being here and for the tour of the facility as well. I think we all found that very illuminating. I note in your submission you highlight some of the issues with uranium mining in the environmental context. I also note that there are issues with all mining in the environmental context. With uranium mining, are there any particular issues you see, and have there been any experiences in South Australia with environmental consequences from uranium mining?

Dr GEE: With respect to that, the uranium mines that are permitted in Australia are done so under very extensive legislation and regulations around the environmental effects and there has certainly been a lot of work over the years. There has been a progression in the regulation that has occurred. If you look back to when uranium mining started in Australia in the 1950s to today, it is a whole lot different. The mines that are there and permitted today are doing a very good job of managing to those. There is a lot of information that is on the record about how particular performance has gone, but I am not aware of any significant environmental issues that are sitting there today that would prevent the application of the technology in other areas and would say to us you should not be applying it.

The Hon. SCOTT FARLOW: Is it fair to say that with all mining there are certain risks but there are also mitigation measures that are in place for all forms of mining because of potential environmental consequences?

Dr GEE: That is certainly true. Uranium mining is no different to all types of mining in that there are safety risks associated with the mining process and the operations, as well as the environmental aspects of any type of mining operation that is removing something from the earth. Those things are common across all types of mining today and I think there is always a question with uranium mining about whether there are additional requirements there. With regard to that, there are criteria around those that have been developed to ensure that they are managed well. That is the same as the chemical requirements around most other chemical processing operations that are in mining, whether that be copper, titanium, or any other metal. It is very similar.

The Hon. SCOTT FARLOW: Professor Edwards, when you were talking about the small modular reactors, or the fourth generation, is it, nuclear facilities?

Professor EDWARDS: Yes.

The Hon. SCOTT FARLOW: And them being inherently safe, you mentioned briefly about the maximum capacity size being one of the determinants. What is the maximum megawatt capacity size that would allow them to be inherently safe?

Professor EDWARDS: It actually depends, obviously, on how you do the design. To dispense some very basic physics, if you have an air-cooled reactor, the final heat sink is the air. So there must be some radiation convection from basically the outside containment vessel, and you do not want that to get too hot, by definition. Quick physics, a little bit of calculation comes in, and you end up—and it depends exactly on how you do the design—but it is about 150 megawatts thermal, so about 100 megawatts electric. Above that, you can do clever things, like make toroids and doughnuts, but then it gets very expensive, and there might be some more innovation in the area. But in principle you are talking about of the order of 100 megawatts electric as being the sort of sensible size for something that would be totally echoed.

The Hon. SCOTT FARLOW: In the presentation that we had from NuScale a couple of months ago now, they talked about having the small bolt-on reactors and effectively grouping them in a facility.

Professor EDWARDS: Yes.

The Hon. SCOTT FARLOW: Still with that grouping process it would be inherently safe?

Professor EDWARDS: In fact the Chinese are going to their next system. They have got a high-temperature reactor [HTR] there which has got two of these modules already running one turbine. Their next

[1] In correspondence to the committee dated 9 December 2019, Mr Steve McIntosh, Senior Manager Government and International Affairs, Office of the CEO, ANSTO made a clarification to the evidence of Mr Paterson.

stage is to have six of those in the same, and it is very interesting—sorry, I do not want to get too technical—because it is a very high-temperature reactor it has got a lower power density, which is one reason it is safer. The actual reactor vessel is about the same size as a light-water reactor vessel, and they are going to put six of those into one sort of power station, which is the size of a gigawatt light-water reactor. Then each one is independent and each one is passively safe. So what you do is you split up the heat source, if you like. Instead of having one big one, you have lots of small ones. And there are manufacturing advantages of that. Also, in terms of financial risk, there are advantages. You can bring them on one by one. You could start off with one, then go to two and three, and I am sure that is something NuScale told you as well, because it is an advantage they have got.

Dr PATERSON: The other advantage of having a number is that you can be refuelling one and all the others are operating, so it is always on. That is almost unique in power supplies, that you never have in principle in the system outages for care and maintenance because one of them is always being refuelled and the rest are operating. So it has the capacity of really providing a very high capacity factor, as we call it, close to 100 per cent. Nuclear globally is in the high eighties and some of the countries are in the early nineties in terms of the availability of those reactors. So the challenge of intermittency in some energy sources is fully offset by the capacity to use a range of reactors in series and be refuelling one while the others continue to operate.

The Hon. SCOTT FARLOW: Dr Paterson, referring to one of the comments made by the Hon. Wes Fang earlier with respect to the workforce capability and what ANSTO's capability is, it is often said in this debate that we do not have the capability in Australia, we need to import people to work on nuclear facilities and we do not have that expertise. I think you mentioned when we were on our tour about somewhere in the vicinity of 100 to 150 people who may be trained at ANSTO. If you can clarify that figure for the record as well?

Dr PATERSON: Yes.

The Hon. SCOTT FARLOW: But also how long would it take to be able to train up a domestic workforce in this area, from your perspective?

Dr PATERSON: The first thing is the assumption that Australia wants to play in a league of nations where we cannot do the top end of engineering I think is a bad assumption. I think we should always aspire to be able to do all forms of engineering that impact our economy. ANSTO over the last decade has built up our engineering workforce. When we built the Open-Pool Australian Light-water [OPAL] reactor we had a very capable nuclear procurement capability where we could actually source the knowledge to be a good buyer, but over the last decade we have tried to develop a competent workforce for engineering design and engineering application of nuclear knowledge in that way and we now have around about 150 engineers who are deployed in one way or another around the aspects of that. That is in a bigger group of about 350 engineers at ANSTO.

ANSTO is one of the largest engineering employers in New South Wales and those engineers also do research, they look at longer-range questions and so on. ANSTO as an engineering organisation has had an aspiration to build up that capability. That has helped us, for example, to design the Synroc facility that we are currently building and it also allows us to then effectively interact with engineering capabilities in other countries. So I think that number of 150 who have got design capabilities that can lead to construction of nuclear facilities is right and I think that over time as the aspirations of Australia might change, the ability to scale that is already demonstrated.

I think it would be highly interesting and valuable for nuclear engineers who train in Australia to have an experience, for example, of spending time with the engineering development of these new classes of reactor, for example. Our membership of the Generation IV International Forum makes that highly probable in the next decade. So I believe we should have high aspirations for nuclear engineering capability in Australia, if only to be an intelligent observer of the world but maybe an intelligent participant as well.

The Hon. SCOTT FARLOW: One final question from me, Dr Paterson. New South Wales of course has the zero carbon emissions target by 2050. With the current mix of renewable technologies, would it be possible to meet that target with reliable power by 2050 if you did not have something like nuclear in the mix?

Dr PATERSON: That is probably another inquiry in itself. My sense is that if you look at the long-run rear-view mirror approach to this and just one data point which I saw in one of the publications that I think came out of the International Energy Agency is that the United States has just gone below Germany in terms of the amount of emissions per capita. Germany has just popped up post shutting down some of its reactors. These figures are always subject to hedge effects, but my sense is that it is incontrovertible that the greenest energy in the world from the point of view of carbon mitigation is produced by France, which has a factor of five times better than any other European economy, and that is easy to demonstrate for carbon production.

The Hon. SCOTT FARLOW: And France has, of course, a significant nuclear footprint.

Dr PATERSON: Yes, it is over 90 per cent of its energy, and that was because of the 1973 oil crisis that they have made that sovereign energy decision and I think it has proven to have a certain wisdom associated with it.[2]

The CHAIR: Thank you again for your time here this morning and particularly for the submission from ANSTO, which goes into quite a bit of detail across numerous issues relating to uranium and nuclear power. Can I start by picking up on what was discussed earlier by Professor Edwards on the different generations—Generation III and the next generation, Generation IV, to come online? Can I ask if the State and Federal bans were to be lifted, what are the chances that, say, a Generation III reactor would be built? Would that be almost ruled out from the start, in your experience?

Professor EDWARDS: I do not think I understand the question. Is it technically capable? Yes.

The CHAIR: Is it likely not only technically but in terms of an entity a power company choosing to install or construct one?

Professor EDWARDS: I think that is beyond my expertise. My job is to make sure that this technology exists and the decisions we make by it.

The CHAIR: Anyone else on the panel?

Dr PATERSON: I think my sense would be if one looks at the future requirements of the mix that one would look at all the options. I think the tendency would probably be to go towards inherent safety.

The CHAIR: On that then, with your discussion and the public debate on nuclear power and what it might look like, what if instead of the ban to be lifted altogether the ban was to be amended and we would have a situation where inherently safe designs, where walkaway safe designs were allowed for, but anything that does not fit that bill would be banned still? Would that be something that would work for Australia, in your opinion?

Dr PATERSON: I think it is difficult for ANSTO to comment; it is more a question for a regulator.

The CHAIR: Okay, fair enough. We discussed earlier on Canada. Canada is quite a similar country to Australia in many ways. Why is it then that Canada has such a successful nuclear industry and Australia has nearly none outside of Lucas Heights?

Dr PATERSON: I think with the time that I have spent with Canadian policy specialists they have a slightly different articulation between their provinces and the central government and I think that is a factor that needs to be looked at carefully, the way that individual States can make choices relative to their population, where they are and how they sit in the Federal system. I also think that Canada has developed a consensus about how policies are adopted for very complex issues at the Federal level, which I find quite attractive, where they put all of the relevant stakeholders into a single room in order to think about these complex issues. Their Federal structure allows that to happen. It is way beyond my pay grade to know if that is possible in Australia. But they have got consensus-forming processes that I have spent some time studying in relation to how they make choices, because I am interested in sovereign nations' capacity to adopt nuclear but I have not reflected on that in the Australian setting.

The CHAIR: In your submission there was a very interesting part on page 19 around reactor designs and where they are going towards. One part that peaked my interest was the ability to burn radioactive waste to close the fuel cycle. Could we hear a bit more about that? That is quite interesting.

Professor EDWARDS: Again, I am sorry if I go into a little bit of an explanation. When we first developed sort of humankind nuclear reactors they seemed to be basic stuff, but there was a worry that uranium would run out. From my personal observation, it is a bit like peak oil. If you remember peak oil, it does seem to have reached peak oil, it seems to have gone away, so there was a worry there. So they immediately started looking at mechanisms to create more fissile material to replace it and that is why we came to fast reactors, and these reactors were designed to breed nuclear fuel—in other words, you put other fissile materials in and you produce more and more materials. That was the technology, if you like. However, it was soon realised that we could also use those same fast reactors not to breed nuclear material but actually to burn it; in other words, you can put fissile material in and it comes out with a much lower radioactive lifetime. So basically you put in isotypes that would last for a long time and you get a now that lot of short-lived out and you get a lot of energy out.

[2] In correspondence to the committee dated 9 December 2019, Mr Steve McIntosh, Senior Manager Government and International Affairs, Office of the CEO, ANSTO made a clarification to the evidence of Mr Paterson.

I think what has happened—and this is my observation again—globally is that the need to close the fuel cycle has sort of gone away because I think people are not looking so much to use these reactors now to breed fuel; they are interested in using them to burn the fuel. France has got something like half its reactors running on mixed oxide fuel burning off the plutonium, and that is in light-water reactors. If you go to fast reactors it is even more efficient. Probably the most obvious one is the Russians have been using one of their sodium fast reactors to actually burn off weapons grade plutonium, which is a very laudable achievement. The United Kingdom has also been looking in the long term to look at similar reactors to burn off its civil plutonium. What that means is that the drive, in my view, now for a fast reactor is no longer to increase the fissile stockpile but to reduce the fissile stockpile and particularly to make it. The big advantage is you can make it so that you only have to store it safely for hundreds of years instead of hundreds of thousands of years, so it makes it a lot more tractable with energy systems.

The CHAIR: Thank you very much.

The Hon. MARK BANASIAK: Just one from me. You are talking about nuclear technology. How fast is nuclear technology advancing? If we go down this route of lifting all the bans and looking to put in nuclear power stations, which is a significantly lengthy process in terms of building them—

Professor EDWARDS: Yes.

The Hon. MARK BANASIAK: Do we build something and then in five years it is obsolete and then there is new technology? Do we have the capability to upgrade the existing facilities to keep up with the technology or is it the case that you throw that one out and you build another one?

Professor EDWARDS: No. Because of the regulation we have had—I am actually a structural integrity guy. I have worked on aerospace and nuclear, so I have worked on the A380 and I have worked on nuclear power stations in my lifetime. It is interesting to compare the aerospace where we have got quite substantial change. We can tell. So I worked on the A380. If you have been in an A380 you can tell it is not a small aircraft. Because of the regulation and because of the huge capital cost, actually the changes in nuclear have been slower as an engineering system than the science and technology; it has raced ahead, if you like. One of the things I worked personally on is at the moment if I want to go to the reactor I have to use mechanisms and materials that were made in the sixties because we have not got the processes. One of the things that GenIV is doing is to see if we can make the nuclear industry more agile. It is not an agile industry at the moment. That is why there is so much private money in the small companies, in the SMRs, because they are seen as disruptive.

They are seen as something that can change and it is changing how we do it. Now it will become faster but it is not fast by any of the technological comparisons. I think the same thing will probably happen when we create a new reactor out of these competitive ones; that is, we will replace the light water reactors. That will probably be the reactor for the next generation—I go into teaching mode again. I personally think that the light water reactor has reached its peak. So the next question is: What is the next type of reactor that will come to take it forward? We all hope that one day fusion will do it. We know that fusion will not be there in our lifetime; it is really a physics experiment, but I have got no worry about the fact that implementing ITER; that this is still a large, relatively slow implementation. Because of the safety and other regulatory concerns, it is not fast-changing. Having said that, it is changing faster now than it has for 30 or 40 years but it is still not fast.

The Hon. MICK VEITCH: It is interesting that you say that. Just recently Australia decided to buy another fleet of submarines and we had the opportunity to put nuclear into those but we went with diesel. I suspect at some stage there may be a change of view about that and subsequent submarines will be constructed with nuclear power. One of the issues that has raised, though, is people's exposure to radioactivity. When we were having a look at your facility, which was quite amazing, and when we were in South Australia looking at the mine over there, there were some examples given to us of comparisons around exposure to radioactivity. For instance, a lot of people do not realise when they walk into Parliament House in Canberra—poor old Mark Latham is probably shining because he is still radiated from his time down there—

The Hon. MARK LATHAM: More than that.

The Hon. MICK VEITCH: There is more radiation coming out of the—

The CHAIR: The granite.

The Hon. MICK VEITCH: Out of the granite in Federal Parliament than there would be out of a reactor. How do we overcome this issue around radioactivity and exposure?

Dr PATERSON: I think it is a matter for education and to find a way to explain this to people. I normally try to make three different points. One is that life has co-evolved with radioactivity. The radioactivity, when the first single cells evolved, were significantly higher around the earth because it gradually decays away the earth

like a frozen ball where decay is happening all the time. Over the time that we have evolved, radiation levels have gone down so we have co-evolved with it, so we can tolerate certain levels, I believe. This is not demonstrated scientifically but it is an ongoing discussion. People are, I think, then aware of these single-point large events and the consequences and so there is an inherent uncertainty about radiation.

My feeling is that you can start this in about year 5 or 6 at school and expose people to taking their cell phone, putting a black sticker on, putting an app on it and they can go and measure their granite benchtop at home, they can measure their bananas, which are probably the most radioactive stuff. If you do lots of bananas you are more radioactive than if you do not eat bananas. So you get people introduced to the idea of low-level background radiation. Probably the two biggest impacts on modern humans in relation to radiation is now the number of flights we have in aeroplanes because the higher you get the more neutrons go through you. By the time you get to sea level most of the neutrons are gone. So we are living in an era where there is more radiation around us and then medical uses, where in order to save lives, you expose people to significant radiation.

My feeling is that for most reactors—and the OPAL reactor is a really good example—you are essentially, for most of the operations for the vast majority of the time, in the reactor you are at essentially background levels of radiation. If you are working in the nuclear medicine production facility you are monitored as a radiation worker. Over the last decade the average dose per worker has been coming down over time as we have improved the practices and so on. I think it is very manageable. My feeling is that we should be able to teach people about ionising radiation in a way that they embrace it as part of life rather than to see it as some sort of add-on that is inherently damaging.

The Hon. MICK VEITCH: The other thing I wanted to explore is around the Australian Radiation Protection and Nuclear Safety Association [ARPANSA] and how often you have interactions with the regulator and if we remove the prohibition the capacity to scale up the regulator's capacity?

Dr PATERSON: Yes. Firstly, at the Australian level, in Vienna we meet as colleagues, so I meet with both regulators, the Australian Safeguards and Non-proliferation Office [ASNO], which looks after the safeguards, and ARPANSA, which looks after the radiation side. We are peers in the International Atomic Energy Agency. Back here at home I am regulated by these agencies and in that regulatory environment we are subject to the appropriate governing regulations and laws. So formally we have agreed to meet twice a year for workshop type of activities and the future structure of licensing. We worked very closely on the changes a few years ago to the ARPANS Act to make it more efficient and we have some views about how we can improve the licensing framework that we discuss on a regular basis. In relation to our licences, of which there are a significant number, we are subject to a pattern of inspections by ARPANSA inspections, so at any time on a planned basis or on a notification basis, they can visit our facilities. The shortest notification period tends to be about 24 hours and that is regularly used to come and visit, see how we are going, see if we are conforming to our practices, and so on. I think it is a mutually respectful relationship. We do not try to do their job, which is to make sure that we have an operating environment inherently set up for safety, and we retain the responsibility for safety.

The Hon. MARK BUTTIGIEG: I am conscious of time so I will not go into some of the detail I was wanting to explore. I was interested that in your opening statement, Mr McIntosh, you said—I think the term was, was it "agnostic" about nuclear energy. That is not the impression I have got from the last half an hour discussion which is perfectly understandable. You are in that industry. I would expect that you would take a stance on that. At an intuitive level, if I could summarise where I think the public is at with this stuff, they are thinking, "Look, you have this high cost." We think people are saying this is potentially a waste product involved in going to a much bigger scale which is production for electricity as opposed to medical isotopes which people find quite beneficial and it is worth having the trade-off. I am summarising what I think is in the public mind now. To go to that larger scale given what people are telling us about the technological trajectory of renewables. A vast amount of people would have a reluctance to embrace that given where renewables looks like it is going on that technological trajectory. What would you say to that argument? Because that would be a summary of what is going on in the public's mind at the moment—at least a significant portion of it.

Dr PATERSON: I have a background in energy policy in a previous life. My feeling is that the approach to energy policy that was best summed up internationally was the comment by President Obama when asked, "What should we explore in order to have a really reliable energy future?" And he said, "All of the above." There is great wisdom in that because picking winners in the energy stakes internationally at the moment is really, really challenging. The history would favour nuclear. The current reality does not necessarily favour intermittent renewables and the storage options are at a very, very early part of the S-curve. The best that I could do is, as a previous energy policy person, would be to say President Obama probably had it right—all of the above.

The CHAIR: Thank you very much. What a good note to end on. The Committee has resolved that answers to questions take it on notice be returned within 21 days. The secretariat will be in contact with you in

relation to any questions taken on notice here this morning. Thanks again for your written submission and your time this morning.

(The witnesses withdrew.)

JOHN HARRIES, Secretary, Australian Nuclear Association, affirmed and examined

MARK HO, President, Australian Nuclear Association, affirmed and examined

ROBERT PARKER, Vice President, Australian Nuclear Association, affirmed and examined

The CHAIR: I would like to welcome our next witnesses. Would anybody like to make an opening statement?

Mr PARKER: Thank you for the invitation. I will make a very brief one. I am here today with my colleagues from the Australian Nuclear Association but, as I said initially, I also look after the Nuclear for Climate campaign. It is in that context that I will make this statement. Nuclear for Climate Australia campaigns for carbon reductions to limit global warming to less than two degrees. This requires economy-wide reductions of at least 90 per cent by 2050. To do this, the New South Wales economy must remain buoyant, inventive and prosperous with a power system to match. We draw on the insights of the grandfather of climate change science, Dr James Hansen, who stated in 2018:

> A carbon fee is crucial, but not enough. Countries such as India and China need massive amounts of energy to raise living standards. The notion that renewable energies and batteries alone will provide all needed energy is fantastical. It is also a grotesque idea, because of the staggering environmental pollution from mining and material disposal, if all energy was derived from renewables and batteries. Worse, tricking the public to accept the fantasy of 100 percent renewables means that, in reality, fossil fuels reign and climate change grows.

The search has been on for the most realistic means to build low carbon nuclear energy in Australia. Nuclear for Climate Australia campaign settled on the South Korean nuclear industry who have a record of building their plants on time and to the required price. We visited their industry in May last year and arrived at a ballpark cost of A$6,200 per kilowatt, which is in line with their established record. This was incorporated into a comparative cost model of the Australian National Electricity Market designed by Dr Robert Barr of Electric Power Consulting. I can discuss that model in question time. At deep carbon reductions we found that systems based on renewables alone were three times more expensive than those including nuclear energy. These results were in line with a separate analysis contained in an OECD report carried out by the Massachusetts Institute of Technology [MIT] who looked at the Texas grid. They found a 100 per cent renewable scenario was two-and-a-half times more expensive than one which included nuclear energy and the generating capacity was some six times higher than one which included nuclear energy. Finally, our key findings have been: Firstly, one gigawatt-sized nuclear power plants are likely to be economic on the National Electricity Market [NEM].

Secondly, the OECD study concluded that taking options off the table such as nuclear creates extra cost to society. Thirdly, it states that under stringent targets some options, such as wind, for example, may not be present in the optimal mix. It is therefore suggested that both small modular reactors and larger nuclear power plants be investigated in more detail by the New South Wales Government. Thank you.

Dr HO: I would like to start by thanking the Committee for inviting the Australian Nuclear Association [ANA] to be part of today's hearing on the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019. My name is Dr Mark Ho and I am the president of the Australian Nuclear Association, an independent incorporated scientific institution whose members include scientists and engineers from the nuclear profession. The ANA advocates for the peaceful, safe and effective use of nuclear technology. We engage with government, industry and the community on discussions around nuclear. The ANA has no paid positions and it works in the service of the public to inform and educate on the state of nuclear developments around the world.

Before we begin I would like to declare that the statements we are about to make are our own, separate and independent from other businesses and institutes we might otherwise represent. New South Wales is Australia's most populous State, with our nation's greatest economic output. To retain the title of the premier State requires the continued and unfettered access to essential infrastructure. Cheap, reliable and, in the future, low-carbon electricity is part of the essential infrastructure for ensuring New South Wales' prosperity. In the past New South Wales' electricity came from the burning of fossil fuels, particularly coal. Today coal still supplies over 80 per cent of the State's electricity but our coal fleet could soon retire, starting 10 years from now when the age of coal plants reaches 50 years.

Of course the question is what will replace these plants. In answer the ANA would like to present the case that nuclear power has an integral role to play in the State's energy future. Nuclear power provides clean, zero-emissions dispatchable electricity generation. Nuclear is the only low-carbon, non-storage firming option for intermittent wind and solar generation. Nuclear power plants are concentrated thermal units which maximise current grid infrastructure and minimise expensive transmission grid build outs. Nuclear has a capacity factor of up to 92 per cent compared to lower capacity factors for coal, wind and solar. With an operational life of 40 to 60 years the longevity of nuclear plants far outstrips all competing forms of energy. In the future small modular reactors promise lower capital costs, reducing construction times from eight to perhaps three years.

Nuclear power is tightly regulated by law and must account for its waste, which again is small for the amount of power it produces. For these reasons nuclear power is a key component of many countries' plans for a clean energy future and is an integral part of their strategy to decarbonise. With around 450 reactors operating around the world, nuclear power is proven to be clean, reliable and safe. Every year Australia exports enough uranium to power the whole of the National Electricity Market, yet Federal and State legislation prohibits its use. The ANA hopes the current State and Federal inquiries into nuclear power will show that nuclear power's merits far outweighs the community's concerns about this technology and that one day we may see its use in New South Wales to reduce our carbon emissions, protect the environment and maintain our prosperity. In closing I thank the Committee and invite questions from the panel.

The CHAIR: We will go into questioning.

The Hon. MARK LATHAM: Thanks very much for your presentation and thank you, Chair. On page 4 of your submission you develop the concept of the levelised cost of electricity [LCOE]. Could you elaborate on this? I think it is fundamentally important to this argument about cost. Antinuclear people say the costs are prohibitive and they say that renewable unit costs are very low. What are you doing here with this LCOE? Are you building in what I think logically should happen with renewables? Are you building in the transmission costs, the backup generation costs and the excess capacity requirement to try and have a level playing field of cost comparisons? What does figure 1 at the bottom of page 4 show? Could you just elaborate?

Mr PARKER: This is in respect of the ANA's submission, is that correct?

The Hon. MARK LATHAM: Yes.

Mr PARKER: To your first question on levelised cost, all wind and solar generators operate in aggregate over one year to produce a certain amount of energy. If you take that energy and you divide it by their ability to operate at 100 per cent of their output for the full year you will get a factor; that is the capacity factor. As Dr Ho described earlier, for a nuclear power plant you can get up to around 92 per cent capacity factor. For wind and solar systems it is different. For example in Germany you get values of solar down around 9 per cent. In Australia you can get it up to 15 per cent to 18 per cent. Likewise, wind varies according to the density of wind you have in the area. Levelised cost of electricity is at the system, as the generator connection point to the transmission grid. After that, you quite correctly raised other issues such as ancillary services in those.

Those are additional costs that go into what we call the system levelised cost. For example in New South Wales we are spending about $1.50 a megawatt hour on an ancillary cost and we are spending the best part of $42 per megawatt hour on our transmission and distribution. These are over and above the levelised cost. Levelised cost stops at the point where that generator is connected to the grid. But when we then go to the concept of system levelised cost, we look at these individuals but we say, what happens if you have the case of something like a gas-fired turbine that is backing up wind or solar? Well, you could run it at 100 per cent. I mean, they are darn efficient. But it is a peaking backup plant. So we see, for example, in Western Australia one of its backup plants has a capacity factor of only about 8 per cent or 9 per cent. Many of them are down around 15 per cent.

What happens when these backup plants have to go into the cost of energy, their capital costs, their recurring overheads drive up our energy prices. So it is all of these extra bits of backup and ancillary that drive up our total system levelised cost.

The Hon. MARK LATHAM: It is a wretched economic scenario, is it not?

Mr PARKER: It is.

The Hon. MARK LATHAM: You have notionally low unit costs of renewable power generation but you need the backup power because the renewables are intermittent.

Mr PARKER: Correct.

The Hon. MARK LATHAM: Once you build in those backup costs and, by virtue of it, the low capacity at which they have to run, you are getting the worst of both worlds, are you not, when you combine the costs?

Mr PARKER: Correct. It is not only limited just to the generator. If you have a connector such as at Narrabri South Solar Farm, it might have the ability to put out 150 megawatts, for example, but if on average it is only putting out around 20 or 30 megawatts you find that you have to actually size your interconnector to the maximum output, not the averaged output. With some of these variable renewable generators it is not just the generator but it is the wire to connect to it and it is the substation that takes that energy. All of those have to be sized for the max but in aggregate they only operate at the lower level of about 18 per cent in the case of a solar farm.

The Hon. MARK LATHAM: So your graph or diagram at the bottom of page 4 is showing that by far the most efficient, optimal capacity mix is nuclear power and renewables?

Mr PARKER: Yes.

The Hon. MARK LATHAM: Whereas if you just go renewables you are having to run so much extra capacity and a large part of this is battery storage, a technology that is essentially unproven as of today.

Mr PARKER: That is correct. That graph represents the generation spectrum that came out of a study done by MIT researchers on the ERCOT grid, that is the Electric Reliability Council of Texas. They came up with that particular spread. On the left-hand side of that graph you have the generators where you exclude nuclear. On the right-hand side you have the system mix if you allow nuclear in. Along the horizontal line you have the amount of carbon emissions. So as you try to increase your carbon replacement, down to about 200 the two systems are effectively the same. This is another one of the incredible traps. You go down this route to about 200 grams of carbon dioxide per kilowatt hour and then you find something takes off.

The nuclear starts to take over because it beats out the batteries and the gas. And so it takes over. And the trap, which is what we are going to experience in Australia if we continue on this route, is that the OECD tells us you must be designing your system for the end target. There will be no gentle transition. You could land on a platform, you have done your dough, you cannot get off that intermediate level to get to even lower targets because you have spent your money—a little bit like the National Broadband Network [NBN], and we do not want to do that again.

The Hon. MARK LATHAM: In what you are saying about cost, the large up-front costs of nuclear are followed by lower unit costs over the 60-year lifespan. Isn't the problem with private sector construction of nuclear in Australia at the moment that the market is fraying, sort of like the prisoner's dilemma, that nobody really knows what other sectors are going to be doing by way of investment? And why would anyone invest in high up-front capital costs of nuclear without the government subsidies that, say, the renewables get? Does this not lead us to a conclusion that if nuclear is to happen in Australia and meet these large up-front capital costs it will need to be government funded?

Mr PARKER: It will need clear government support—that is the conclusion. Most of the successful programs around the world which we heard from Dr Paterson earlier have had very strong government direction. That does not mean that in a competitive economy—and my background is as a civil engineer, project managing large projects—that you do not use the competitive tools within your economy to drive down the costs of construction of them. But, as the British Government has found more recently, there is a very strong case for governments to ensure that the interest rates that are charged for the construction are more in line with what sovereign risk can take as compared to the private sector.

This would inevitably be—and it is my sense that we would need a strong collaborative effort between government and private enterprise, that private enterprise would probably manage them and private enterprise would strongly build them, but in the financing we would need assistance from government. That is exactly the situation that the current NEM has landed us in. Without a subsidy no-one is out there wanting to build a coal plant; no-one is out there wanting to build new gas. Without a subsidy no-one is out there wanting to build new wind farms either. No-one who does not have a guaranteed power purchase agreement or some form of guarantee can finance anything under the current regime.

The Hon. MARK LATHAM: Yes. I think this is a really important point. Because some of these funding scenarios are completely fantastic. You hear the renewable advocates talking about pumped hydro as a storage option, but no company in their right mind would go out and buy the private land needed and then the construction of pumped hydro to simply be notionally—I do not think it is, technically—a storage system for speculation about renewable prices in the middle of the day. The only pumped hydro of any significance is Snowy 2.0, which is going to cost a huge amount of money for very little return. So this criticism of nuclear as needing public subsidies is quite unfair, isn't it?

Mr PARKER: It is common to everything.

The Hon. MARK LATHAM: It is common to everything. If you get into an environment where there is complete market failure and blackouts, government will have to re-enter the market as a generator of power otherwise the whole economy and society melts down.

Mr PARKER: We did not question when the New South Wales State Labor Government built the coal-fired system. They built the 500kv transmission network. That was the people with their government moving forward to put the power system into place so that industry and everything else could flourish. We have to kind of revisit that model. Energy is a facilitator of wealth elsewhere in the economy, to stimulate industry, to stimulate development. It cannot be used to strangle innovation within our economy, which unfortunately it currently is. There is a very strong place for the people working with their government and private enterprise directly and cooperatively.

The Hon. MARK BUTTIGIEG: I am interested—and I am quite naïve about this sort of stuff—but we have not had much of a discussion about the perceived negative effects of waste in this whole cycle. Where is that at now in terms of safe storage of waste, the life of the radioactivity associated with the waste, future generations? It is one of those things that I guess is off in the never-never in people's minds because a lot of us will not be here when it becomes a problem. Where is all that at? I have seen all sorts of scenarios where the sophisticated facilities in northern Europe are quite good now but into the future there are still concerns about how long you can safely store this stuff.

Mr PARKER: I was going to ask Dr John Harries to answer that.

Dr HARRIES: The thing is that waste is not a difficult problem but it is a political problem. There are different sorts of waste. There is low level waste, intermediate level waste and high level waste. In Australia we are still struggling with the low and intermediate level waste because we are trying to site a national repository or national storage facility or national management facility, which is presently going to be in South Australia, but that is a process that has been going on for 30 years. This is a small amount of waste which is solid, readily managed and is causing great difficulty.

The issue for public acceptance of nuclear plants that is always talked about is the high level waste, which is a longer term, which is really the spent fuel from the reactor. Nuclear is interesting because it is the only power generation source which looks after all its waste—we have to deal with the waste from the uranium to the spent fuel which can be reprocessed. The waste itself is solid and it is non-reactive but it gives out lots of radiation and it gives off heat. There have been nuclear power plants operating for 50 years around the world and the waste from reactors is solid, generally it is a relatively small amount but if you should ingest it or breathe it in it could be very hazardous. At the present time it is all solid. It is stored at sites. What has been difficult has been disposal of this waste, I suppose because of some of the material.

The Hon. MARK BUTTIGIEG: Can I just clarify something, Dr Harries, while you are on that point and it occurs to me?

Dr HARRIES: Yes.

The Hon. MARK BUTTIGIEG: The low level waste you are talking about, the stuff that is not benign but is more manageable because it is low level, is that the result of the sort of things we do at Australian Nuclear Science and Technology Organisation as opposed to electricity production, which would be much—

Dr HARRIES: Even a nuclear power plant will produce low level waste. It will have the protective clothing that is used around the plants—anything that is slightly contaminated or might be contaminated has to be dealt with. So a nuclear power plant also produces low level waste similar to the plant waste which comes out of ANSTO. You might have seen that at ANSTO.

The Hon. MARK BUTTIGIEG: But the larger scale potential production we are talking about for electricity necessarily involves a higher level of waste.

Dr HARRIES: It involves high level as well as the lower level.

The Hon. MARK BUTTIGIEG: Thank you. Go ahead. Sorry to interrupt. I just wanted to clarify that.

Dr HARRIES: That is all right. So the question is the high level waste, say, in different countries. In France the spent fuel is reprocessed and it is reprocessed into a vitreous waste, which is a glass. This is insoluble, it is solid and it is stored in steel containers. At the present time France is working towards—and I think they have licence applications in for—a waste repository for disposing of this stuff in geological facilities. At the present time it is stored in storage facilities which are well managed. I guess the only thing one has to be concerned about is any radiation coming out, but it would be stored in concrete. In the US the spent fuel is stored at the reactor site.

All the reactor sites have concrete facilities, concrete casks that hold the spent fuel and these are just outside the reactor.

The thing is it is not a difficult problem. The waste is solid, it is non-reactive, it can be dealt with. Politically, the problem has been to find a geological disposal site. The uranium that the fuel is made from is, of course, the radioactive. It has a half-life of over 1,000 million years. You have taken it out of the ground. It has come from the geology. The geology has lots of naturally occurring radioactivity in it. Putting the spent fuel back into geological facilities is putting it back where it is out of the our environment, under control and at a distance. It is all quite feasible, it seems, from a technical point of view.

Politically, it is easier just to keep storing it. At the present time there are only three facilities. The Finnish have licensed a facility that is about to start disposal. The United States has a facility for disposing of defence waste in salt but other countries are just storing the material. There is a political issue in disposing of it but it is a relatively small volume of material. It is easily stored in concreted casks until the facility. It needs to be stored for 50 years anyway just to reduce the heat output and then it can be disposed of. There are lots of disposal concepts out there. The Finns are putting in shafts and putting casks in them.

The Hon. MARK BUTTIGIEG: Let us say, for example, you store this stuff and then, 200, 300 or 400 years down the track, there is a major geological event or something happens. What is different about the risk associated with that compared to the naturally occurring substance in the geology of the earth now? Essentially you are saying it is no different to what is there now; it is just that we are reverse-engineering it to put it back how it was.

Dr HARRIES: Yes, putting it back into a more engineered facility than it was originally in.

The Hon. MARK BUTTIGIEG: Why is the perception generated that there is a problem, ad infinitum, down the track because you cannot safely store this stuff forever? I think that is the general idea people have.

Dr HARRIES: If one looks at the Olympic Dam uranium resource, and that uranium resource was formed—I cannot say exactly—something like 100 million years ago in South Australia and it has not moved since. The uranium is still in the same place it was when it was first formed hundreds of millions of years ago. It might be 1,000 million years ago.

Mr PARKER: You are right. It was deposited there in that deposit 100 million years ago.

Dr HARRIES: Yes. One has to select the geology. One has to select the geology with as little water movement. The material is going to be insoluble.

The Hon. MARK BUTTIGIEG: If we had nuclear material naturally occurring on, say, a fault line, and there is an earthquake, does that mean you could be exposed to radiation as a product of that event? Is that what it means?

Dr HARRIES: The possibility is there. You would not put it in a fault line.

The Hon. MARK BUTTIGIEG: No. I am trying to get the analogy right.

Dr HARRIES: You would select your geology. There are some very old geologies around.

The Hon. MICK VEITCH: I think what my colleague is saying is there is a community perception. If you talk to people at the moment as part of an education process, they have recently been well informed by *Chernobyl*, the TV show. I am not sure that helps the cause.

The Hon. SCOTT FARLOW: I hear some criticism about to come.

The Hon. MICK VEITCH: To advance the cause of uranium mining or nuclear power generation, you have to educate people about the evolution in safety, their current exposure to radiation in their day-to-day life, just to give them the sense of—

Dr HARRIES: If you go back to Chernobyl, it was a Soviet reactor, built with no containment, almost unregulated. It was a reactor that would never be built in the West. It went wrong, it was a disaster, but it is not—

The Hon. MICK VEITCH: Part of educating society about the realities of uranium mining and nuclear generation is that Chernobyl was a long time ago and that would not occur anywhere else. I think—and one of the submissions says this—that Chernobyl is the only occurrence where people died from radiation exposure.

Dr HARRIES: Yes.

The Hon. MICK VEITCH: It has not happened in the other events—Three Mile Island and—

Mr PARKER: Fukushima. No, that is correct.

The Hon. MICK VEITCH: That is correct, yes.

Mr PARKER: That is correct. Just to assist with the geological comment, Dr Harries was talking about the geology where the uranium is extracted. The South Australian royal commission was looking at placing this used fuel in granite 500 metres down. The geological age of a lot of the granite in Australia—we are talking about two billion and three billion years old. We are talking about 2,000 million years of age. It is that old. When they look at depositing the material in there, they drill there and they go down and they ensure that there has been no water transmission through that granite in millions of years. There will always be water down there but, provided the water is not migrating through the deposit, it can never convey anything. When you are 500 metres down, it is not coming back. So this sort of education of the long-term nature of geological formations is another thing that needs to get into the public consciousness.

The Hon. MICK VEITCH: You appreciate that is the difficulty.

Mr PARKER: I do. Totally agree.

The Hon. MICK VEITCH: If politicians from all sides—crossbench, Government and Opposition—want to advance this, the current information levels in society would say, "It is all based on Chernobyl. We do not want it." When you say to them, "You are exposed to more radiation walking into Parliament House in Canberra or hopping on an A380 to fly to London", they do not realise. It has to be put in context. Clearly there is a lack of information and education in society.

Mr PARKER: I will give you another example we found. After the Fukushima events we got a considerable amount of angst that people were expressing about fish species in the Pacific Ocean. A couple of kilometres off the coast of Fukushima, they found that the radiation that was in the fish species there was about a quarter of the natural background. If you take that fish—and Pacific bluefin tuna do this; they go all the way to California—when it gets to California they find out that the radiation it got at Fukushima is one fortieth of the natural background. Yes, you can detect it, but it is at such an infinitesimally low detection level that there is no risk. But you are correctly observing that the public hysteria is "radiation found off California from Fukushima". The relative perspective is never described. You never see numbers in the journalism.

The Hon. MARK BUTTIGIEG: The other point, as my colleague, Mr Veitch, correctly points out, is the massive gap between the public perception and the science on this stuff. The other one is: there is a general idea that, particularly when you look at countries in northern Europe, the market has moved on with this stuff. It is going towards renewables. Technology is bringing the price down. When you have big companies like BHP saying, "Look, this is where it is at"—and you mentioned the market before—why are we having this debate when nuclear reactors take 20, 30 years to build and it is going to be too late then anyway? I think that is a general summary of how a lot of people feel. What do you say to that?

Dr HO: We have to be careful when we are thinking about the future energy mix here. Despite the positive numbers being put forward about the eventual penetration of renewables being about 50 per cent, perhaps even 100 per cent, on the grid, currently, if you look at what is actually installed around the world, there is very little evidence of anything above, say, 20 per cent of actual penetration on the grid. This is for good reason as well. For example, let us bring it back home and look at the New South Wales situation. The New South Wales electricity system was put into place by the Electricity Commission of New South Wales many years ago by very able, talented and intelligent engineers.

What we have are essentially five thermal plants that are in close proximity of the centres of demand, of industry and population. If you look at, as we were talking about, the 500 kv lines, they are the backbone to connect those coal-fired power plants in Lake Macquarie, in the Hunter, over at Lithgow. So this makes for a very very cost minimised system. We are talking about where that generation is supplying where the demand is and then these tendrils that extend out for the furthest reaches of New South Wales, which currently are being supplemented by small amounts of 5 megawatts of solar and a little bit of storage that they want, that makes sense. But, still in the end those variable renewable generation sources are at the far reaches of New South Wales are being supported by some form of firming which is actually the New South Wales NEM currently.

The Hon. MARK BUTTIGIEG: Could I just pull you up there. Maybe the more interesting analogy or more relevant one is northern Europe where people have a perception that Germany and Scandinavia have moved way down this path but is it the same analogy that France is propping it up with nuclear or is that too simple?

Dr HO: Europe is highly interconnected. You might have the Danes saying that they have huge amounts of renewables penetration but in reality they have the luxury of being connected to Scandinavia, to France, to coal powered Germany as well as renewables powered. We are in a very different situation. When we are talking about high penetration renewables in New South Wales it is not only the question of the cost of renewables but the cost

of connecting all of those renewable assets to the network and I am not sure where that costing is or who will be paying for those very very expensive transmission lines.

The Hon. MARK BUTTIGIEG: I think the perception is that because you have a pre-existing infrastructure, a spine, then you have a multiplicity of sources feeding into that existing spine, that is the idea. That may be totally misplaced, I do not know. That is the idea.

Dr HO: I have seen the AEMO integrated system planning documentation and there are renewable energy zones that are in those areas that are not currently connected and there is this question of who will be paying for that resource.

Mr PARKER: May I just make a comment in respect of northern Europe which has come up, if we compare the costs of energy in the European situation we see that Germany who has made the greatest efforts, or its efforts are more advertised than others you might say, and they have about the second highest costs in Europe for electricity energy costs. They are in for around 250 billion Euros so far into this game and they have spent a lot. At present their emissions intensity is about 10 times that of their neighbour in France. You find a similar high cost trend in places like Denmark, which have very high levels of wind. You find lower costs in a place like Sweden and Sweden is basically a country that has hydro plus nuclear. They are low. Norway have 100 per cent hydro, so they are laughing. This trend is variable across Europe. We are not seeing anywhere—if you take jurisdictions like California or South Australia or Western Australia where people try to put in a lot of renewables they run into big grid complexities that drive cost.

The Hon. MICK VEITCH: We have heard evidence earlier today and in our submissions around SMRs and how Canada are rolling these out to replace some of their diesel operations in the far north of that country, in the inhospitable country, you would refer to it. What are your views with the potential for that to happen in the remote communities of New South Wales and Australia?

Dr HO: I think a lot of people might not know that internationally there is lots going on with the small modular reactor development. It does not matter if we are talking about Canada or the United Kingdom or the United States of America there are billion dollar public private partnerships to look into this. I would say the small modular reactors are built in a factory and can be built for a lower cost compared to a large nuclear reactor. Even within this category of small modular reactors there are two separate categories, I would say. For example, you might have the NuScale design which is one of the first cabs off the rank in terms of the new SMRs to be developed in the USA. They are 60 megawatt units and they are usually deployed in 12 units in all. All these are completely under water for the passive safety aspect. The generations are 700 megawatts, which is the kind of numbers of say a coal-fired power plant. That is appropriate for switching out retiring coal fired power plants.

The other type of reactors, such as anything from one to 10 megawatts, they might be considered micro reactors. These are the kind of units that are shippable, that could be put on a barge or on a truck, trucked out to remote locations, installed, probably with highly automated passive safety systems, to supply the local communities with uninterrupted power. Especially in Canada's case they require that power a lot more than we do because if power fails people are going to freeze to death. It is a little more difficult in their situation. I think if Australia were to remove the restriction on nuclear power we can truly capitalise on the investments being made overseas in order for everyone to have decarbonized base load or a dispatchable source of electricity.

Mr PARKER: Can I make a comment with respect to the actual deployment on our grid of SMRs or large scale reactors. If we go to the grid, which Dr Ho described earlier, we have the 500 kv power line and that is the spine in New South Wales. We have a similar spine sitting down there in Victoria. We have areas in New South Wales right now and in Victoria where we could be putting one gigawatt plants in and if we had the legislation, and if we had the will, there is no reason we could not be putting them into both states right now to replace large generators.

But, when you go to places farther afield that are only served by 320 kv or 150 kv lines that is where the beauty of the SMRs really comes in. I do not think that it needs to be a polar thing or either/or. If you go to Queensland there is no 500 kv in Queensland, to my knowledge, and yet you have a very large State. Western Australia is the same. In those locations SMRs are the perfect option, as and when they come up, to fit into 150 kv, 250, 230 kv lines. That is ideal for those locales. The SMR requires a lot less resource provision in terms of cooling. You could have either. I think the important thing with all of this is we have the tools to do it. We have known how to do it for 40 years. We have the clear and present need to do it. I would wish that we could focus on doing it and not make it too nebulous, to be quite honest.

Dr HARRIES: Can I add a comment to that. It worries me that we are so focused on SMRs when around the world there are 55 nuclear power plants of one gigawatt or greater under construction. When you go around the world and you visit all those different countries that have nuclear power, the units they are putting in are one

gigawatt or 1.6 gigawatt, they are big plants. These are modern plants, they are safe, they are reliable, they are known. I would be very concerned if we are just focusing on SMRs. SMRs have a role but there are no SMRs presently commercially available. There might or might not be. We are not sure which ones will actually end up with a factory. It is very important in this whole process not to just say we will only accept SMRs, which are still a gleam in the engineer's eye.

The CHAIR: That is a good point.

The Hon. WES FANG: I had two lines of questions I wanted to ask. The first is the education program. Have you as an organisation looked at how we might go about better educating the population about the benefits and the perceived risks of nuclear or have you got an opinion on how we may conduct a program?

Dr HARRIES: I might start off. I do not think education is the way. People get their perceptions of a whole lot of hazardous issues from their leaders or from a group of people. There are opinion leaders. I think it is a mistake to think that we could educate people about radiation. Radiation has been around forever. This question of how much radiation people can take—people are very happy to go and get their MRIs and their CT scans and they are very happy to fly in planes. But to talk about an extremely low level radiation from an operating reactor at, say, the Australian Nuclear Science and Technology Organisation, which you almost cannot measure, and there is a totally different perception there. So I am just tipping a bit back from thinking that education in the way that we would talk to people—we talk to communities and ANSTO had a lot of people talking to communities and making school visits—we have to be open and honest about it, but there is no straightforward education solution.

The Hon. WES FANG: Accepting that, how do we counter the perception problem we have?

Dr HARRIES: It is a challenge, isn't it.

Dr HO: I would answer that question somewhat a little bit differently from John Harries. I think we need to move forward on all fronts in terms of our education. I was a beneficiary of the New South Wales education system. I did physics and chemistry. I remember that there was a nuclear component in one of the physics electives. I am very happy to hear that the New South Wales Government's Department of Education would like to make maths a compulsory component. I think all these are very, very fundamental for a modern society to make intelligent decisions, right? So I would say that including our research efforts, should the New South Wales Government or the Federal Government also want to lift the ban on nuclear power, yes, I would say that an education program would be part and parcel. But of course I think that, yes, while it is part of an important component of reaching out to the population and letting them understand that, yes, we have considered what nuclear power is with the best intentions in mind and there are good reasons to consider it. I think we need to educate on all roles and on all aspects.

Mr PARKER: Could I make a comment? I have spoken to probably 50 or 60 different presentations and community groups. I do them all the time. I guess if I have one lesson it is familiarity. If you keep the message going and it can come from a source—it could be, for example, the New South Wales energy commission—and it could put out information so that within the community a dialogue occurs, the more people who get used to that dialogue the more they have their thinking moments in their private time. That is when they change their mind. I will never change their mind. They will assemble information and they will make up their mind in their good time but the dialogue needs to be had.

Governments can do a lot to facilitate the dialogue in an objective manner. But if you look at the polling on "Are you in favour of nuclear or not?", we are seeing a gentle increase. We are now to just over 50 per cent. This is gently going up. I think, if I had to pick it: Why is that? I think it is because of instruments like this or the Federal instrument or the one that will happen in the Federal Parliament and the increased dynamic of the discussion and the narrative in the community, which you are leading. This is where we will gently see these things come up. But you are not going to see it suddenly go skywards.

The Hon. MARK LATHAM: Are there not two big factors around—that nuclear has greater acceptance are because of the climate change debate?

Mr PARKER: Yes, and there is also the hip pocket.

The Hon. MARK LATHAM: For people on the Left, there is the benefit of zero emissions and for people on the Right, there is the benefit of energy security. Nuclear helps to keep the lights on.

Mr PARKER: Correct.

The Hon. MARK LATHAM: There is a bit therefore everyone, if it is addressed in a rational way.

Mr PARKER: And the promise of stable prices for industry. At present, if you have an energy-intensive industry, you do not know where you are going to invest. When I was in Western Australia recently, I looked at

the way their power prices are going up. They are a basket case, quite frankly. Anyone trying to put in place a secondary industry that requires a lot of energy over there seriously needs to have a double-take. That will apply to the rest of Australia as we keep this de-industrialising caper going.

The Hon. SCOTT FARLOW: Just picking up on that question in terms of community support, were you involved in the South Australian process at all?

Mr PARKER: Yes, in so far as I assisted in the Australian Nuclear Association making a significant presentation to that. I went down to conferences in South Australia as representative of the ANA in the public dialogue. So, yes, there were a number of forums that the ANA attended during the course of that.

The Hon. SCOTT FARLOW: From your perspective in terms of the South Australian experience, where did community support sort of evaporate from? What was it in that debate that potentially skewed community support?

Mr PARKER: Okay. The biggest disappointment that the royal commissioner, Kevin Scarce, expressed directly to us was that it should not have gone to a public forum as quickly as it did. As I just described, it is a slow burn of education. What they did is they took the findings, which are very good, and his express desire was that that should have taken two or three years of dialogue within South Australia. But what happened is that they got the report and they went straight out to a citizen's jury within a couple of months. Then they had a few chat fests over a few weekends and, lo and behold, the panel got loaded and down it went. It should have been a slow burn within the community and it was setting itself up for that until they some how had a rush of blood to the head and off they went to the citizen's jury. That is where it derailed. It needed, as Kevin Scarce observed, two to three years of education for people to get used to the idea and for them to make the merits of it. So don't do it too quickly.

The Hon. SCOTT FARLOW: With respect to energy-intensive industries, which you were speaking about before, and heading towards zero emissions by 2050 is our target, is it possible with Australia's resources environmentally and the current mix of renewable technologies to be able to power heavy industry reliably without nuclear?

Mr PARKER: If we take the modelling that the OECD did with the MIT and if we take the modelling in Australia we have done with Dr Robert Barr's model, which I invite you to inspect and I think the Chairman already has, every indication is that it is not possible because the costs of power will become excessive without nuclear. The analysis we have done quite clearly says—and it is not an exclusive game—you can have solar in there in the day period and that can go down—provided that it does not go down below the base level, it has a great home—and you can have hydro in there and you can have those mixes and you can have some pump storage in their, Snowy Hydro 2.0, great scheme. But when you get into that base load where business needs to plan, then that is the home for nuclear. So you need the mix. That is what all the reports are telling us. Apart from an opinion, two reports we have got: the OECD and our own one. Also studies done in Germany have verified that.

The CHAIR: Thank you. That is all we have time for today. I again thank you for your written submissions and of course for your time here today In the hearing. The Committee has resulted answers to questions taken on notice be returned within 21 days. If any have been taken on notice the secretariat will contact you in relation to those questions. Thank you again.

(The witnesses withdrew.)

(Luncheon adjournment)

JIM GREEN, National Anti-Nuclear Campaigner, Friends of the Earth Australia, affirmed and examined

DAVE SWEENEY, Nuclear Policy Analyst, Australian Conservation Foundation, affirmed and examined

CHRIS GAMBIAN, Chief Executive, Nature Conservation Council of NSW, sworn and examined

The CHAIR: Would anyone like to begin by making an opening statement?

Dr GREEN: Yes, we all would, with your permission. I am going to speak about nuclear power. Dave will speak about uranium, and Chris will speak about New South Wales energy issues—opportunities, road blocks and so on. I am going to quickly run through issues canvassed in our joint submission, and in particular the reasons why we believe that State and Federal bans against nuclear power should be retained.

The first one is that those bans have saved Australia and saved New South Wales from the catastrophic cost over-runs with every reactor project in Western Europe and the United States over the past decade. It is a sad truth that every one of those reactor projects is at least A$10 billion over budget. That's $10 billion—with a 'B'. It is hard to believe that but it is true. Perhaps the most catastrophic of all those catastrophic projects was in South Carolina, where they have had to abandon a reactor project mid-stream, having already spent over A$13 billion.

Nuclear power could not possibly pass any reasonable economic tests, and it certainly would not pass the tests set by Prime Minister Scott Morrison. It could not possibly be introduced or maintained without massive taxpayer subsidies. There are a couple of examples. Hitachi has recently walked away from a project in Wales in the United Kingdom, despite the offer of staggering, unprecedented subsidies. Also in the UK, the lifetime subsidies for the Hinkley Point project alone—a 3.2 gigawatt project—are estimated by the European Union to be A$55 billion for a two-reactor project. Other credible estimates put those lifetime subsidies at A$91 billion. These are extraordinary figures. I know it is hard to believe but it is all documented.

The other economic test set by Prime Minister Morrison is that nuclear power would need to reduce electricity prices, and clearly it would do no such thing. It would clearly increase electricity prices. Legislation banning nuclear power should also be retained because of the lack of a social licence, and in particular numerous polls over the past 10 years have found that only 20 per cent to 28 per cent of Australians would support living in the near vicinity of a nuclear power plant. As the Clean Energy Council put it, in its submission to this inquiry, it would require "a minor miracle" to win community support for nuclear power in Australia.

There is a lot more that could be said about nuclear economics and I am happy to field questions on that issue. There is plenty of information in our joint submission and in the separate Friends of the Earth submission dealing specifically with small modular reactors. There is one point that I would particularly like to make to the committee and to the secretariat, which is that there is an excellent critique of some of the claims made by nuclear lobbyists, both to this inquiry and to the Federal inquiry. This article neatly corrects and debunks those claims. The article is by Giles Parkinson. It was published at reneweconomy.com.au on 23 October. It is called, "Why the nuclear lobby makes stuff up about cost of wind and solar". Our joint submission also does some of that work—debunking highly questionable claims made by nuclear lobbyists about nuclear economics. In particular I would draw your attention to sections 3.5 and 3.6 of our joint submission.

The next issues is that we believe legal prohibition should be retained because the pursuit of a nuclear industry would almost certainly worsen patterns of disempowerment and dispossession experienced by Australia's First Nations. To give just one example of that, the National Radioactive Waste Management Act dispossessed and disempowers traditional owners in many different ways. To list one of many, the Act states that the nomination of a site for a radioactive waste dump is valid even if Aboriginal owners were not consulted and did not give consent. I would ask this Committee to consider recommending that those appalling and indefensible clauses of the National Radioactive Waste Management Act be repealed.

Legislation banning nuclear power should also be retained because no-one could have any confidence that satisfactory solutions could be found for waste streams. Globally, no country has a repository for high-level nuclear waste. There is one deep underground repository for long-lived intermediate level waste in the United States. It was set up in the late nineties. Almost as soon as it was set up, safety standards and layers of regulatory oversight were peeled away, and those failures led to a chemical explosion in an underground waste barrel, which shut the repository down for three years. Direct and indirect costs amounted to about $3 billion. The thing that I really want to focus on there is that safety standards and regulatory standards fell away straight away—and you are dealing with plutonium, with a half life of 24,000 years. We need to safely manage this waste for millennia; they failed to safely manage it for one single decade.

I want to make a quick point on wastage of another sort. That is that nuclear power reactors are voracious consumers of water. A single reactor typically consumes 50 million litres of cooling water every single day. Their

water intake pipes are slaughter houses for fish and other marine creatures. Arguably, the best way to destroy a local fishery is to build a nuclear power plant nearby. This is just considering routine operations of a nuclear power plant. In the case of Fukushima, that disaster has crippled and almost killed the local fishing industry. Currently fishers in the region are fighting plans to dump vast amounts of contaminated water into the ocean surrounding the nuclear plant.

I have one final point. Legislation banning nuclear power should be retained because the introduction of nuclear power would delay and undermine the development of effective economic energy and climate policies based on renewables and energy efficiency. A December 2018 report by CSIRO and AEMO found that the cost of power from small modular reactors would be more than twice as expensive as power from wind and solar PV, even with some storage costs included. CSIRO and AEMO are about to release another report, which firms up that conclusion and also considers the costs of a higher degree of storage attached to renewables. They have canvassed the findings of that report. They find that, even with a considerable amount of storage factored in, renewables are still far cheaper than nuclear, comparable to the costs of existing fossil fuels and are almost certain to become cheaper than fossil fuels because of the clear cost trajectory of renewables and storage.

So nuclear simply is not even in this debate. There has been a big spat about the CSIRO and AEMO costings with respect to small modular reactors. Their costing is $16,000 per kilowatt of installed capacity, and the nuclear lobbyists are furious with that and strongly contesting it. What I would say is that if you average the cost of small modular reactors, which are actually under construction in China, Russia and Argentina, that average is higher than the figure given by CSIRO and AEMO. Also, if you look at the reactors being built in the United States—the large reactors—one again, the CSIRO and AEMO figure for nuclear is lower than the real-world cost for reactors that are actually under construction in the US. So the CSIRO and AEMO figure is entirely defensible. In conclusion I quote the senior vice-president of Exelon, which is the largest nuclear company in the United States, who said:

> I don't think we're building any more nuclear plants in the United States. I don't think it's ever going to happen … They are too expensive to construct …

That is in the US where they have a vast amount of infrastructure and expertise but nuclear has clearly priced itself out of the market. The calculations in Australia would certainly be worse because we do not have that infrastructure, we do not have that expertise and we are blessed with renewable energy resources. As the Climate Council, comprising Australia's leading climate scientists, puts it, nuclear power reactors "are not appropriate for Australia—and probably never will be." I will leave it there.

Mr GAMBIAN: Thank you, Mr Chair. I thank the Committee for the opportunity to present to you this afternoon. The Nature Conservation Council of New South Wales represents over 150 local community conservation and climate change action organisations. As such, it has a strong interest in the large-scale reduction in reliance on coal-fired power and, as such, we have a deep interest in the future of clean electricity generation in this State. We believe a pragmatic and open-minded view of the future design of the energy generation, transmission and storage mix is essential in dealing with the existential threat posed by global heating.

We have engaged with both scientific and economic analysis of the State's energy needs and opportunities and produced a report called *Repowering Our Regions*. The report represents a vision for energy generation, storage and transmission that would see New South Wales able to move to 100 per cent renewable sources by 2030. It is an ambitious but necessary goal and includes options that include rooftop solar, which can produce up to 25 per cent of the State's energy needs by 2030 and create 14,000 jobs; and large-scale investment in storage technologies that will ensure power is available when it is needed most. This includes lithium-ion batteries but also includes solar thermal plants and off-river pumped hydro. Pumped hydro in particular is appealing because it would allow existing coal mines to be repurposed after their life ends. This is a huge opportunity to transition the Hunter Valley in particular as the domestic economy as well as the world moves away from coal over the next 30 years.

Large-scale wind and solar projects in those regions of the State are most suitable for such generation. These include many areas that are currently experiencing devastating effects of the drought. A renewable industry would provide much-needed additional income to farmers. By way of example, TransGrid has identified 5,000 megawatts of solar farms in western New South Wales alone. I would be happy to make available our report and the technical report that accompanies it to the Committee, if required. The New South Wales Government plainly understands this potential. We are supporters of its Transmission Infrastructure Strategy, published in November 2018. That strategy contemplates transmission projects that would support up to 17,700 megawatts for new generation in several energy zones.

These include a series of smart new interconnectors that will help ensure that the grid is fit for the future. This approach to securing our energy needs into the future will ensure that new jobs can be created, new

opportunities as well as certainty for business, and cheap, reliable power consumers. On any fair assessment, nuclear power is simply not necessary in New South Wales. In our view, the negative consequences of cost, waste and risks far outweigh any potential benefits from new, clean energy generation. We urge the Committee—and through it, the House—to turn its attention towards a sophisticated generation, storage and transmission system that promises enormous opportunity for the State.

The CHAIR: Mr Sweeney, did you want to make an opening statement?

Mr SWEENEY: Yes, thank you, Mr Chair. I acknowledge that we are on the lands of the Eora nation. As a visitor here to that, I would like to acknowledge that. The inquiry is being asked to consider removing the State ban on uranium mining, apart from the nuclear dimension of the State ban on uranium mining. The position of the Australian Conservation Foundation [ACF] and many others is that the longstanding prohibition is prudent and considered and should remain. I would like to provide a bit of a snapshot of the Australian uranium sector. We have about one-third of the world's uranium in this country. We have a declining market share. We started this century providing about 20 per cent of the world's mined uranium and we are ending this decade providing around 10 per cent. These figures highlight the trajectory: it is constrained, it is stagnant, it is declining. The uranium sector in Australia has long been talked up by advocates very fulsomely but it has never realised these claims. This failure to do so is a combination of industry underperformance, overenthusiastic projections, a lack of broad social licence and poor demand and a low commodity price.

I would like to stress for the Committee that this failure is not due to a lack of public subsidy for exploration. It is not due to regulatory constraints, a lack of favourable column inches, political access or support. Unlike the ore itself, the uranium sector has had those factors in spades. Last decade a Senate inquiry into the uranium sector found that it was characterised by underperformance, routine regulatory noncompliance and risk, and it still is. There are only three commercial mines in Australia. One of these, Ranger in Kakadu, has long stopped mining and will end processing of ore stockpiles in January 2021. It is not far away. Mine owner Rio Tinto is now spending around $1 billion to try to clean up of this heavily impacted site. The largest of the uranium mines is BHP's Olympic Dam operation in South Australia. It is seeking to expand but this expansion is based on BHP chasing the mine's main commodity, which is copper, not uranium. That point was made clear by BHP CEO Andrew Mackenzie last week at Darling Harbour at the annual general meeting where he spoke of mining as the engine room of a renewable energy future.

The smaller Beverly Four Mile mine in South Australia is effectively market-sheltered because it produces ore for its United States-based reactor utility. In Western Australia—and this is lived experience that I think is important for the Committee—a decade after the conservative Barnett Government made opening up uranium mining as one of its foundation policies and stated that Western Australia would become the Saudi Arabia of nuclear fuel, there are no commercial mines. In June 2011 the then Australian Uranium Association said there would be four or five mines in three or four years. There are none. Again, it is not because of a lack of political support. Rather, it is the profound lack of uranium market fundamentals. I think on Remembrance Day, it is timely to remember, as Churchill said, that behaviour speaks louder than words.

The Canadian uranium mining company, Cameco, is the world's largest uranium miner. It holds the two largest uranium deposits in Western Australia. Recently it reduced the book value of one of those deposits, Kintyre, to zero—no dollars. It purchased it for US $350 million in 2008. The other project, Yeelirrie, had its approval rushed through in the dying days of the Barnett Government and its Federal approval announced is by clear commitments to the contrary by the then Minister Melissa Price on the day before the May Federal election was announced. Despite this, Cameco has announced that it is not advancing this project in the short or medium term. In Kakadu, Rio Tinto has declined to advance a permitted underground expansion in order to put focussed attention on to the complicated and costly challenge of closure at Ranger.

If you look at this, even the sector's most reliable uranium operation, the multi-mineral Olympic Dam, is seeing the post-Fukushima expansion based on a 90 per cent lower spend and a deliberately reduced uranium focus. Communities have concerns. Traditional owners have concerns. Civil societies have concerns. I draw the Committee's attention to submission No. 55 of the Joint Civil Society, which includes a broad range of trade unions, faith groups, public health groups, and environment groups and others. Above all, I suppose the market has its concerns and is sure that there is and will be no uranium bonanza. In conclusion in this context, it makes scant sense for New South Wales to jump-start or attempt to jump-start a contested and contaminating sector that is in decline.

Not doing so will save the environmental and taxpayer cost of rehabilitation of mines, like we have in Queensland, Northern Territory and South Australia. In closing it is useful to note the observation from an earlier New South Wales example. When the O'Farrell Liberal Government and that then Minister for Resources and Energy, Chris Hartcher, made the amendment to remove the ban on exploration, Minister Hartcher stated that this

is an exciting opportunity for New South Wales and he spoke of the government looking forward to a vibrant uranium exploration industry. No licences have been granted—not one—and in May 2016, reflecting on this reality, the then Minister Anthony Roberts stated that the expression of interest process made it clear that "there is currently no interest from the market in exploring for uranium and the ban on mining remains in place." So it should. There is no evidential or rational basis for loosening this. Thank you.

The CHAIR: For the benefit of consistency—I have done this in the past—Mr Gambian, your name seems familiar. Did you run for a seat earlier this year?

Mr GAMBIAN: I did. A Federal seat. I clearly did not win.

The CHAIR: Which seat and which party?

Mr GAMBIAN: The seat of Banks for the Labor Party.

The Hon. WES FANG: Thank you very much. I note all three opening statements. Let me pose this question to you: If you are right that there is no economic reason for allowing uranium mining or nuclear power, what is the harm in us passing this legislation to lift the ban and allow nuclear facilities to be enacted? Clearly nobody will do it if the market says so.

Dr GREEN: That is a really good point. It is a likely outcome that if bans were repealed that it would make no difference. What I am worried about is that over a period of time we would see the same thing that happened in the UK. The UK's recent nuclear program kicked off with the Prime Minister saying that there would be no subsidies. Now we have got Hinkley Point with subsidies amounting to $55 billion to $91 billion for a twin reactor project. There are obscene subsidies. That all happened in the space of a decade. They are very sophisticated lobbyists and they are very good lobbyists. I would be concerned about that. The other thing is that it is never good policy to give away something for nothing. I would say to the industry: Get your act together; stop selling uranium to nuclear weapon states that are actively expanding their arsenals; stop selling uranium to Ukraine, where there is a low-level war going and where uranium international safeguards have broken down; and clean up contaminated sites around Australia, and we could list many of them. I will not, because it would take so long—

The Hon. WES FANG: I appreciate your response so far, but I come back to the question. What is the harm in us enacting the bill if the market says there is no value?

Dr GREEN: It is a lost opportunity to get the industry to improve its performance. A creative way—

The Hon. WES FANG: How is it a lost opportunity? How would lifting the ban have an affect on the rest of the market, given that the market drives it? What you are saying is around the adoption of pricing and costs in this risk analysis. If all those risks exist with nuclear then us removing the bans should have zero effect and it should have no effect on the market either. Where is the risk?

Dr GREEN: The risk is exactly what I said initially, which is that sophisticated lobbyists will arrive in Australia in droves and they will convince State and Federal jurisdictions to give them multi-billion dollar subsidies.

The Hon. WES FANG: Is that similar to the renewable sector, which is receiving subsidies?

Dr GREEN: Absolutely, but there is a difference of scale there. You will not find a 3.2 gigawatt renewal energy project that is getting subsidised to the extent that Hinkley Point is—$55 billion to $91 billion. You will not find subsidies that were on offer to the project in Wales, which Hitachi walked away from. That is one of the risks. But again, there is the lost opportunity. Why not be creative and say, "Demonstrably improve your performance and clean up some contaminated sites and then we will revisit this issue in a decade." Otherwise it is just a lost opportunity.

The Hon. WES FANG: The way you are phrasing that answer is that you want to use a lever to say that if we were to remove the ban first x, y and z must happen. Are they not mutually exclusive? Is it not the case that at the moment the ban precludes companies that have demonstrated good corporate governance and that want to produce energy without carbon emissions from doing so in this country?

Dr GREEN: I am here to answer questions; not ask them, but can you name one?

The Hon. WES FANG: Again, I am—

Dr GREEN: For radioactive sites in Australia, I would love to know the name of one site that has been properly cleaned up. I could list a dozen that have not been properly cleaned up. Also, surely you would want some confidence that waste could be properly managed. How could you possibly have that confidence when the

only deep underground repository in the whole world was shut down for three years following a chemical explosion?

The Hon. WES FANG: I am unaware if you heard the evidence earlier today, but we heard from Australian Nuclear Science and Technology Organisation about the advances that have developed not only in the development of power but also in the way that waste is handled. ANSTO is not a lobbyist; it is a scientific organisation.

Dr GREEN: ANSTO is a lobbyist and its claims about nuclear waste are demonstrably false. I mean that quite literally. If you take the example of the integral fast reactor, the idea is that you can use high-level nuclear waste, consume it in a reactor and then turn it into low-carbon power. That is an incredibly enticing proposition but the reality in Idaho—where they operated one of those demonstration reactors and are now trying to deal with the waste—is that they have turned one difficult, challenging form of nuclear waste, namely spent fuel, into multiple forms of challenging, difficult nuclear waste. They have not improved the situation; they have made a bad situation worse. That is the reality of the theoretical arguments that you have heard from ANSTO this morning. I would also strong recommend that you read the articles that we have pointed to in our submission from Dr Allison Macfarlane, who is a former chair of the US Nuclear Regulatory Committee. Once again, she has looked at demonstration advanced reactor projects. They are not improving waste management issues; they are making those issues more difficult to deal with—demonstrably in the real world, as opposed to the theoretical nonsense you have heard from ANSTO.

The Hon. WES FANG: Can I take you back to that statement you just made about ANSTO being a lobbyist. I have two points. First, is that not incorrect? ANSTO is made up of scientists and they look at the scientific evidence. Second, is it not the case that the argument could be made that the organisation that you represent is also a lobbyist and that you are here presenting a view that nuclear, no matter what—despite all the arguments you made—does not stack up? You want us to retain a ban for an industry that you say will not stand up on its own legs.

Mr SWEENEY: I might jump into this. I have a couple of quick comments. If decisions were made on the basis of evidence and economic rationalism all the time we would have absolute confidence that this would not stack up. You look at where the money is moving and it is not moving into nuclear. But I think all of us in this room know that decisions are not always made on such a basis. We are also of the view that there is an urgent need for urgent climate action to move to a low-carbon economy. Nuclear is not a bridging technique for that. Mr Fang, nuclear is a cul-de-sac that will draw time, energy and capital. The opportunity costs of pursuing what will effectively be a dead-end are profound and adverse.

A further concern would be that in relation to uranium and the issue I spoke of, what I tried to convey to the Committee is that the big players—the deep pockets and the companies that have been in the game for a long time and have produced and are producing in this sector—are moving away or reducing exposure to it. The big players will not be in it. Your Rio Tintos, Camecos and BHPs will not be kicking around in New South Wales. What you would be left with would be the experience you were left with after the exploration licence period—small-scale companies whose enthusiasm far exceeds their capacity or their competence. That could lead to a real problem. It could lead to a short circuit issue in Western New South Wales, where there is a legacy mine issue. It failed but it has unearthed a problem. We are concerned about this for a range of reasons, including the need to get into significant, urgent and effective climate responses, the need to use our dollars and time wisely, the need not to be distracted from real solutions and the need not to open the door to underperforming opportunists.

In relation to ANSTO, I would just say that whilst it might not be a lobbyist in the plain sense of the word—it is not on the corporate lobby register and that sort of stuff—it effectively, often and routinely prosecutes its case and advocates for its case for nuclear solutions. That is its job. It is are Australia's centre for nuclear excellence. I understand that. And it also works hard to ensure a profile in State and Federal Government. It has have people like State McIntosh and others, who prosecute a case routinely and professionally to ensure that they are well-regarded. It is a lobbyists? It is arguable. Is it a strong advocate? Absolutely.

The Hon. MARK LATHAM: Thank you for the submission and also the presentations, which obviously are a comprehensive critique of nuclear power as you see it. Mr Sweeney, in saying that the money is going out of nuclear, would it be your advice to China—which is by far the biggest player in this field and in terms of global emissions absolutely dwarfs Australia's contribution—that in moving from 3 per cent to 20 per cent nuclear power share as its response to climate change and as a signatory to the Paris Agreement that it should forget about nuclear and go 100 per cent renewable?

Dr GREEN: Perhaps I can take that one, Mr Latham, if that is okay with you? I could quote from Steve Kidd, who is a former executive of the World Nuclear Association. He notes that the growth of renewables "dwarf" the growth of nuclear in China. China is the one and only country in the world with a significant nuclear expansion

plan, but it is stop-start. It stopped after the Fukushima disaster, understandably, and stopped again in 2016. It is not at all clear where it is going with nuclear power but it is certainly not getting to 20 per cent, or if it is, it is not happening any time soon. I think it is implausible. It is facing exactly the same problem that other countries are, which is lack of social licence and escalating cost, which is why it has got this stop-start program and which is why nuclear is being dwarfed by renewables in China.

The Hon. MARK LATHAM: I do not think social licence is a big concept in China's politics.

Dr GREEN: Interestingly, it is becoming an issue and nuclear projects have been stopped by social protests in China.

The Hon. MARK LATHAM: China has 45 nuclear power reactors and has 15 under construction. Are we not in an environment where internationally there is an interest in saying that nuclear seems to have answers on both sides of the policy-making dilemma? That is, how do you make a legitimate, rational response to climate change while keeping the lights on? Churchill was quoted earlier on. He said, "Those who never change their mind never change anything". Is it not time for people to forget about—well, not forget about, but to set aside old ideological objections about nuclear, old 1980s-type arguments, and recognise that for policy-makers, legislators and people who have got this challenge of making a response to climate change while keeping the lights on that nuclear should be part of the mix? It is not a context of nuclear versus renewables, but you need a comprehensive energy mix that does bring down emissions while offering energy security.

Mr SWEENEY: I absolutely agree with the urgency for action, Mr Latham. I absolutely agree with the openness to consider options. We do not sit here in a position of, "Oh, this is what happened in 1975 and this was the party line and now it still is". I am in an organisation where routinely our members ask, "What is the position on how we address climate change? What is the role of nuclear?" You cannot just spit out a sentence and expect intelligent people—and the Australian Conservation Foundation membership is the A-B demographic, by and large. We routinely look at options, cost, trajectory, all sorts of stuff. For a range of reasons, we come up strongly and freshly that nuclear does not stack up and does not cut it. It certainly does not cut it in a greenfield country, Mr Latham. There is an argument that people can make and it is made where facilities exist that you hay-band and hope and extend them. We do not agree with that argument, but you can see the rationale. But if you are talking about a massive new spend on energy in Australia to address climate change, you would not go nuclear. It is not ideological. It is dollars, cents, opportunities and the trajectory. Renewables have now outpriced nuclear—that's it.

Mr GAMBIAN: Can I offer a supplementary answer on that, Mr Latham? As the Chairman rightly identified, I am a newcomer to this space. I have not got a background in the environment movement; I have got a background in politics. I even campaigned for you to become Prime Minister once.

The Hon. MARK LATHAM: Well, you obviously did not do enough, and nor did I.

Mr GAMBIAN: So we are both losers, in that sense.

The Hon. MARK BUTTIGIEG: He is not Robinson Crusoe there.

Mr GAMBIAN: I have been learning a lot about the science of climate change and the need for transition and how all of that works. One of the things I observed during my election campaign was that you would have these discussions with people that would start with a vehement denial that climate was a problem or that there was any sort of change necessary. You would spend 10 or 20 minutes on that on the street corner or in a coffee shop or the pub or wherever we were having the campaign event. Then the conversation for a particular cohort of person would suddenly jump from "climate change isn't real, there is no problem to be addressed, coal is the only cheap, reliable source of fuel" to, "Well, what about nuclear?" We jumped straight to nuclear. I actually would support your suggestion of an open-minded discussion about fuel options, but we are not in one. We are just not in one.

All the evidence that I have seen is that there is a credible series of options for energy security for this State into the long term. The Government—and I say this as a former Labor candidate—has got credible policies that can take us to a clean energy future. Yes, they might need a bit more meat on the bones and they might need a bit of money and some timelines and things like that—I am not here to completely congratulate the Government, but the Government is taking this stuff seriously. However, there seems to be a portion of the community that has this sort of fetish for nuclear power, as if we need big, heavy machines and some sort of phallic symbol to ensure that we are serious about having manly fuels and not these namby-pamby renewable fuels. I think that is a really counterproductive way to have this discussion. I have got an open mind. I am here to be convinced that nuclear stacks up, but I have just not heard any of that evidence. I welcome the existence of this Committee but you have got to be prepared to accept that renewables can be one of the options, just as much as being willing to entertain the idea of nuclear.

The Hon. MARK LATHAM: Mr Gambian, that is well and good, but I think you have got to understand legislators have got a heavy duty of care to keep the lights on, in particular. Nothing will damage the climate change cause more than mass blackouts.

Mr GAMBIAN: I agree.

The Hon. MARK LATHAM: We had the email earlier in the year talking about the heightened risk, particularly in Victoria but also in New South Wales after the closure of Liddell. This is serious business to get that right, because the economic and social damage of the lights going out is extreme—and ultimately the environmental damage, because it would effectively destroy the climate change cause in the public's mind. Are there not obvious difficulties in talking about renewables as an opportunity for 100 per cent energy supply—Mr Gambian, you mentioned pumped hydro in old coalmine sites. Where is the guarantee that any company would think it is going to be profitable to buy old coalmine sites to create pumped hydro as some sort of de facto storage mechanism for renewables, speculating on renewable prices in the middle of the day? There is no proven evidence that that would ever happen.

So too AGL last week announced a 15-year agreement with battery storage that it said was the coming of the age of batteries. The deal it has got would power up the New South Wales economy for one minute. That is less than the period I have been talking here in addressing this question to you. There are other science-fiction-type scenarios about battery storage and hydro that no responsible legislator exercising their duty of care to the people of New South Wales to keep the lights on in our hospitals, our schools, our homes, our factories, our businesses could ever contemplate as reasonable. At least you can say about nuclear that the technology is proven. It has powered up all those things in other countries over an extended period of time. This other stuff about pumped hydro and battery storage is so unproven that to go down the path of 100 per cent renewable—what you are saying—has got to be regarded as grossly irresponsible.

Dr GREEN: Could I take that one up? Pumped hydro is established technology, but I take your points about market mechanisms and all those sorts of logistical issues. Battery storage is relatively new but, as with renewables, the costs are coming down impressively. We are in a brave new world. There is no point in looking at what has happened in the past decade or so when we are in a new world where the cost of battery storage is a fraction of what it was a decade ago. It is interesting—

The Hon. MARK LATHAM: Storage for one minute of the power supply in New South Wales. We have got to deal with today's technologies as we know them today, because legislators have not got the luxury of hoping with goodwill or magic that somehow things will improve 10 years from now to make those decisions valid.

Dr GREEN: You can make short-term estimates as to the trajectory of these technologies and their costs. We have seen that with renewables. It has been a clear downward spiral, the same with storage costs. I appreciate that you cannot do that over a long period of time. With respect to your other comments about 100 per cent renewables, well, by all means you can discount the claims of two anti-nuclear lobbyists and one former Labor Party hack, if Mr Gambian does not mind me calling him that. There is a body of expert scientific knowledge. We have referred to it, probably briefly, in our submission, but I am delighted to take that on notice if you would like me to, Mr Latham, and provide you with a whole lot more information, detailed, rigorous scientific studies published in peer reviewed journals and so on and so forth.

The Hon. MARK LATHAM: About what? Someone wrote a peer reviewed article that 100 per cent renewables is viable? How do you answer this problem of, say, battery storage? A 15-year-long deal will deliver one minute of power capacity for New South Wales. Or pumped hydro, where is the evidence that that is enough storage for 100 per cent renewables in a couple of coalmine pits? It is just fantastical, is it not?

Dr GREEN: Would you like me to take that on notice and I will provide you with some of this?

The Hon. MARK LATHAM: Okay. I just find these things fantastical.

Dr GREEN: Just for us as being non-scientists, and with you being sceptical about the claims of environment groups, which is fine, here is Peter Farley, Australian Institute of Engineers, an engineer by profession: For the cost of the 2,200 megawatt plant under construction in the US, Australia could build 7,000 megawatts of wind, 7,000 megawatts of tracking solar, 10,000 megawatts of rooftop solar, 5,000 megawatts of pumped hydro and 5,000 megawatts of batteries. What are you going to choose? It is a no-brainer.

The Hon. MARK LATHAM: Yes, but does that keep the lights on?

Dr GREEN: Yes.

The Hon. MARK LATHAM: His scenario would keep all the lights on in Australia?

Dr GREEN: No, his scenario is indicative. He is in the process of writing it up.

The Hon. MARK LATHAM: We do not have the luxury of being indicative. I am sorry. This is a heavy responsibility, because the social and economic calamity of mass blackouts is supreme. Being indicative is not good enough. It must be a proven technology.

Dr GREEN: It cuts both ways.

The Hon. MARK LATHAM: A proven technology.

Dr GREEN: The proof with nuclear is that costs have consistently escalated over the decades. It is the only energy source with a negative learning curve. So, what is your assumption with nuclear? Are you assuming that after decades and decades of cost escalations that costs will suddenly plummet and it will become economic? It does not make any sense whatsoever.

The Hon. MARK LATHAM: The Ontario Energy Board has got the unit cost of nuclear as low as hydro and lower than wind, natural gas and solar, and they are moving to a zero carbon economy. There is one place in Canada comparable to Australia that seems to have got both sides of the equation right. I am just saying, would you not want that here?

Mr SWEENEY: What you certainly want here, Mr Latham, is certainty. What you certainly want here is the lights on. Everybody wants that. You mention a lot about proven. With nuclear, there are two sorts of nuclear. There is the nuclear that exists, which is your real world proven, and that is high capital cost, enormously high capital cost, prohibitive. But, it exists, it does work, it generates electricity. You get three years of electricity from a fuel rod and you get 100,000 years of waste. So there is still an intergenerational burden. It might not be a carbon burden, but it is a massive one. That is the one that exists. The other one that gets talked about a lot in the Federal inquiry and in this inquiry no doubt, is small modular reactors and the new generation and the new, very cute low risk, et cetera. They do not exist. If you are talking unproven, that is completely unproven. That is completely out there with Star Trek. As a serious legislator, taking seriously your responsibilities to assure energy supply, that is not a credible alternative.

When it comes to nuclear, your alternative is to build old scale, big scale, high capital plants, or it is not. Dr Green has just given one example of the opportunity cost of that. We will provide others, but I think that is important. The other thing, some other regulators—and this is not a left-right issue—but the Liberal National Party of Queensland has come out and formally said, "Let's not explore the nuclear option. It is a waste of time. It is a dangerous distraction. Renewables is the future." That is the Queensland LNP. In evidence recently to the federal inquiry, Mr Latham, the Government of South Australia, again a conservative State government, which has had an absolute—it has been in the frame with the storm that knocked out supply that then was seen as the failure of renewables, et cetera, et cetera. You would be well aware of it. The Government of South Australia made a robust defence of renewables and said that nuclear is not the way forward, renewables is. These are conservative States—one is in government, one is in opposition—but they are conservative State players who grapple with the same degree of integrity, with the same issue that you are grappling with. They have looked at it, not me, not Friends of the Earth, and they have said it is not the way to go, renewables is.

The Hon. MARK BANASIAK: Mr Sweeney, at the start you quoted some figures about the amount of uranium resources in Australia.

Mr SWEENEY: Yes.

The Hon. MARK BANASIAK: Have you got any sources for that? I am bemused that the Australian Conservation Foundation can give us those figures, but the Government witnesses this morning said those figures were not actually known.

Mr SWEENEY: Really?

The Hon. MARK BANASIAK: Yes. Do you have any of those sources available that you can table?

Mr SWEENEY: Yes, absolutely. I will certainly table them and I am really surprised, because those figures are routinely put forward and they are put forward by industry associations. They are available on the internet.

The Hon. MARK BANASIAK: They said they were very speculative.

Mr SWEENEY: Oh no. They are in the OECD in the International Atomic Energy Agency "Red Book".

The CHAIR: To be clear, for the benefit of the witnesses who were not here this morning, would you like to clarify exactly what it is?

The Hon. MARK BANASIAK: At the start you quoted some figures about—

Mr SWEENEY: About Australia's proportion of the—

The CHAIR: The market share.

Mr SWEENEY: —global reserve? Or the market share?

The Hon. MARK BANASIAK: Both.

Mr SWEENEY: Okay, happy to provide information on both.

The Hon. MARK BANASIAK: That will be great.

Mr SWEENEY: Yes, no trouble.

The Hon. MARK BUTTIGIEG: One of the things that strikes me, and I am sure other members of the Committee, is the chasm between each side of the argument here from clearly intelligent and dedicated people who take science seriously. I know economists have developed a bad name over time but it seems to me there is room here for an objective analysis by someone who has not got a horse in the race, so to speak. My question is this: You have got a number of parameters here; you have got market externalities, things like waste; you have got the trajectory of technological change, both in nuclear and renewables; jobs creation, one versus the other; a whole range of factors. Has any government commissioned a detailed economic cost benefit analysis of the two different sources trying to factor all those things in? It seems to me that if we got an objective analysis, which everyone would respect, that would go a long way to advancing us.

Dr GREEN: It is such a difficult question. One of the externalities you would need to factor in is accident and insurance costs. The costs of Chernobyl are estimated at roughly A$1 billion, a thousand million. It is obviously a rough guess. For Fukushima the current official estimate is $300 billion, but that is rising sharply, and if you included indirect costs that would already be in the trillions of dollars. I think, despite all our disagreements with the other side of this debate, we would all agree that nuclear is an absolute non-starter economically if they had to pay real world insurance costs, if those insurance costs were not covered by taxpayers, which is the norm. So again, you could look at, add a factor in those externalities, some submissions to the federal inquiry, and presumably also to this inquiry, have done some economics, some costings on what insurance costs would be if they were not subsidised by the taxpayer. They are alarmingly high. I have absolutely no idea if those figures are accurate but they struck me as being alarmingly high and they would certainly be a show stopper. But we have already got a show stopper, we have got multiple show stoppers in the US and Europe of reactors which are obscenely expensive and at least A$10 billion over budget.

The Hon. MARK BUTTIGIEG: Some of those things you are touching on, we have some very clever people in these fields with some of the most elegant, complicated mathematical models you could ever imagine. The idea that no-one has actually commissioned an economist to look at this is somewhat surprising to me, if that is the answer. You have highlighted certain areas, insurance costs, whatever, but it seems as though no-one has done a holistic analysis. Is that right?

Dr GREEN: There may or may not be such holistic analyses, but the thing is that it becomes very arbitrary. One aspect of those analyses is that you put a cost on a human life, which is immensely problematic and immensely arbitrary, but that is one thing you need to do if you want to go down that path.

Mr SWEENEY: There have been detailed assessments of specific projects, the cost of a project and explanations of blowouts or relative comparisons, et cetera. But your point of a whole industry, I suppose one of the real difficulties there, you mentioned the words objective independent expert. It is the pieces that you feed into your model that matter.

The Hon. MARK BUTTIGIEG: Always.

Mr SWEENEY: Exactly. Like the costs of waste management, how do you prioritise or how do you weight that into the future et cetera, et cetera. Those things bring with them value judgements, they are not just straight figures. You make an assessment and a value judgement, which then shapes your outcome. I am not familiar with a whole-sector one; I am familiar with site-specific ones.

The Hon. MARK BUTTIGIEG: Those site-specific ones, the results of those, what do they say?

Mr SWEENEY: The back of the envelope of them is that things always take longer and cost more by orders of magnitude.

The Hon. MARK BUTTIGIEG: Mr Sweeney, you raised a very interesting example in Western Australia where you say they have already gone down this path—in other words, they have opened up mining and extraction.

Mr SWEENEY: But there is no commercial mining. I think it is important to get that clear on the record.

The Hon. MARK BUTTIGIEG: That was the interesting point. Why is that? Why do you think that has happened? Is that because you are saying the global market just is not there for the development of uranium, therefore no-one bothered?

Mr SWEENEY: Absolutely. We have got the world's largest uranium miner holding two permitted uranium projects in WA—the largest ones in the State. They have put the dollar value of one down to zero; they have said to the other, "We are not going to advance it in the short to medium term because of challenging market circumstances." What it basically comes down to is uranium is measured in US dollars per pound, that is the way the commodity is measured. A decade ago it was travelling very high; there was a lot of buoyancy and enthusiasm, talk of a renaissance, and it was US$120 a pound. Fukushima happened, smashed the uranium market, has absolutely changed the uranium market and in a permanent way, and the price now is around US$25—so it is a massive fall. The basic rule of thumb in Australia for a greenfield site is you need to be around US$60 a pound for a greenfield site to turn and at 25 you are well south of that, and that is what is happening.

AMP Capital recently said that 90 per cent of uranium mining companies around the world are losing money; it is a haemorrhaging industry, so they are just holding it. And the Camaco chief executive said last week in a statement—it was reported in last week's *The Australian*—that the best way to preserve the value asset of uranium is to leave it in the ground, and that is what we are doing.

The Hon. MARK BUTTIGIEG: Just one quick follow-up for Mr Gambian. You touched on jobs—I think it is one of the key points that people want to know about. Has any analysis been done on the likely outcome of renewable-created jobs as opposed to nuclear-created jobs, if we were to go down one path or the other?

Mr GAMBIAN: I am not aware of the comparison, but, as I said in my opening statement, quite a bit of work has been done on the potential for jobs from the renewable sector, and we are talking about tens of thousands of jobs. So it is hard to imagine constructing a single power reactor would be anything like the kind of opportunity that renewables presents. The other advantage of renewables is that we are talking about some of the areas of the State that are in most need of some economic development would be the biggest beneficiaries of it; we are talking about the far west, the New England, the south-west—these are all regions that, as everybody knows, are struggling with the drought. For a very small outlay of land, relatively speaking, we could significantly enhance the viability of some of those properties and some of those farms. So the support for renewables, again, is not a left-right issue or a greenie-versus-farmer issue; there is widespread support across the State and the one missing piece—and as I said in my remarks, we are hopeful that the Government is interested in this stuff—is a big sort of clear set of goals and some ambition. It is well within our reach—it is not speculative, it is not abstract, it is well within our reach.

The Hon. MICK VEITCH: Can I follow-up on that. I think it is in one of the submissions but we have also heard somewhere else on one of our site visits, that if we move towards renewables, essentially that means there is going to be a fundamental remake of our economy where we move from an industrial manufacturing-style economy to more of a recreational-style economy. The argument put to us is that renewables will not be able to provide the baseload required for some of that manufacturing capacity in our current economy. What do you say about that?

Dr GREEN: I would say that is a work in progress and ground zero for that I would say is Whyalla where there are plans in train to have a heavy manufacturing industry based on renewables, but they are not there yet, so I cannot say it is proven. But that is one test case, and I certainly would not accept as a proposition that moving to renewables necessarily means moving away from an industrial economy towards a recreational economy. I do not think the evidence supports that.

Mr SWEENEY: Last Thursday I was at the BHP annual general meeting and they were at pains to say that their future is buoyant and it is buoyant because they said repeatedly that the mining sector is the powerhouse, the engine house, the driver of a renewable energy future. They were saying that the commodities that they mine and process may change, but they will be doing lots. They were also speaking very strongly about iron ore and steel as a future. They are expanding Olympic Dam for copper. So there was not a hint there in the world's biggest miner that we are all going to become Gilligan's Island for renewable energy.

The Hon. WES FANG: From the evidence we heard this morning, a number of witnesses were supportive of nuclear power and their testimony indicated that there is a role for nuclear in conjunction with

renewables as in they can coexist and complement each other. Can you see a scenario where that is the case or is your objection to nuclear and power generation without carbon output not possible using nuclear power?

Dr GREEN: Essentially that is a technical question and the technical response is that nuclear power plants are terrible at load following, which means they are not a good complement at all for variable renewables. The nuclear industry's response to that, which you presumably heard this morning, is that the next generation of nuclear power plants will be good at load following. Again, it is just speculation. That may come to pass; if it does come to pass, fine—we have got a new set of inputs into decision-making on these issues—but it is absolutely not the case now. Nuclear power plants are notoriously bad at load following and are rarely used for that purpose. That is why we need a whole suite of different options—variable renewables, baseload renewables, pumped hydro storage, battery storage et cetera, et cetera, run-of-the river hydroelectricity. All these different options are looking very promising for Australia.

The Hon. WES FANG: If that is the case where, for example, renewables require gas peaking stations to provide that backup when they are not able to produce the baseload power, would it not be worth governments investing into nuclear power to see whether nuclear could provide that high response rate that is required because it will produce without the need to burn fossil fuels and produce carbon emissions?

Dr GREEN: It would be an extraordinary investment in an unproven option. I would first be looking at all the other options. Gas is one, and obviously it is available, but biofuel gas with low emissions, and all the other ones we have been talking about—batteries and pumped hydro and so on.

The Hon. WES FANG: But if we are looking at having a zero emission economy, nuclear potentially offers us that solution, does it not?

Dr GREEN: No, nor does renewables. There are always going to be carbon emissions associated with energy generation.

The Hon. WES FANG: So you do not believe that a zero emission economy future is possible?

Dr GREEN: Net zero is absolutely possible but for a wind turbine, it is concreted steel, there are energy and emissions associated with the construction of those.

Mr SWEENEY: Mr Fang, if I could just say another way of looking at are renewables and nuclear compatible, can they coexist in that sense as a climate abatement solution, I think the only context where I could see that working is in the situation where there is an existing nuclear industry. If you are proposing a new-build nuclear industry, that is completely different, and that is what we are proposing here. Like it is a first spend.

The Hon. WES FANG: Actually we are not. What we are proposing is to remove the ban.

Mr SWEENEY: Indeed, with a view to encouraging the development of a nuclear industry. That is clearly what advocates are seeking. I think when you get a situation where you have the fifth largest industrial economy in the world, Germany, or the sixth largest industrial economy in the world, the state of California, where they have made decisions by 2025 to accept nuclear, there is a role for coexistence while renewables ramp up. If we are talking twenty-first century Australia, New South Wales, to build New South Wales as a coexistence with renewables, it really does not make sense and it is the opportunity cost dimension. Some people view this as flippant but it is not. There is a view that renewables do not work and yet nuclear does. Yet if you look at the thing that powers life on this planet, it is a fusion reactor. Like sun is a fusion reactor and from the point of view of: If terrestrial nuclear makes no sense, galactic is already there. It is installed, it is permanent, it is operating, it is shielded, it is licensed. We do not have to deal with the waste.

The Hon. MARK LATHAM: What do we do at night time?

Mr SWEENEY: We capture. It is a really good question but the issue is not any more: How do we generate? It is how do we capture, store, transmit and use efficiently? There are such vast amounts of solar energy that are delivered that the challenge is to find mechanisms that deliver, capture and storage. That is a challenge far less than the challenge of let us isolate radioactive waste for 100,000 years.

The CHAIR: I am very conscious of the time. We have gone almost five minutes over. Before we rap up, Dr Green, you mentioned something a few moments ago about base load renewables. Would you be able to give us some examples of what you mean by that?

Dr GREEN: Yes. Hydro can sometimes be used as base load. Geothermal has had a rocky start in Australia but is effective elsewhere and perhaps has some component to play in Australia, and biofuels. There are several base load renewable options. I am not sure if that term is widely used but it will suffice for our purposes.

The CHAIR: Thank you very much. The Committee has resolved that answers to questions taken on notice be returned within 21 days and the secretariat will contact you in relation to any questions you have taken on notice. Thank you again for your time here today.

(The witnesses withdrew.)

DANE ECKERMANN, General Manager, Bright New World, before the Committee via teleconference, sworn and examined,

JAMES FLEAY, Chief Executive Officer, Down Under Nuclear Energy, sworn and examined,

DONALD HIGSON, Private Citizen, sworn and examined

The CHAIR: Would any of you like to make an opening statement?

Dr HIGSON: Perhaps I had better say in advance that although I am here in a private capacity I am the Secretary of the Nuclear Engineering Panel of the Institution of Engineers of Australia and in the past I have been an executive committee member of the Australasian Radiation Protection Society and the editor of its newsletter for about 10 years. But, as I say, I am here in a private capacity. I am not speaking on behalf of those organisations.

The pursuit of reductions to greenhouse gas emissions from power generation has led so far to an energy crisis in Australia which could have been avoided if nuclear power had been included in the energy mix. But this is prohibited by legislation that has no justification. This New South Wales Uranium Mining and Nuclear Facilities (Prohibitions) Act of 1986 was, I understand, enacted in response to the nuclear reactor accident that occurred earlier that year at Chernobyl in the Ukraine.

This response was entirely understandable at the time but it was inappropriate because the Chernobyl accident had no relevance to nuclear power plants elsewhere in the world or to reactors that might be built in Australia. The type of reactor in Chernobyl was badly designed, badly operated, unregulated and would not have been licensed outside the former Soviet Union. By 1999, that is, 20 years ago, the world had begun to realise that Chernobyl did not properly represent the nuclear industry in general. If construction of a nuclear power plant in New South Wales had started then, it could have been operating safely before the Fukushima disaster in 2011, thus giving us a more rational basis for assessing the real significance of that event for nuclear power in Australia. Now it is being said it is too late for nuclear power to have any chance of resolving our energy crisis; it is said by some people.

I am sure that is not so. In any case, it is no justification for continuing the nuclear prohibition. So let us get on with it, otherwise 10 years from now the situation will be far worse. New South Wales needs base load generation of electricity now and in the future. My particular concern has been, and is now, why not nuclear? It could certainly provide reliable base load power with minimal greenhouse gas emissions. I have shown in my submission that objections on the grounds of safety and waste disposal do not stand up to critical examination. I do not intend to go on about that but I am very happy to answer questions around it. Cost, I do not believe, was a deciding factor in the prohibition of nuclear-related activities in New South Wales in 1986 but the expectation of high cost now really is not a reasonable continuum of that prohibition. However, I suppose it might be a disincentive to go through the process of repealing the prohibition. However, I do not think high cost should be a credible expectation.

The cost of nuclear power has been greatly misrepresented in Australia, largely on the grounds of several serious cost overruns for first-of-a-kind plants of new designs overseas, and we just heard about that. The cost of well-established nuclear power generation overseas and professionally estimated cost of nuclear power in Australia are among the lowest costs for any source of energy, and are the cheapest for low carbon emissions.

[*Portion of transcript missing due to technical difficulty*.]

These cost overruns which have been cited overseas, very similar plants have been and are being built in China and in North Korea. North Korea has just built a large nuclear power station for the United Arab Emirates—

The CHAIR: Do you mean South Korea?

Dr HIGSON: South Korea, sorry. Did I not say South Korea?

The CHAIR: You said the other one which I did not think might be a possibility.

Dr HIGSON: No, I do not think so. I do not want to do business with them.

The CHAIR: That is okay.

Dr HIGSON: They are building very similar power plants and they are building them on them on time and to budget. Figures I have cited in my submission were that the cost of nuclear power is very competitive in China and certainly has shown to be competitive in South Korea and previously in France, although the latest example Flamanville is not very encouraging I must say. Again, similar plants are being built in China. There is a very good chance that nuclear power would be competitive in Australia. In fact, better than a good chance. There

are uncertainties about this cost, certainly, and the first nuclear power plant in New South Wales, the Government may need to provide loan guarantees to encourage investment because the potential benefits of the nuclear industry in New South Wales are huge. I am happy to go into that. Finally, these benefits would include the mining of uranium which is being done safely and profitably elsewhere in Australia. At the moment this would be a long-term prospect but there is absolutely no reason for it to be prohibited in New South Wales.

The CHAIR: Thank you. Mr Fleay, did you wish to make an opening statement?

Mr FLEAY: Thank you. Down Under Nuclear Energy [DUNE] is a nuclear energy start-up formed 18 months ago for the purpose of bringing nuclear energy to Australia. We are grateful for the opportunity to speak and answer questions today. It is highly encouraging that this Committee is examining the merits and prerequisites for a nuclear energy industry in New South Wales. We hope we can be of assistance to the Committee. The challenge for policymakers and industry is to deliver affordable, reliable, zero-emissions electricity. Affordable reliable electricity today is not enough if we knowingly transfer the costs of today's decisions to future generations. Equally, clean power today such as it is, is not acceptable if it consigns future generations to energy poverty and a moribund economy. We submit that nuclear energy deserves an opportunity to be part of the solution to this challenge. The world and the future present us with many hard constraints, to further constrain ourselves by refusing to consider a proven zero-emissions source of electricity is hard to comprehend.

The value of options is understood by businesses and investors who place a premium on acquiring and retaining options. Options theory is a thoroughly developed field of academic inquiry. Artificially reducing this State's options with regards to zero-emissions electricity will produce suboptimal outcomes. The consequences of decisions taken today will primarily fall on future generations whose real options become further constrained with the passage of time. Much recent commentary by nuclear energy sceptics focuses on the costs to deploy the technology. This is a conversation that we welcome because many current claims are either selective or meaningless. Comparing the cost to deploy a kilowatt of capacity between different technologies tells us almost nothing about the end cost of electricity to businesses and households for different combinations of electricity supplies. With a wide range of electricity options that each have different deployment and operating attributes, total system costs are now widely acknowledged as the only meaningful basis of comparison. However, policy makers do not need to guess at the economics of a nuclear energy industry in New South Wales.

If government and business cannot find a way to deploy it economically, the private sector will not build it, but let us not rule it out before business has an opportunity to thoroughly evaluate the nuclear option and to bring their proposals forward for government consideration. Like the chicken and the egg, business will not do this until the prohibiting legislation is removed. Our preliminary assessment indicates that there is a prospective investment case for nuclear energy in New South Wales which justifies a more detailed analysis of deployment costs and contemplation of the NEM market structure as it is and as it could be. The special focus this inquiry has on SMR is encouraging. Our own assessment of traditional, large scale nuclear technology is that it may be economical in New South Wales, but that the project delivery risks are too high for the private sector to countenance the investment—not so with SMRs. However, some discrimination is required when discussing SMRs as this acronym obscures vast differences in technology readiness, lead time and deployment costs between different designs. A SMR design that is a miniaturisation and an elegant simplification of traditional light-water reactor technology cannot be considered new technology, "In the same way that other Gen IV designs must be."

The deployment and investment risks for a light-water reactor SMR are much lower than either traditional large scale reactors or other classes of SMR designs. What if renewables, storage, demand response and smart grids do not fully deliver on the promises made by lobbyists and advocates? There is a material probability that they will not and New South Wales policymakers must have other options ready to go. What future economic hardship might New South Wales face if we discover that renewable energy by itself is not capable of delivering affordable, reliable electricity? What could be the implications for social stability and welfare? And who will be held accountable for this State's decision to put all its eggs in one basket? We ask all sides of politics that the policy of technology neutrality be extended to nuclear energy. State and Federal cooperation with regards to nuclear energy is critically important. Once the prohibition is removed, business can devote resources to exhaustively testing the investment case for nuclear energy in New South Wales and present these to the State and Federal governments of the day. Thank you very much for your time and consideration.

The CHAIR: Thank you. Mr Eckermann, would you like to make an opening statement?

Mr ECKERMANN: Yes please. Thank you Chair and members of the Committee for giving Bright New World the opportunity to present today. Bright New World is a not-for-profit environmental NGO that exists to promote positive solutions for complex climate and environmental problems. Our core ethos is: Stable climate, rich nature, prosperous humanity. We know that humanity can prosper alongside nature. We do not subscribe to

the Malthusian environmentalist thinking where only one pathway to a better environment is through reducing the quality of human life. We believe in working with people and our institutions because it is people who can solve these challenges. Our message is one of hope, not despair. In our submission we presented the evidence that affirms nuclear's place in a low-carbon world. We demonstrated that while there have been notable examples of harm, expense or delay, these are specific case studies and no inherent issues with a whole family of technologies. To the contrary, the vast weight of data attests that nuclear provides clean, reliable and affordable power.

That Australia has left its run late means that we can only choose the best projects based on global experiences. However, it is prohibitions that have hamstrung any nuclear development or proper analysis in Australia. The common theme we hear when talking to vendors, analysts or economists is, "But it is prohibited." This is a crutch for poor analysis and create a self-fulfilling cycle has delayed our embrace of these solutions, but the world will soon overtake us. There is no justification for keeping the bans in place. They serve only as protection for market incumbents who wish to exploit our technical reticence for financial gain. In short, there is no national interest whatsoever in prohibiting an entire class of power technology. Thank you again for the opportunity to speak. We represent a small but growing community of people who believe climate change is too important to hold hostage to outdated technology prejudice and who also understand that the path forward must provide plentiful clean energy for human wellbeing. We are pleased to take your questions today.

The Hon. WES FANG: Thank you all for appearing today, whether in person or via the telephone. I am sure that some of you had the opportunity to hear our previous witnesses, who were less than enthusiastic with the concept of nuclear energy and were in favour of renewable energy. Their argument was that we should not lift the ban even though it makes no economic sense. Would you consider if the ban was lifted that companies would invest in the sector without it having an economic rationale?

Dr HIGSON: You say "without having an economic rationale". It is difficult to know exactly what nuclear power would cost Australia whilst it is illegal. I mean, you ask anybody who is able to answer that question and they will say, "Why should I spend time working it out? I would not be able to build a plant anyway." We have some academic estimates. In my submission I gave what I think is probably the most professional estimates that are available which show that nuclear power, as I said, is the cheapest way to get reliable electricity without carbon dioxide emissions—without greenhouse gas emissions, I should say. There seems to be an obsession with carbon dioxide but really it is all the greenhouse gas emissions we have to be concerned about.

I am not in the business of building nuclear power stations. I am not sure whether it will be attractive. The way the energy market works at the moment it is very attractive to build renewable energy simply because you are pretty well guaranteed profits, quite large profits too. But I think the long-term interest to Australia, or the long-term interest to New South Wales, which is what we are talking about today, is really served best by having a mix of energy sources, which would include a substantial amount of nuclear power. As I said in my submission, because of the uncertainties relating to the cost of first of a kind it may be necessary to provide some loan guarantees. Now, subsidies—I do not know. I mean, I am quite certain that renewable energy is only viable because of the subsidies given to it.

I am told that coal is subsidised as well but I think that is mainly the infrastructure like roads, railways, ports and things like that. Anyway, I am not really into completely understanding the subsidies. I do not believe that in the long term nuclear power would need to be subsidised. As I have said, to begin with I would think a loan guarantee is probably the thing that we would look for.

The Hon. WES FANG: Mr Fleay, have you ever experienced a company investing in an area where there is unlikely to be economic return?

Mr FLEAY: No.

The Hon. WES FANG: The idea that was presented by our previous witnesses—that, even though it is their belief that there is no economic return in nuclear power, the ban should be continued—would seem to be counterintuitive, would it not?

Mr ECKERMANN: I might add to that conversation. With regards to prohibition, when we have spoken to vendors, particularly SMR vendors, they have also said that they are unwilling to outlay any capital investment in Australia while the prohibitions remain. It is very difficult with these messages to justify to the company to outlay millions of dollars on studies, assessments and all those sorts of things when a prohibition is in place. That is just a fact. What we have heard from the Commonwealth inquiry that is underway at the same time is that the Australian Energy Market Operator and the CSIRO have both stated that they do not pay a lot of attention or put a lot of effort into studying nuclear's role in Australia's energy mix because of the prohibitions in place.

On that point we see that the prohibitions are a big inhibitor for companies to put their money where their mouth is and say, "Look, we want to do this here, this is how we can do it," and also our statutory institutions that are set up to provide these independent assessments. But on the argument that was mentioned from the previous comment, with projects that have no economic return it is a bit hard to justify prohibiting those technologies because—I do not know if the members of New South Wales are aware, we had a very popular, very well thought out solar thermal project here in South Australia that had a government power purchase agreement [PPA], it had popular support with the public and it had all its ducks in a row but could not achieve financial close.

That sort of logical argument, you know, I would be saying, "Well, these groups you presented before, are they going to allow us to ban solar thermal technology because it is uneconomical here? It could not achieve financial close." So it is a bit of an interesting argument that is made that because something is not economical at a certain point in time that it deserves to be banned. At Bright New World we do not see the logic in that sort of argument at all.

Mr FLEAY: Mr Fang, if I can just speak to that. The people who work for DUNE primarily come from the oil and gas sector. The way that we would approach something like this in that sector, and I think it would be the same here, is once the prohibition was removed we would then be able to justify the time and money to invest in a commercial feasibility study. That is very different from an academic inquiry; that is not the same thing. We would do a bottom-up class 2 estimate. We would say, "These are the figures that we need to be viable. We need to be selling 70 per cent of our power for 20 years. We need some government assistance to pay for the licensing of the first plant because the regulatory regime would be uncertain. We do not want to wear the cost of an uncertain regime for the first plant."

It would be incumbent on the business to propose to government what it needs to be viable and for the government to say, "Yes, we are willing to support you," or "No, we are not, because we think it is too expensive." So it starts a dialogue but, ultimately, no-one is going to invest if it is not financially viable.

Dr HIGSON: Can I just add that the study that CSIRO did for nuclear took a figure of $16,000 per kilowatt, I think it was quoted earlier on, was it not? I think that is right. The figures we have had presented to the Nuclear Engineering Panel is that that is about three times higher than reality. It might be that the first of a kind would cost something like that but if you ask the CSIRO where it got that figure from I do not think it really knows. It cannot justify it.

The Hon. MARK LATHAM: I have a question for Mr Eckermann. On page 5 of your submission you talk about your conversations with nuclear vendors and their frustration with the bans in place. What is your feeling about the level of investment interest if the bans were lifted? Do you think there are serious players who would put their money forward?

Mr ECKERMANN: What we have heard from these vendors is that they see Australia as a quite mature country in terms of nuclear science technology. We already have a facility over there at ANSTO. ANSTO is a really highly regarded science and technology organisation that these vendors say, you know, "You basically have everything here ready to go. It is just a matter of the Government signalling to the rest of the world that we are open for business." I am giving you another example here. The United Arab Emirates back in 2007 decided that they would pursue nuclear power in their country. They had practically nothing. They had the International Atomic Energy Agency [IAEA] come in and advise them and help them on developing and building an entire nuclear regulatory operations system from the ground up.

When we talk to vendors about Australia they look at us and they see us with a radiation regulator that is already here, a nuclear science and technology organisation that is well regarded, we have a highly skilled workforce here, we have experience with large civil projects and the only real thing could be having the IAEA come in and look at what we have and suggest what the next best-practice institutions or processes are and basically go from there. So they do see us as a place that would be suitable for nuclear technologies.

The Hon. SCOTT FARLOW: On that point, what determines what is suitable for nuclear technology?

Mr ECKERMANN: We have not had, I suppose, the specifics but you can go to the IAEA guidelines and they outline what Australia needs to have in place to be suitable. But the feedback we get—this is the face value feedback—is that Australia is a mature country. We basically have everything here ready to go. It is just a matter of removing these prohibitions and then they can come here and say, "Look, this is how we're going to do it, this is how much money we can outlay," and those sorts of things. But until those certain things happen and movement happens on that, it is basically the desktop studies at the moment.

The Hon. SCOTT FARLOW: But in terms of the things they take into consideration, would they be the regulatory environment, the capital environment, the skilled workforce? Do they take into account geological conditions and that in Australia as well?

Mr ECKERMANN: Yes. That is correct. All those factors do play a part.

The Hon. MARK LATHAM: Mr Fleay, you mentioned that the acronym SMR disguises many options and possibilities. Can you elaborate on that? I must say the Committee has got itself into thinking about a dichotomy. There is the SMRs and then there is the big established ones with the older technologies that we know about. What is in-between? Is this dichotomy valid and how would you describe the stuff in-between?

Mr FLEAY: Sure. Within the acronym SMR you have a family of reactors. Some of them are little more than a design on paper. Others have spent US$1 billion on developing designs, prototyping, licensing and all that sort of thing. So at one end you have a light water reactor—the tradition technology that has been miniaturised and simplified. It is the same fuel technology. It is the same physics code. It is very similar regulatory requirements. The technology step out is very minimal. At the other end you have things like molten salt reactors with thorium fuels, you have sodium-cooled reactors, you have fast neutron reactors, all of which are prospective but people should be aware that they are at least a decade if not two decades away. There is a very long way to go for that class of SMRs. But the light water reactor SMRs or the boiling water reactor SMRs—that is not a big technology step out at all.

The Hon. MARK LATHAM: They have been miniaturised but there is a range of sizes in-between. Basically now in that old light water technology you can get any size of reactor, effectively.

Mr FLEAY: Not any size. There are two that are probably the most developed. One is a 60 megawatt reactor and one is a 300 megawatt reactor. They both borrow heavily from previous technology.

The Hon. MARK LATHAM: This morning the Australian Nuclear Science and Technology Organisation was talking about air cooling reactors. Where are they at? Are they in your one to two decade horizon?

Mr FLEAY: You could do air cooled reactors today. Air cooling is used extensively in the liquefied natural gas [LNG] sector. The problem is it imposes an efficiency cost on a plant. For the amount of uranium that you burn you cannot get the amount of electricity out of the back end of the plant because you have a parasitic load for air cooling, running all those fans. But the air cooling technology is used in other facilities all over the world. It is just not as efficient as water cooled.

Dr HIGSON: Can I just insert a comment here about small modular reactors? The typical small modular reactor, as my colleague here just said, is somewhere around about 100 megawatts, I suppose. The one that is most advanced and probably would be a good bet for Australia is about 50 megawatts. Of course the big ones—if we had gone for a reactor 20 years ago it probably would have been about 500 megawatts and if you went for one nowadays, and it might be looking at being online in 10 years' time, it might be 1,000 megawatts. In between that, which I think is what you are getting at, I would like to draw your attention to the Rolls-Royce reactor which has been developed for the British Government, which I think is 450 megawatts.

Rolls-Royce has an enormous background in small modular reactors. They have been building them for submarines for over 50 years and of course a submarine reactor is not going to be a commercially viable proposition but they have had in the background the possibility of building commercial reactors for a long time and the technology for doing it. They have got feelers out internationally with quite a number of nations for this size of reactor and 450 megawatts might be quite a good size to install. But that is just a possibility.

The Hon. MICK VEITCH: One of the issues raised around Chernobyl is that there was a failure of the regulatory regime, essentially, at that time. If the prohibition were to be removed here in New South Wales or even Australia, what sort of scaling up of our regulatory regime would be required?

Dr HIGSON: It would certainly require some scaling up. At the moment it is really oriented around uranium mining and the other uses of other things that might involve radiation in the world and of course just the one reactor we have at Lucas Heights, the OPAL reactor. Once we have removed the anti-nuclear legislation the next step would be to establish the proper regulatory infrastructure which would be necessary before we could start—obviously we have to pick a site for a nuclear power station before anybody can start to give quotations. They want to know what the site is going to be and what the regulatory requirements are going to be. So it would require some expansion of a regulatory authority. Are you talking to them at all—Carl-Magnus Larsson?

The Hon. MICK VEITCH: The Australian Radiation Protection and Nuclear Safety Agency is coming in this afternoon.

The CHAIR: At a quarter past four today ARPANSA will be witnesses to this inquiry.

Dr HIGSON: I think that is a very good question to ask him. There would need to be some expansion and you would probably need to recruit some people from overseas. I think he probably has most of the regulatory

requirements more or less ready to put on the table. The big thing, I think, would be the selection of sites. That is going to take a while because the anti-nuclear people will fight tooth and nail any site that is proposed. It might be a good idea to start off with something like a site where there has been a big coal-fired power station that is going to shut down and there is an obvious one there—Liddell. Whether Liddell will be a suitable site for a nuclear power plant I am not able to say but it would certainly be worth looking at. There would be other sites where you have the transmission in place already. We do not want to have to start building multitudinous power lines like you do to chase the possibilities of wind farms. So, yes, ask Carl-Magnus Larsson. He would be the man to answer that question.

Mr FLEAY: I was in the United States in July and we had meetings with a series of US-based consultants, one of whom was a regulatory expert, ex-United States Nuclear Regulatory Commission [NRC], and he was involved with the licensing of the OPAL reactor, and he is well-connected here in Australia. We spent some time in those workshops talking about the cost of the regulatory regime.

For Australia and New South Wales, we would need to consider regulatory harmonisation. If we look to take credit for the work that has been done by the NRC over 70 years, by the ONR (Office of Nuclear Regulation) in the UK and by the Canadian regulator—just to start; there are others there—we would not want to reinvent that because if we were going to try to license reactors that had already been licensed, that is quite a big step up in expertise that I do not think we would have access to quickly. We would need to take credit for the regulatory regimes in those countries, and then our expertise would be more in site licensing, as opposed to technology licensing. They thought there were lots of opportunities there. To Mr Eckermann's point, they were very impressed with the work they did with the Australian regulator to get the OPAL reactor licensed, and they did not think it would be a big step up at all, provided we went down the pathway of regulatory harmonisation.

The CHAIR: Mr Eckermann, do you have a view about the regulatory requirements for scaling up?

Mr ECKERMANN: I would add onto that that, yes, there are other regulatory institutions in places like Canada and the United Kingdom that do go through these licensing processes that are quite in-depth and there would be an opportunity there for the Australian Government, the New South Wales Government—whoever it is—to harmonise some of those regulatory processes with those agencies because they, in some cases, have already licensed particular reactors, and it would be advantageous for Australia to piggyback off those processes in terms of licensing to see what reactors would be suitable for Australia.

The Hon. MARK BUTTIGIEG: One of the more interesting or cogent pieces of testimony I heard earlier was the fact that we have a real-life example where these restrictions have been lifted. There is a lot of contestability around what the facts are on both sides of the debate and I find it quite interesting that there is such a wide chasm, depending on who you talk to.

Dr HIGSON: Excuse me. I cannot hear you very well.

The Hon. MARK BUTTIGIEG: Sorry. Did you get the first bit?

Dr HIGSON: I think so but my hearing is very bad.

The Hon. MARK BUTTIGIEG: Dr Higson, I was making the point that it is interesting that there is such a wide chasm on both sides of the argument for what are clearly well-informed, well-researched and intelligent people; that, depending on which side of the debate you are on, you get wildly different claims. Earlier on we heard testimony that, in some sense, a real-life example of this having been tried in Australia is in the Western Australian jurisdiction where there is no restriction on uranium mining and, yet, the industry has failed to advance. That is quite potent to me in the sense that a real-life experiment has not worked. What do you say to that?

Mr ECKERMANN: I might jump in and answer that. In a previous capacity, I was representative of the mining sector here in South Australia. In terms of those mines in Western Australia—the uranium ones that have not gone ahead—it is more that the mechanics of the market conditions for uranium as a commodity are quite depressed at the moment and then that the economic viability of these projects is not ascertained as yet. Those projects have gone through all their processes to assess whether they are suitable to be developed in Western Australia but the thing that is holding them back is basically the economics of uranium at the moment. We saw that here in South Australia when the market became depressed and we had mines here go into care and maintenance.

So, in terms of that argument saying that it has not been in Western Australia, so it does not go ahead, uranium mining has not been in South Australia and we have a great industry here, so it is a bit of an interesting argument to make on that point. The ones in Western Australia, it is just basically the economics of uranium at the

moment. It is just not favourable. It is likely to increase in the future but, yes, it is not a case of that. You can do it and no one is not doing it. They are doing it but it is just financial at the moment.

The Hon. MARK BUTTIGIEG: If you were on the other side of the debate, you would say, "On the other hand, look at the take-up of renewables and the trajectory of that industry compared." If you are one of these people—I am not necessarily in that camp, but the market does have its place and can price things fairly effectively in many parts of the economy—your argument would be, "Well, this is clearly where the market is going. It is not going towards nuclear; it is going towards renewables." That is a very common argument I hear and does seem to have some evidence behind it.

Mr ECKERMANN: On that point I could say that having a renewable energy target and subsidies given to solar and wind development dramatically helped them get up and get going in Australia. If you had something like, say, a clean energy target where it is not discriminatory based on what technology you have—it is open to all technologies that have an emissions intensity of, say, below 100 grams or 50 grams per kilowatt hour—you might see it, in terms of renewable energy certificates, receiving upwards of $50 per megawatt hour for electricity produced. That is an incentive to develop those technologies and that is what we are seeing here, particularly in South Australia and in other states—that you have a favourable regulatory environment and they will develop.

In terms of nuclear, if nuclear was afforded the same benefits that renewable energy has in Australia, you might see a few projects get up. When Bright New World looks at nuclear development in Australia, it is alongside renewable energy development. We see there is a good market in Australia for at least 10 gigawatts of nuclear power. Most of it will probably be in the eastern States, although we would like to see some here in South Australia. If nuclear was afforded the same benefits that renewable energy has received, then you could likely see some projects become viable.

Mr FLEAY: Could I make one point there? As a company that would, one day, like to bring nuclear energy to Australia, low uranium prices are fantastic news. All that does is drive our operating costs and fuel costs lower. So, while uranium prices might be depressed and that might be hard to get uranium mining projects off the ground, that is fantastic for power. I would say that that is a very good reason to introduce competition into the market and say, "You have lower uranium prices. It makes nuclear power more competitive." You want to bring electricity prices down. That is part of the equation.

The Hon. MARK BUTTIGIEG: Does that not contradict the experience in Western Australia, because, if that was the case, you would think that would have gone ahead in leaps and bounds? My understanding is they have had a deregulated regime for quite some time.

Mr FLEAY: That is right but the demand is not there for uranium because there is enough low-cost operations around the world. If you look at the big mines in Canada, Kazakhstan, Russia and our own Olympic Dam, the price that they can get yellowcake out of the ground for is extraordinarily low. Those mines out the back of Western Australia—and I was with the Cameco chairman at the Perth leg of the Federal inquiry and we were discussing this—just cannot get their costs down as low as the existing mines. It is a market that is well supplied.

The Hon. MARK BUTTIGIEG: Can I ask about this concept of low-level, medium-level and high-level waste? From what I can gather, some of these electricity-scale production requirements would produce the high-level waste. Is that correct?

Dr HIGSON: Yes. The high-level waste, essentially, is the spent nuclear fuel, or, if it is reprocessed, the product of that reprocessing. That is what the high-level waste is, essentially, yes.

The Hon. MARK BUTTIGIEG: We were told earlier on in testimony that there are no high waste level repositories to store this stuff. Those existing facilities around the world which could produce electricity on a big scale, such as France, where do they store this high level waste?

Dr HIGSON: I cannot tell you exactly where it is. The technology is to first of all store the spent fuel rods at the reactor sites and this would take some tens of years for the nuclear fission products—because they are highly radioactive they are the ones that decay most quickly—you would have some tens of years when those spent fuel rods are kept in ponds of water. Then eventually they would be taken out and put into dry storage and that happens with most of them around the world in various places.

The Hon. MARK BUTTIGIEG: Could you clarify, when you put the rods in it is high level and after decades it becomes medium level, does it?

Dr HIGSON: That is still regarded as the long-term fate of high level waste. It is not just a matter of levels of radioactivity, it is a matter of managing the material itself in the long-term. The intermediate level is the stuff that comes out of the radio isotope industry, which we have in Australia. It is not so much the level of radio

activity it is the type of material you are handling that is called high level waste. In the long-term people want to know where it is going to go and there are two extreme options of what to do with it. You either keep it as just spent fuel rods and dispose of it somewhere and the most favoured idea is to put it into deep stable, dry rock formations that have been stable and dry for millions of years and have a good chance of a staying that way.

The other extreme is to chemically repurpose that fuel and separate out the highly radioactive parts of it. Although the really high level stuff has decayed away it is still pretty nasty to handle. You can separate out those fission products, the highly radioactive part of it, from the longer lived and less radioactive materials like the unburnt uranium, plutonium and the other transuranium elements which are called minor actinides. This can be recycled into the nuclear fuel cycle leaving, as I said, if you have reprocessed the fuel those still quite highly radioactive materials to be disposed of in the long-term. The idea would be to turn those into some non-leachable form and encapsulate them and bury them deep in a stable dry rock formation.

The Hon. MARK BUTTIGIEG: Those two courses of action you outlined, reprocessing to attenuate the radioactivity and storage in the earth's geology, are those concepts or solutions still at the theoretical level or are they actually being used today?

Dr HIGSON: Yes, they are actually being used. I think we have been told there is a lot of social objection to having the fuel repositories but there are some nations that are going ahead with those, Finland is one of them. This was mentioned earlier by the previous panel of people. Britain is going ahead with looking at this, and the French are. It is a political problem, long-term disposal of waste, it is not a technical problem. That can be done and it is being done. It is the social acceptance of this and the political reaction to that social acceptance that is the problem.

Could I go back to a couple of points made earlier. I think in the long-term the main issue is the economic viability of nuclear and someone made the point that renewable industries are powering ahead whereas the nuclear industry is staggering to some extent in Australia because of the way the energy market operates. The energy market pretty well guarantees substantial profits for anybody who wants to build solar and wind power plants, particularly solar plants. It discourages base load generation of any sort. Who would invest in a coal-fired plant which is going to have to be turned off half the time because renewable energy can undercut it?

The CHAIR: That is a great point.

Mr ECKERMANN: Just on the spent nuclear fuel discussion. As Dr Higson said, the issue with spent nuclear fuel disposal and management is more of a political one than a technical one. What the Fins are doing on Olkiluoto with their geological repository—they are well advanced now—they are actually testing their canisters underground in granite as we speak and the facility in the champagne district in France is quite well advanced. The difference between the two approaches is that France reprocesses a lot of their spent nuclear fuel to make new fuel and the majority is stored as vitrified waste. It is stored in a glasslike substance so it is immobile. That is stored in canisters. The facility they have at La Hague, which is around Brittany in France, you can walk on top of the floor where the spent nuclear fuel is stored.

In terms of when we go to the temporary storage in what they call dry casks, which is the big 100-tonne concrete cylindrical objects, they are now rated by the NRC to 100 years. To give some context to that, when spent nuclear fuel comes out of a nuclear power plant it is stored for two to five years in a spent fuel pool to cool down and then they take that into those giant concrete casks. When we are talking about those they are rated for 100 years. You can go on to YouTube and look up Sandia National Laboratories testing those things against rocket propelled trains and all sorts of things and the canisters are completely fine. In 100 years time that spent nuclear fuel has lost about 90 per cent of its radio toxicity; how harmful it is to humans.

By that time you are more concerned with the long lived isotopes that are remaining in that fuel. If you reprocess that fuel you are then shortening that lifespan. You have the disposal of that nuclear waste from 10,000 years down to 300 years. One thing that the Brittany build advocates for in addition to that is use of this spent fuel as an additional fuel source in fourth generation reactors. These are your sodium cooled or metal cooled reactors. In the Idaho National Laboratory they tested this concept in the eighties and nineties and they found it to be a viable option. It is the type of reactor that you can have—we have mentioned this in our submission as well—the type of accidents that they had at Chernobyl and Fukushima with the loss of coolant and the reactor shuts itself down.

They were so confident of this that they tested it in April 1986, which is the same month that Chernobyl blew its top, and they turned off all the coolant pumps and the reactor just shut itself down just based on natural physics. At Bright New World we see that the spent fuel storage issue is a political issue. The technical solutions exist and they are being implemented today in places like Finland, France and also Canada. Reprocessing is well

understood. Potential use of fourth generation reactors was tested in Idaho. As Dr Higson said, it is not a technical issue it is more of a political issue. That is where the industry sits on the waste issue.

The CHAIR: I am sure we could talk about this for the rest of the day. Thank you for your time here this afternoon. The Committee has resolved that answers to questions taken on notice be returned within 21 days and the secretariat will contact you in relation to any questions that have been taken on notice here today.

(The witnesses withdrew.)

(Short adjournment)

ZYGMUNT EDWARD SWITKOWSKI, Private Citizen, sworn and examined

Dr SWITKOWSKI: My background includes being Chair of the Australian Nuclear Science and Technology Organisation.

The CHAIR: Would you like to begin with an opening statement, or we could go into questioning?

Dr SWITKOWSKI: Chair, if I could have a couple of minutes I would like to introduce my session.

The CHAIR: That would be great, thank you.

Dr SWITKOWSKI: Thank you for the invitation to participate in your inquiries. Of the many issues to be reviewed by this inquiry I think there are two that are very important. The first is: Should we change the Commonwealth Environment Protection and Biodiversity Conservation Act to allow for active involvement in the nuclear fuel cycle? In my view, unambiguously yes. In 2019 we really should be confident enough and mature enough to allow for engagement with nuclear technology and not be prevented by legislation passed in 1999 reflecting the views of 1979. Secondly, the question is: Should electricity generated by nuclear reactors be seriously considered as part of a long-term—say, 2030-plus—energy strategy for Australia? Again, my answer is yes.

But even so, introduction of nuclear energy into Australia faces considerable challenges, especially financial ones. We are late to the game. Clean renewable alternatives are available. Development time scales for reactor builds are very long. The capital costs are high and political and community consensus are lacking. My submission attempts to summarise the pluses and minuses associated with deployment of nuclear energy, hopefully in an objective way. This inquiry already has contributions from groups which are deeply expert and passionate in their convictions and very polarised. But we are a nation with great technologists and engineers with competent regulators and advantageous geology.

If an entrepreneur and nuclear advocate like Bill Gates wanted to partner with an Australian organisation to introduce nuclear energy into Australia—and he has a company that he has an interest in, TerraPower—rather than make that unlawful, which is today's situation, we should enable it in much the same way as we did with Elon Musk and his Tesla lithium battery in South Australia. Thank you.

The CHAIR: Thank you. We will start with questioning from the Government by the Hon. Wes Fang.

The Hon. WES FANG: Thank you very much for appearing today. We really appreciate you taking the time to come to speak with us. What is before us is, I guess, a number of stages but the most pertinent stage is: Do we support or not the bill to remove the prohibitions around mining and nuclear facilities? If we were to remove those bans and allow the market to do what it does and either support nuclear technology or not, do you think that the market would find ways to work out the issue that you identified? How long do you think that would take?

Dr SWITKOWSKI: First of all I do believe we should remove any obstructive legislation. I do believe we should let the market find ways then to work with the nuclear fuel cycle. I do not expect there will be a rush into this particular market, as I heard with an earlier witness. There is a sufficient supply of uranium around the world. We do not need additional investment or investment in additional capacity but over time that could change: But certainly for the next decade or so, uranium availability is not a limiting factor. The other question is as important, and that is: If industry or investors were allowed to work on aspects of the nuclear fuel cycle, particularly the design and construction of reactors, would that happen? History suggests that there is quite heart.

Countries that have nuclear programs by virtue of historical military programs have made the move to civilian nuclear energy relatively easily. That is partly understood in the sense that obviously the experience is there, the technological capability is there and there is some degree of investment already made. There is no known example to me of a country that has gone nuclear without very, very strong Government support and financial support. That step requires expression of interest and skin in the game on the part of certainly investor classes, infrastructure funds and other consortia in combination with Government. You are probably in a better position than I am to form a view as to how probable that is, but it suggests to me that the process is a slow one.

The Hon. WES FANG: I asked a similar question of ANSTO this morning and I will ask you the same question in that removing the bans on mining and nuclear facilities is one thing, but do you perceive that there is an opportunity here for New South Wales to not only just remove the bans but potentially become a leader in, for example, mining and refining uranium to supply reactors around the world and potentially have a construction arm that would produce small modular reactors in the future? Do we have the expertise in this country and in this State to have a view towards that?

Dr SWITKOWSKI: Firstly, I do not know what the resource levels are in New South Wales of uranium. Probably there is not a lot of understanding of that because of the prohibitions, but that is not where the value is in the nuclear fuel cycle. You have mining, enrichment, making fuel roles, having reactors and then the management of waste. It is likely to be relatively small in an economic sense for New South Wales or the country as a whole in terms of uranium mining and the creation of yellow cake. Of more interest is whether, as the small modular reactors go through their design and approval process, we in the country but particularly in New South Wales could play a part.

As ANSTO no doubt has described we have a working research reactor at Lucas Heights. Interestingly—and I do not know whether they covered that with you this morning—in terms of community support for nuclear energy or things nuclear, you are likely to find the highest level of support in the communities in the vicinity of nuclear reactors. In the time that I was involved with ANSTO, say 10 years ago, surveys that were done of various municipalities around the country had the community that was most supportive of the nuclear fuel cycle—that of the Sutherland shire, where a reactor is located. That is no longer a surprise because the people who live in the vicinity of reactors are often working with the reactor site or have family members that work there, or have lived there a decade or two happily and are not inhibited by some of the concerns that others express about nuclear power.

I think that is distinctive about New South Wales—that this reactor and primary reactors have been here since 1955-ish. There is good experience. The universities, particularly Sydney, New South Wales to some extent as well as the Australian National University [ANU], provide very talented people. My suspicion or expectation is that if they were permitted to get involved in developing the technology by researching in the nuclear fuel cycle they could make a significant contribution, as happened during the war years with Australian scientists. It is quite interesting. When I was at Lucas Heights we were constantly reminded that we were not permitted to do any research in the nuclear fuel cycle. It was unlawful. Does that make any sense today? I do not think so.

The Hon. MARK LATHAM: Thank you, Ziggy, for appearing. Can I ask for reflections on your 2006 report and lessons in that process that this Committee might find relevant?

Dr SWITKOWSKI: Thank you, Mark. It was a different time. We were talking about projections that saw demand for electricity grow endlessly and, in particular, the requirement of baseload power to grow with it. And there were the early stages of awareness of the difficulties of fossil fuels and greenhouse gas emissions. So there was, at that point—this was obviously post Three Mile Island and post Chernobyl—the beginnings of community interest in nuclear power. In fact in 2006, 20 years after Chernobyl, the younger generation that was entering university had no legacy concerns about nuclear power.

So the community was shifting, and surveys at the time supported nuclear energy. Nuclear power appeared to be able to supply base load electricity very cost competitively, and for it to be at least as clean as wind and solar. So there was a degree of optimism about the outlook of nuclear power. In 2007 the government changed and interest in nuclear power fell away. I think that was a missed opportunity, although I acknowledge it would have been a big call on the part of the government to want to lead a debate around nuclear energy.

One of the things that has changed since then is that even though the views around the nuclear fuel cycle are highly polarised they are much better informed than they were in 2006, because prior to that period of time there was no community discussion of the nuclear fuel cycle. It was like it was never going to happen and it was vaguely disreputable. Now people, even though they have contrary views, they are, to some extend, rooted in a good awareness of what the nuclear fuel cycle represents and the recent history of the performance of nuclear reactors. So I think we are dealing in a positive way with a community that can make reasonable decisions. Nevertheless, there are still residual strong feelings.

Let me use this as an opportunity to make another point. I recall that in 2006, as we were drawing the conclusions together for the report, when we modelled scenarios that involved coal, nuclear power, gas and renewables, if the cost of electricity moved much beyond CPI, which was then about 4 per cent, the bureaucrats got quite weak-kneed. You cannot have an outlook with different technologies combining that would increase the price of electricity. That was in 2006—4 per cent a year. Today it is 4 per cent a month. What happened? How have we gone from being an energy rooster to an energy feather duster, Mark?

The Hon. MARK LATHAM: I could give you that answer, but it takes a bit more than our Committee deliberations.

The Hon. SCOTT FARLOW: Do you mind if I ask one question to follow on from that?

The Hon. MARK LATHAM: Sure.

The Hon. SCOTT FARLOW: One of the things that I noticed from your 2006 report compared to your submission today—one of the large differences in that intervening period—is that in 2006 there was some suggestion that it needed to be located close to the coast. Now with the advancement of technology—I note your submission backs it up as well—you can locate facilities outside of the coast, and you do not need to have a large water source for a facility. Is that partly the case, as well?

Dr SWITKOWSKI: It is, but it is dependent upon the scale of the reactor. If we are talking about the sorts of reactors—

The Hon. SCOTT FARLOW: The small modular reactors?

Dr SWITKOWSKI: In 2006 there was one size, really—1,000 megawatts, a bit like a big coal plant. Those need a lot of cooling and they need to be sited near rivers, lakes or the coast, to this day, although I think the opportunities for those big reactors in Australia's comparatively small grid is not there any longer. But the small modular reactors—the sorts of reactors that power nuclear subs; are typically about 100 megawatts or about one tenth the size of a big reactor—are being designed so that they can be gas cooled. They do not have to have access to water. Because of their scale—they are about the size of two shipping containers—they can be built underground. For that reason alone they are a little safer and a little less inhibiting. They do not dominate the horizon. The technologies are certainly being developed that will make them not require water cooling.

The qualification about small or medium reactors is that the features of them at the moment look compelling but the design of the first of these reactors is still undergoing testing and review by regulatory authorities. You may have more recent information than I have by virtue of this inquiry but I think the first of the SMRs in the West are likely to appear in the mid-2020s. Until you get a fleet of those you will not have verification of some of these early expectations.

The Hon. MARK LATHAM: If we take the ban off in New South Wales we will still have the bans at Commonwealth level. Can you fill us in on their nature? They are quite by accident, aren't they? The Parliament never—

Dr SWITKOWSKI: It is not my area of expertise.

The Hon. MARK LATHAM: Wasn't it a minor subclause in the diversity Act? It was not a conscious decision of the Parliament to say, "Today we are banning nuclear in Australia."

Dr SWITKOWSKI: It was not. As it was described to me it was like an addendum—an afterthought. It was convenient to do that. There was a wave of interest in it. It happened. When I went back, ahead of this inquiry, to have a look at what it actually said, it is a very long bit of paper and it occupies this much on a page. It is remarkably casual.

The Hon. MARK LATHAM: Yes. We blame Robert Hill, I think. At the bottom of the first page of your submission you say:

> … many spaces can be found to house a storage facility for spent nuclear fuel which are away from population centres, and not near water …

Are those spaces available in New South Wales?

Dr SWITKOWSKI: Even without knowing the details of any one of the States' population distributions and geographies—I think I heard an earlier commentary on this—look at what you need. You need to find an area which is geologically stable; you need it to be away from running water; you need it to be generally away from people. Three-quarters of the continent, I think, satisfies that criteria.

Just to give you a really simple view—the early comments you got were exactly right but you can think about this. When you go to a reactor site, typically on reactor sites you have at least two reactors. You need two; you cannot just have one, and often they are designed to accommodate many reactors. The fuel rods go into a reactor. They come out of two or three years with the enriched uranium being consumed. They are very radioactive. They are queued up in something that looks like an Olympic sized swimming pool about 10 metres deep. They sit there for between five and 15 years because they are very radioactive and they are thermally hot by virtue of the disintegrations that were going on.

So let's say they are in the pool for 10 years. The most radioactive stage is then expended. They are then taken to a facility. They are crunched up and mixed in with ceramic, concrete or other forms of vitrification and outcomes a cylinder. The cylinder is about a metre wide and about three metres high. It looks like a concrete cylinder. They put it in a paddock adjacent to the reactor, and queue them up. You might get three or four a year. Gardeners work around them. They ride their ride-on mowers. If you stand up and touch them they are vaguely

warm so you know something is going on in there, and it is just the disintegration. They are largely benign. They are awaiting permanent storage, and this is where the industry is still to licence a permanent storage facility.

The engineering of a permanent facility is very straightforward. In a way, if it were not for the fact that people think that there might be value in the future of these radio-active components, all you would need to do is to drill a hole 500 metres deep, which is not a deep mine. I am being colourful, but you could just drop these in there and put in a bit of concrete and some soil and go away. It is really that simple.

The Hon. MARK LATHAM: How deep is the hole, sorry?

Dr SWITKOWSKI: Five hundred metres. There has been no known incident or accident with spent nuclear fuel and these kids on containment vessels since the beginning of nuclear reactors in the mid-fifties. You can get yourself quite worked up about the half life—30 years. The longer the half life the better. The half life of thorium is 14 billion years. It is the age of the universe. People think it is radioactive for 14 billion years—no. Uranium is the same. A lot of the others are also long. The long ones do not bother you. It is the ones that have the half-life of about a generation and that are biologically compatible—so you have got caesium. That is like sodium. That is salt; that is an electrolyte. You have got iodine. That is like chlorine; that is another electrolyte. They can be absorbed in the body. They last 30 years. They are very damaging. The rest of the stuff is not so much.

The Hon. SCOTT FARLOW: Dr Switkowski, I think it was credited in 2006 that you did not believe that wind power had a huge role to play for Australia's base load energy needs. Has anything changed in that period?

Dr SWITKOWSKI: In 2006 our view was that the post-fossil fuel future would be nuclear and solar because we could see how the cost for solar was going to come down and we could see the components that, with the costs, would move quickest and the efficiency of the solar cells would improve. Wind felt at the time as a transitory technology. Thirteen years on, I think we underestimated how good wind would be and how the design of the blades et cetera could have gone as far as it has. Offshore wind was really not a consideration either. I think wind will be in the mix, I am sure, for longer than we expected. I do think we will get to the point where either the design cannot be scaled more than—I mean the blades at the moment are 200 metres. The velocity on each of the blade is 400 kilometres an hour. These are huge constructions.

Whether they can go much further, I am not so sure. Then, unless you have offshore, the need for land and a footprint is pretty substantial. I think there might be some limitations there, less so for solar. Solar looks very credible. Marry that up with hydro or battery backup, which is today much more likely. In 2006 we did not contemplate that for the intermittent renewables, there would be an affordable capability to smooth out the energy generation, whereas in 2019 that is looking very possible in the not-too-distant future. The possibility of having renewables together with backup is now greater than we might have contemplated back in 2006. For the future, fossil fuel, coal and gas are running down to the middle of the century. Solar is growing, wind is still important, and batteries and hydro are backup. If you make a decision about nuclear today, then may be in about 2035 it begins to make a contribution; by 2040 it becomes meaningful.

The Hon. SCOTT FARLOW: We have a target in New South Wales of net zero emissions by 2050. If we were to phase out coal and all coal-fired power plants by 2050, would it be possible to just replace that capacity in the market with renewables purely at this stage—

Dr SWITKOWSKI: With renewables—

The Hon. SCOTT FARLOW: —and still have the same base load capacity and the same reliability in the system?

Dr SWITKOWSKI: I do not think my view is any more expert than anybody else's on that. I can see in 2050 that a large amount of our energy generation will be via renewables, partnered with hydro or giant batteries, yes.

The Hon. MARK BUTTIGIEG: I guess this is a really important question. I want to explore this because I think there is a lot of confusion around this concept of base load and dispatchable power and what is achievable and what is not via different sources. What you seem to be saying—unless I am misinterpreting—is that you can actually provide that base load dispatchable power with a combination of renewable—the generation sources being solar and wind—so long as you have the storage mechanism to overcome the variability of those sources. In other words, when the sun goes down and when there is no wind. Is that, in principle, the position?

Dr SWITKOWSKI: That is an in-principle view of a likely scenario because I cannot—or maybe you can—point you to where it is happening at scale. Clearly batteries are not yet big enough to partner with large solar or wind installations sustainably. There is significant effort in South Australia that provides for backup that

lasts 30 minutes. It is important but not the answer. There is still some work to be done—a lot of work to be done—on battery backup. Snowy Hydro 2.0 is a step in that direction. We will see how that operates when that is completed. I think the elements of a solution are understood, but we will not see evidence of that for some years yet.

The Hon. MARK BUTTIGIEG: The other factor in all of this—my colleague the Hon. Scott Farlow touched on it—is the time. Let's leave aside the debate about whether or not we are in an existential crisis with regard to climate change. If we were to agree on a target of—what is it?—2050, then it is very difficult for nuclear to play a role in that because the lead in time for construction and getting it up to speed in order to contribute on a scale that is required is almost prohibitive, whereas if you were to put yourself back in 2006—we are in 2019 now, 13 years down the track—in another 13 years, given the technological uptake or that curve that you referred to, it is quite possible that those other sources, coupled with the storage that you just identified, it could move along at such a rate that it could actually be a solution.

Dr SWITKOWSKI: It is quite possible. I will make two points. One is that when we are talking about energy and when we are talking about these platforms, you are not talking long timescales in the hopeful context that we have an energy strategy, and we probably do not. Investors cannot be sure that the decisions they take today will survive the next Federal election or the one after that, or a shift in sentiment for whatever reason. That is a real issue for these long timescale developments. Leave that to one side, then. Take New South Wales. I think the energy generation capability of New South Wales is of the order of 10 gigawatts, plus or minus. Let's say half of that is base load and half of it is other forms of energy, which might be renewable plus, in whatever timescale—2040 or 2050. The half is five gigawatts.

In 2006 we said we can do that with five big reactors. I do not think anybody has now the financial wherewithal or the risk appetite to invest in a big reactor. But if you are confident that these small modular reactors will arrive and deliver on the expectations, and let's say each of them is—I think they are talking between 60 and 300—say 200 megawatts. That is 25 of these units at $1 billion each. These are my numbers, by the way, and you will learn that they are highly unreliable at times. Let's say that you place your first order in 2025, in seven or eight years. It means that all through to the 2030s you are adding three or four reactors a year, gaining experience, learning how to minimise costs—because the first reactors will not necessarily be difficult—and you hit 2040 and you can have half of your energy appetite delivered by these reactors. They will be of a scale not dissimilar to what you have at Lucas. They will be bigger and more trusted generation, but in terms of footprint design et cetera, they will be smaller than what you have at Lucas Heights. Twenty-five would probably be located in three or four locations. It actually sounds very doable, if you speak fast enough.

The Hon. SCOTT FARLOW: Dr Switkowski, just to pick up on Mr Buttigieg's point in terms of 2050 and the reliability of nuclear power and the likelihood of investment into the market, does it make any sense—going back to what Mr Fang asked at the commencement of your questioning—to have any option off the table and prohibited in terms of our legislation?

Dr SWITKOWSKI: It does not. As policy makers you should err on the side of not picking winners. You should be creating the right environment, establishing what you want to be the look and feel of our energy system in the 2050s or whenever, and then be open to discussion with whoever wants to be in the generation or distribution business. I know I do not speak as an expert on SMRs—other than the fact that I have a better-than-layman's understanding of much of it—but it does look like it is very promising technology. There will be a number of countries that will be introducing SMRs in the 2020s. They are undergoing development and accreditation. They look very safe and there will be less radioactive toxicity in the spent fuel. They will be like batteries. Every 10 years you will take out the nuclear battery and put another nuclear battery in. They really do look like they might be a very important part of the answer.

They are also being designed to have low facilitating capability. It used to be the case that for big reactors like coal-fired power stations if you needed to respond in half an hour you could not. It would take you hours before you wound things down. That was true of nuclear. But these new reactors can move up and down in minutes, according to the specifications. Given this combination of modern design, a scale that you can kind of get your head and finances around, the modularity—they talk about a string of pearls, so you put one in and then another—and it not being very demanding of either real estate or water, if we were able to think about 2030, 2040 or 2050 timescales, it would have to be in the mix.

The CHAIR: On that, can I run a hypothetical situation by you? You said a moment ago that there is no appetite for a big reactor. In response to some of the public debate about repealing the Federal ban and the State ban, which we are looking at, what if I were to put it to you that rather than a total repeal of the ban, what if we had an amendment of both the State and Federal bans in such a way that previous, historical technologies remained banned but technologies deemed as walkaway safe or inherently safe—by the Chief Scientist, say—

would be permitted? Would such a way forward help to realise an emissions-free power future in Australia and New South Wales?

Dr SWITKOWSKI: That is a Solomonic approach.

The CHAIR: Okay. Do you have anything more to add?

The Hon. MARK BUTTIGIEG: I think he is saying that it is your baby, Chair.

The CHAIR: You say that all obstacles should be removed, but it might be quite difficult to remove both the State and Federal bans on nuclear technology altogether. If we are to work together on some kind of middle ground approach, would that be acceptable? Particularly with all the enthusiasm for the small modular reactors.

Dr SWITKOWSKI: I think the answer is yes. I think if you are able to craft legislation that saves that for the nuclear fuel cycle, in as much as it applies to reactors that are 300 megawatts and smaller, that would go most of the way to what I think is the solution.

The CHAIR: Can I invite you to comment on the future of hydrogen? We have heard about it from some people in the wider alternative emission-free debate and hydrogen seems to be an idea that comes and goes. At the moment it has got a bit of interest from other jurisdictions that have hydrogen strategies and what not. I know Japan and South Korea are keen. Would you be able to provide comment on the future of hydrogen?

Dr SWITKOWSKI: I follow the energy debate but I have no particular expertise in hydrogen.

The Hon. MARK BUTTIGIEG: I have a quick question. A lot of this debate is stimulated by skyrocketing electricity prices. I am not quite sure that the public or the people who are using it have got the right attribution as to why that has happened. We did touch on it before and my colleague Mr Latham touched on why that might be the case. It used to be that governments would generate electricity at marginal cost and it was very cheap and very reliable, notwithstanding the fact that you would have rolling blackouts in the 1970s because of a lack of generation capacity. But once we got over that it was fine. In one sense the advent of nuclear would not really solve the problem to a great degree. My understanding is that the bulk of our electricity price or bill is made up of network charges, which is the poles and wires that get the electricity from the generator to the consumer, as well as the retail market being deregulated and retailers gauging the price. To the extent that you replace that with renewables or nuclear, you are not actually going to solve that problem at its source. Would you agree with that?

Dr SWITKOWSKI: Again, I hope that this inquiry will end up having the economics laid out. Otherwise we are just expressing opinions—at least in my case. To do that in an evidence-based and honest way we need to ask what the cost of generation is for these platforms. I think you are right. The costs are elsewhere, frankly, in terms of the costs that have been responsible for the extraordinary increase in electricity costs over the last few years. But you should be able to compare. I think a number of the submissions have tried to do that in terms of what nuclear generation costs would be compared with the others. Everyone has to properly account for externalities. If you have to have back up to cover for intermittencies that needs to be included. In the nuclear case you need to include the costs of long-term storage and the dismantling of a reactor, which is by no means a simple task. But that is also not a new idea. Everybody around the world with nuclear systems knows how to do this—both the modelling and the practicality of it. Then you can compare.

The Hon. MARK BUTTIGIEG: You have made an interesting point because it is one of the things that struck me earlier on in the day. I was quite surprised when I asked some of the other witnesses if they were aware of a holistic economic model or a study that was done. No-one could tell me that that was being commissioned. The very fact that neither Federal nor State Governments have commissioned someone in Treasury or some economist to do a holistic model is astounding to me. Does that surprise you?

Dr SWITKOWSKI: We did it in 2006. I think the South Australia royal commission did it in 2016. That was a very thorough review. It started with the 2006 material and then updated it. It had economists backing up the analysis. It was 440 pages long. I cannot tell you where to look but it is in there somewhere. The elements of the costings for nuclear are well understood. People will debate whether we get it exactly right or not, but every element of the nuclear fuel cycle, including the final stages and extending out over 300 years, has been modelled.

The Hon. MARK BUTTIGIEG: That is very helpful, thank you.

The CHAIR: Thank you very much for your time this afternoon. The Committee has resolved that answers to questions taken on notice be returned within 21 days. The secretariat will contact you in relation to any questions that were taken on notice. Thank you again.

(The witness withdrew.)

ROBERT GODFREY, Director, Facility Safety, Australian Radiation Protection and Nuclear Safety Agency, affirmed and examined

RYAN HEMSLEY, Director, Government and International Relations, Australian Radiation Protection and Nuclear Safety Agency, affirmed and examined

The CHAIR: I welcome our next witnesses. Would either of you like to make an opening statement?

Mr HEMSLEY: We will make a short introductory statement. Thank you for the invitation to this hearing. The Australian Radiation Protection and Nuclear Safety Agency is the Australian Government's primary authority on radiation protection and nuclear safety. The CEO of ARPANSA is charged with responsibilities under the Australian Radiation Protection and Nuclear Safety Act 1998 for protecting the Australian people and environment from the harmful effects of radiation through understanding risks, best practice regulation, research, policy, services, partnerships and engaging with the community. Specifically, this includes regulation of the nuclear installations operated by the Commonwealth. The aim of our regulatory activities, as for all other activities carried out by ARPANSA, is the protection of the health and safety of 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 international partners. We fulfil Australia's reporting obligations under international instruments such as the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel and on the Safety of Radioactive Waste Management. We are also the national competent authority under the assistance and early notification conventions for radiological and nuclear emergencies. We consider transparency and accountability to be fundamental drivers for the credibility, efficiency and effectiveness of the regulatory framework.

I draw the Committee's attention to the fact that in November 2018 ARPANSA hosted an international peer review of our regulatory performance in relation to safety standards by the International Atomic Energy Agency [IAEA]. This was the culmination of a few years' work and involved all States and Territories. We are now working together with our jurisdictional partners, including the NSW Environment Protection Authority, in implementing the actions required to respond to those findings. ARPANSA's activities are relevant to at least some points of interest for this Committee, including waste management, health and safety and environmental impacts. We would be pleased to receive any questions the Committee may have.

The Hon. MARK LATHAM: I do not have any questions. Maybe the Government members do.

The Hon. SCOTT FARLOW: We have heard some criticism with respect to small modular reactors and the fact that they are not actually in operation at this stage. Have you done any work with respect to small modular reactors and followed any of the progress in terms of their development?

Mr GODFREY: We have not—we just have general interest in the developments. The records indicate that there is a small number that are operating, perhaps three operating. Clearly they are something of the future, a development in nuclear power. There are many designs that are well developed and many under construction. There is a much larger number, in fact, that are in the early stages of design development, so certainly something for the future.

The Hon. SCOTT FARLOW: It is something you keep a watching brief on in a personal-interest capacity, rather than any sort of formal charge that you are provided with?

Mr GODFREY: Exactly.

The Hon. SCOTT FARLOW: With respect to the facilities that have operated in Australia, namely Lucas Heights, how many incidents have occurred at Lucas Heights?

Mr GODFREY: I could not put a number on it myself. We can provide that information. To my knowledge no serious incidents have occurred. I spent 20 years at the old High Flux Australia Reactor [HIFAR]. I was involved in the operations planning and commissioning of the OPAL reactor. Having returned from 10 years in the United Kingdom nuclear industry, I am now part of the regulatory agency. ARPANSA has about 33 facility licences, of which 20 are at the Australian Nuclear Science and Technology Organisation and one of those, of course, is the OPAL reactor. But there have been no serious incidents, to my recollection.

The Hon. SCOTT FARLOW: Mr Hemsley, were you wishing to contribute there?

Mr HEMSLEY: When you say "incidents", can you clarify in what timeframe and what you mean by incidents?

The Hon. SCOTT FARLOW: In timeframe, since its operation and with respect to incidents, anything that would be reportable to you and would require your attention. I know that earlier this year or last year there was some report of some individuals being exposed to above-average or above-limit radiation, but we were told when we visited Lucas Heights that it was not anything of significant concern. But I imagine you do have an incident-reporting protocol that would go to you. Is that correct?

Mr GODFREY: We do. Something to draw the distinction from the outset is that people generally refer to everything at the Lucas Heights site as "the reactor". If you think of the OPAL reactor—but the incidents you are referring to occurred in the isotope production facilities, which process the material irradiated in the OPAL reactor. As you rightly say, there has been a number of incidents over the last couple of years.

The Hon. SCOTT FARLOW: But nothing within the reactor itself?

Mr GODFREY: Now that I think of it, there were some incidents in the early stages of commissioning. In particular, there was one issue with the fabrication of fuel elements in the early commissioning stages[3].

Mr HEMSLEY: That is right. It is that important distinction between the operation of the reactor and the wider activities at Lucas Heights. One of the most significant incidents in the past couple of years was in June 2017. A radiation quality control worker was exposed, had extremity exposure to uranium from the production of molybdenum isotopes. That was reported to the International Atomic Energy Agency as a level 3. The IAEA has a scale of incidents ranging from 1 to 7, with 7 being something on the scale of Chernobyl or Fukushima. That incident was rated as a 3. It was the only level 3 incident in 2017. Since then there have been other incidents at ANSTO that have regulatory impacts and consequences, but those were separate to the operation of the reactor. They were all in the production of nuclear medicine.

The Hon. SCOTT FARLOW: What has been the highest-rated incident that has occurred in Australia? Is level 3 the highest?

Mr HEMSLEY: I believe so, yes.

Mr GODFREY: That would be my recollection.

The CHAIR: If State and Federal bans were to be repealed, one would imagine that ARPANSA would be engaged to oversee any operation of such a facility. Are there any jurisdictions in particular that we would look to in order to gain an insight into how to regulate and oversee these operations to keep our workforce safe?

Mr HEMSLEY: Because Australia is a Federal system we would probably look to other federated systems in the first instance. Germany and Canada would be particularly well-suited to drawing comparisons and lessons learnt from how they operate. Obviously, Canada being a Commonwealth and anglophone country would be useful as well. However, those countries have much larger nuclear infrastructure than Australia. They have decades and experience stretching back to the 1950s in operating nuclear power plants as well as other nuclear installations, such as fuel fabrication and uranium enrichment. That would be only one component of what we would look at. Other countries that have recently developed nuclear power programs, such as the United Arab Emirates, would also be useful. They went from almost no nuclear program to having a nuclear power program in a relatively short timeframe. Their experience would be quite useful for us as well.

The Hon. MARK LATHAM: Mr Godfrey, earlier on you said that there is about three of these smaller modular reactors operating. We heard material earlier in the day where people were saying there are none in operation and they are miles off, in terms of delivery. What is the detail there of those ones that are actually in practice?

Mr GODFREY: Well, again, it is not part of my responsibility at ARPANSA, just a watching brief that I keep on it personally. One of the most reliable sources of information is from the World Nuclear Association. I think that is where much of the information for the issues paper that has come to the Committee has come from. As Dr Switkowski mentioned, there is a long history of something like a small modular reactor in naval applications and there is a small number that have been operating for a period of time in the range sort of 70 to 200 megawatts electric.

[3] In correspondence to the committee dated 17 December 2019, Mr Hemsley made a clarification to the evidene of Mr Godfrey.

The Hon. MARK LATHAM: These are the nuclear submarine ones?

Mr GODFREY: No, the land-based ones.

The Hon. MARK LATHAM: Which countries are they in?

Mr GODFREY: I could not say off the top of my head. My recollection is Pakistan, India and China, if I recall correctly.

The Hon. WES FANG: Are those units modularised? Are they produced in a factory in a repeated fashion, or are they just one-offs?

Mr GODFREY: I am not sure. I believe they are one-offs. I do not believe they are at the stage that Dr Switkowski and others have indicated where they are looking at modularising them and having multiple units on a site. A lot of the ones that we are referring to are essentially test type facilities, prototypes.

The Hon. MARK BUTTIGIEG: Just on that scale that my colleague, the Hon. Scott Farlow, was questioning on, Chernobyl is obviously the top end disaster scenario. Is that a linear scale, 1 to 7, in terms of seriousness?

Mr HEMSLEY: Yes, it is.

The Hon. MARK BUTTIGIEG: These incidents, is that publicly available?

Mr HEMSLEY: Yes. The IAEA publishes information on the incidents annually, I think, perhaps monthly. Some incidents may have redacted information, depending if they are security-related but the IAEA does publish details of those incidents from 1 to 7.

Mr GODFREY: In fact that is the intent of the International Nuclear Event Scale [INES], for public communication and correct communication to regulators and others. The information is freely available on the IAEA website, which gives both the criteria for each of the levels and examples like, as my colleague said, the Chernobyl, Fukushima accidents at level 7, and then Three Mile Island and Windscale at level 5.

The Hon. MARK BUTTIGIEG: In terms of the ANSTO facility, the purpose of which is producing medical isotopes, obviously, moving to a different scale electricity production, does it become more problematic managing those safety risks, not only the spent fuel but any other safety considerations like accidents? In other words, does the scale of the reactor required for electricity production then bring other problems with it regarding safety?

Mr GODFREY: I think it is somewhat of a yes/no answer. One thing to point out is that the operational regimes are very different. Essentially with a nuclear power reactor you load fresh fuel into the reactor vessel, seal it up, operate for 18 months or so and then refuel it, deal with spent fuel and waste management at the end of the day. The OPAL reactor is very different. It is an open-pool reactor. There are lots of activities, items being loaded into and out of the pool for irradiation, isotopes that are materials being irradiated and removed and processed. The production of the molybdenum isotope from the ANM facility that some of you will have heard about in recent issues is effectively the same as fuel processing. You are taking irradiated uranium material, which has fisson products, and you are processing it to extract, in this case for ANSTO's purposes, the molybdenum isotope. Different operational regimes in that sense, but you are dealing with a much smaller inventory of fissile material and fission products. The source term, so called because of the quantity of fission products created in the spent fuel from the operation from the fission reaction, is in many orders of magnitude smaller than the inventory of material in the source term, so called in spent fuel in a power reactor, with the potential if things were to come unstuck, as in some of the serious accidents, to potentially impact the public and the environment.

The Hon. MARK BUTTIGIEG: Does that mean there would need to be a corresponding investment uptake in our regulatory capacity to deal with that scale of electricity production if we were to go down that path?

Mr HEMSLEY: Yes, there would, but it is not necessarily a linear scaling up. Other regulatory bodies around the world that have small nuclear power programs have approximately 200 to 300 people, depending on the particular jurisdiction. ARPANSA has just over 130 people, so we would probably need to almost double in size. But that said, we are one of nine jurisdictions that have radiation protection responsibilities. There may not be expertise in regulating nuclear installations in the States and Territories, but there is expertise that would be useful in regulating such facilities in the jurisdictions.

The Hon. MARK BUTTIGIEG: In terms of the two different parts of the chain of production, if you like, with regulatory oversight, presumably there is different expertise and capacity required for the extractive part of the process and the actual production of nuclear-produced electricity. Do we have any expertise in the oversight of the mining process? Is that an issue that we would have to address if we lifted the ban?

Mr HEMSLEY: ARPANSA does not regulate uranium mining in Australia. That is regulated by the States and Territories that operate such mines. While we have some expertise that is useful to radiation protection at a uranium mine site, we do not have regulatory knowledge of that. That resides in the South Australian Environment Protection Authority and the Northern Territory.

The Hon. MARK BUTTIGIEG: Is that a different skill set that is required to understand the safety implications associated with extraction rather than production?

Mr HEMSLEY: Yes and no. I am not an expert on uranium mining but there are basic radiation protection measures that are applicable to any nuclear or radiological site or installation or where radiation is used. So those basic fundamentals would be the same. Specifically, yes, there would be different aspects for a nuclear power plant versus a uranium mine, versus a research reactor, versus nuclear medicine production.

The CHAIR: Can I ask if there are any education programs that ARPANSA is involved with? In some of the submissions that the Committee has received, when we asked particularly about European countries or North American jurisdictions that have had nuclear for quite some time, it seems like education is a critical piece to getting acceptance. There were some very fascinating figures given to us by the Minerals Council of Australia. On average apparently the average Australian will receive 1.5 millisieverts per year from background radiation and natural sources. For instance, Cornwall in the UK will have 7.8 millisieverts because of the geological makeup of Cornwall. To put that into context, 10 millisieverts from a CT scan. They are all very interesting pieces of information as to how much radiation we are all exposed to. A flight crew, 4 millisieverts for their annual does. Things like that. In general it does not seem like Australians are exposed to the education that others in Europe and North America might be in order to understand the nuclear industry.

Mr HEMSLEY: ARPANSA does run a Talk to a Scientist program. Any member of the public can call or write to us to ask about radiation-related inquiries and receive a scientific answer. We have been running that successfully for quite a number of years and it has quite a large uptake of people writing in on various subjects of which probably at the moment electromagnetic energy, so non-ionising radiation, is a key concern. But Australia does not have the geological issues of Europe in terms of natural radon amongst Australian homes. So while ARPANSA has been part of studies into radon in Australia it is not something that exercises much in the way of community interest because it is not such a huge issue.

Radiation is everywhere, it is something that is in our daily lives, and we have a very active communication program on social media and through our website and through other media to try and explain to the public about certain aspects of radiation, but it depends on what is forefront of community interest. At the moment that is electromagnetic radiation with the rollout of the 5G telecommunication network. Constructing a nuclear power plant is not something that ARPANSA is seeing as a community concern at this stage.

The Hon. MARK BUTTIGIEG: Could I just follow on from that? If I could put it in simplistic terms I think the concern of the average citizen would be not so much the fact that we are exposed to X amount of radiation in our day-to-day lives—and driving past a nuclear reactor is no different, they understand that there is not ambient radiation of any high level—the issue is, for example, the number three incident you outlined or in the event of an accident would the exposure go up by 100 times, 1,000 times? That is the issue, is it not?

Mr HEMSLEY: That is right. It depends on the nature of the exposure. ARPANSA, as well as ANSTO for that matter, work closely with the Sutherland shire and residents around Lucas Heights to educate them. So there is a very good local program of education particularly by ANSTO, and ARPANSA is part of that, but in terms of a national education debate around nuclear energy, that is something ARPANSA is not part of. The last time we put a large-scale communication effort around nuclear energy and exposures on that scale would be after Fukushima.

The CHAIR: Thank you very much for your time here this afternoon. The Committee has resolved to take questions on notice within 21 days. The secretariat will be in contact with you in relation to any questions that were taken on notice. Thank you again for your time this afternoon, it is much appreciated.

(**The witnesses withdrew.**)

(Short adjournment)

SATYAJEET MARAR, Director of Policy, Australian Taxpayers' Alliance, affirmed and examined

The CHAIR: I welcome our next witness. Do you have an opening statement?

Mr MARAR: Yes, just a brief one. Thanks for having me here today. I am with the Taxpayers' Alliance; we are the nation's biggest grassroots advocacy group, representing Australian taxpayers. We are supported by tens of thousands of supporters, of civic-minded Australians across the country who believe in our message of fairer taxes, less government waste and rolling back nonsensible or overly burdensome regulations that hold back this country's prosperity. Our interest in nuclear energy stems from a few different things. Firstly, there is this massive ideological battle in this country between different energy sources; we have got people who love solar and wind and they always complain about nuclear and coal; we have got people who love their coal and want to see government funding for new coal-powered plants; and there are people, obviously, who support nuclear.

Our position is that we need to have an energy-neutral mix; we need to let different energy sources compete to see who can deliver the best deal for our electricity consumers. We have amongst the highest electricity prices in the entire world right now and we used to have some of the cheapest. To a significant degree prices have gone up because of a bad policy designed with the good intention of decarbonisation but which has led us to push often our fossil fuel power generators into premature retirement without replacing them with sufficient firming capacity to keep them powerfully reliable, while driving up and making our power prices quite volatile. Of course, other factors play a role, like over-investment in network assets, for example, in the years back when limited merits review was still a thing, but this has played a role.

We do not think that there needs to be a conflict between the goals of decarbonisation to fight climate change and the need to have affordable and reliable power for our citizens. Based on all our research we have seen that nuclear right now offers the most viable option or alternative. All we are saying is let us lift the moratorium that is in place. We have some of the biggest reserves in the entire world of uranium—we have thorium as well. Why is it that our own citizens do not have the right to use this amazing power source for their own benefit when they have the right to use all the other sources as well? We understand that some concerns have been raised about how nuclear plants in places like the United Kingdom—the Hinkley power station—received a lot of taxpayer subsidies. I am here to say that that happens in this country over my dead body—I do not want to see that happen, that is out of the question. But that is a debate to come to once you actually lift the prohibition and we can see where we are at.

Secondly, I thought it was interesting that some of the anti-nuclear advocates were complaining about these subsidies when the wind and solar they push for currently gets about $2.8 billion a year in subsidies, all the way up until the year 2030, and despite those subsidies it still has a problem with intermittency—it needs to rely on battery storage or hydroelectric power or other forms of backup; usually it is fossil fuel backup, which is why fossil fuel is still a majority of our electricity. So we think this option should at least be on the table, and if they are going to have a clear energy policy that advocates funding based on emissions abatement, it should be technology neutral. If wind and solar combined with batteries do end up beating nuclear, then fine, that is wonderful. If nuclear ends up beating them and beating other sources, then that is fine too, but I think the realistic outcome is you will see a grid that is a mix of different kinds of technologies as it already is and you will just have in the long run a better deal for consumers and taxpayers.

I would also like to point out that while there is often a lot of debate about how much the cost will be, we need to understand that one of the biggest factors weighing on how much nuclear costs is the regulatory mix that is in place. We have seen that in places like the USA, where regulations have consistently increased and increased and increased; it is now between $6 billion and $10 billion to construct a standard nuclear plant that is not a small modular reactor. But in places like South Korea which have had more sensible regulations that have still maintained safety concerns, we are seeing prices that have consistently trended down. I have cited research in my submission from the Australian National University, which found that if regulatory burdens had not unfairly increased in the seventies, driven mainly by political concerns based on fear not proportionality, then prices could be as low as 10 per cent of what they are today.

I am also, if you are interested, happy to go through critiques of some of the government reports, which have claimed that firmed renewables are cheaper than nuclear. I am similarly happy to do a comparison on how these different sources have worked against each other or together, but I will leave that to the Committee and any questions that you might have.

The CHAIR: Thank you. That might be a good point to start on, the comparison between firmed renewables and possible costs of future nuclear. Would you like to expand a bit more on that and what you have found?

Mr MARAR: Sure. The CSIRO came up with the GenCost report in 2018, which claims that firmed renewables are much cheaper than nuclear power. I do not want to knock the CSIRO but this report is deeply flawed for a few reasons. Firstly, it assumes an overnight capital cost of $16,000 per kilowatt hour for nuclear; they cite the World Nuclear Association, who have never, ever cited that cost and have told the Federal inquiry that they have never seen that number before. Secondly, the CSIRO assumes firmed renewable capacity of I think it was two to six hours. That is a very small fraction of the capacity you actually need.

That is nowhere near enough to provide affordable and reliable power. When you actually take that capacity factor, which is 25 per cent, and move it up 95 per cent, the cost which they cited, which I think is $1,100, goes up to $5,000. By comparison, the cost of current American nuclear reactors from the World Nuclear Association—the comparable cost is $5,000. So in other words, they are comparable but that is a comparison to the current American cost and as I just told you, in America the regulations are especially strict and burdensome, so costs could be substantially lower in Australia.

The CHAIR: Would you like to expand a bit more on that? That is a very interesting point to make.

Mr MARAR: Yes, sure. I think it is instructive to look at what South Korea has done. I mentioned the regulations but there are also other factors. They have standardised designs which are easy to replicate and they also tend to build plants in pairs or in sets, so all of these practices are quite beneficial and I think we can learn from the best practice and international experience. What is more is South Korea entered the race fairly late, over 20 years after the United States had already started building its plants and today they are overtaking the US on those costs. China had no nuclear reactors in the nineties. It was out of the question. By 2017 they had about 30 and now they are, I believe, applying to export their designs all around the world. What they did was, unlike us, we have the Australian Nuclear Science and Technology Organisation, which has a significant amount of local expertise but they did not even have that.

They simply had foreign engineers working alongside Chinese ones and they were able to have that skill transfer that is so important and today innovation has gone ahead and gone forward. So what are the messages? We actually cannot know what the cost will be in the future. It is a question mark but currently it is trending down. We know that as far as smaller model reactors go—and I know that some of the submitters before have said none have actually been built and deployed—well, a design from a company called NuScale has been submitted for approval in the year 2017 to the US agency and they are due to get approved by 2020 or 2022, I believe. To get this far they have had to not only have a clear design ready, they have had to actually test it. This is more than just a claim that is on paper; this is something that is actually happening. If we lift the ban, we have the possibility of simply taking advantage of and piggybacking off innovations going on around the world, which I think is a wonderful thing. If we are going to have decarbonisation, it is not going to happen because we have constrained innovation; it is going to happen because we allowed it to go forward.

The Hon. WES FANG: Thank you very much for coming in today. I really appreciate that you put together a very detailed submission, which I have read. It is extremely detailed and interesting. This has become a pseudo-debate about nuclear power but what is in front of us now is effectively removing a ban on uranium mining and nuclear facilities in New South Wales. From a taxpayers' standpoint, there really is no burden on the taxpayer if we were to just enact that bill. In fact, there is potential that royalties and the like that could flow to New South Wales would be beneficial. If that were all that was to happen and we were not to go down the nuclear path immediately, would your organisation still be supportive of the bill?

Mr MARAR: Absolutely. At minimum we would love to see at least that happen and after that, we do not know, maybe it will be some time before a company comes forward with a case. You would have to write the regulations down and once businesses have regulatory certainty, they can invest the hundreds of thousands of dollars it takes to fully research a proper case but we would absolutely love to see that happen.

The Hon. WES FANG: Just for our information, when I read your submission I take it that your organisation is very much guided by market forces. You would like to see the regulatory requirements removed or equalised at least to have an equal playing field and let the market decide what technologies you wanted to see to provide those powers?

Mr MARAR: Yes.

The Hon. WES FANG: You have no philosophical concerns about which power source provides the electricity to the grid; it is what is the best value for the market and therefore best value for the consumer?

Mr MARAR: Yes, absolutely. Obviously since we are believers in market forces, we also believe in correcting any legitimate negative externalities there are. There need to be sensible regulations in place around any technology but blanket bans are simply not justified.

The Hon. WES FANG: Thank you.

The Hon. MARK BUTTIGIEG: Thank you for appearing. Obviously you look at things through the prism of efficiency of taxes and value that people are getting for their taxpayer dollars. Do you accept that as representatives, as politicians, we also have to weigh up public sentiment too and if there is a predisposition, rational or otherwise, that nuclear energy is problematic, that is also part of the equation in politicians thinking about how they legislate, which is obviously feeding into our considerations here. Leaving that aside, on the purely efficiency of the tax dollar debate, what is your view then on the fact that the debate surrounding an emissions trading scheme and carbon tax or targets in and of themselves, irrespective of whether nuclear is in the mix, if that is a setting that governments of either persuasion are going to institute—what the target is is a matter of debate of course—then regardless of whether it is nuclear or renewables, would you accept that that is a valid aim for government or do you think that there should not be any targets or any talk of carbon tax, or anything like that? I am just interested to know your perspective as a taxpayers' representative.

Mr MARAR: Sure. Our organisation was founded in the year 2012 actually off the back of a campaign against the carbon tax that existed back then. Our opposition to the carbon tax and to things like renewable energy targets is not based on an opposition to emissions abatement or recent climate change but to the fact that they do not deliver the stated outcome, one of the problems being that in order to have a carbon price actually work, it needs to be applied by at least a significant majority of the world's countries in a consistent manner. What we are seeing is even the Paris Accord Agreement does not quite do that well enough. We think, okay, if that is not an ideal solution and that that creates so much public frustration, which we have seen time and time again—the same public sentiment concerns that you raise that might apply to other things like nuclear, for example—then what is the best answer?

The view that we have come to with our research is that if the problem with the renewables is that they have this firming capacity that makes them expensive and unreliable, then maybe all that money that is being allocated in subsidies to prop them up could be invested more into research because innovation works such that once you get past that bottleneck, that is when things rapidly change. It is the same with any sort of technology and any technological development. Our support of market forces and innovation is not driven simply by the need to lower prices but also equally by the need to address these difficult questions, these problems of how do we deal with the problem of climate change, how do we reduce emissions across-the-board? We think it can be done in a way that does not involve increasing prices for the consumer.

The Hon. MARK BUTTIGIEG: There will be those on the side of the debate who say that renewables can do it and use that very argument you are suggesting; in other words, the technological advancement, the curve for renewables is much sharper than nuclear is ever looking like reaching. Some of the testimony we have heard here today says that is because the Government has not given nuclear an equal footing by subsidising it. Is that your position?

Mr MARAR: It is, but I also want to stress the point that one of the main reasons why the curve on nuclear has slowed down significantly since the seventies—I mean, in the fifties and sixties it was going gang busters. Since the seventies regulations have consistently gone anti-nuclear, a lot of it driven by, to a significant degree, fear-mongering—and some of these regulations have done a good thing. They have made a plant safer, but we believe there is evidence that they have gone too far because countries that do not have strict regulations but still have sensible ones have not had the same problems. We think that if you do have an actual level playing field in this regard then maybe nuclear will have that fast innovation curve. We know that even with the current state of things—in the wake of the years following the Fukushima plant issue, we know that despite that massive setback, innovation has continued and we are seeing newer reactors that do not bear any similarity to the old-scale clunky and expensive reactors. We are seeing designs being rapidly assessed and being tested. If you want to compare nuclear and wind and solar on the innovation front, I do not think we have seen any of that happen for any battery storage capacity that can account for full base load power whereas we have seen it for smaller model nuclear reactors.

The Hon. MARK BUTTIGIEG: We heard some testimony from Mr Switkowski that may suggest otherwise. On that point, has your organisation done any analysis about the relative efficiency of subsidising a nuclear industry? My understanding from hearing today's testimony is that it would take substantial investment from government. The question to the taxpayer becomes, "Where is our tax dollar most efficiently spent? Are we better off going down the renewable path given the technological uptake there? Are we better off going down the nuclear path or a combination of both"? Has your organisation got a position on that and has there been any analysis to back that position up?

Mr MARAR: We have not done any extensive analysis on that specific question. It would be quite difficult to do because of all the variables involved. What I would say is we would need at the very least to have

a neutral policy in place and then we will see how things go in the future. The movements in this sphere are being driven by people who have a background in nuclear science and research and they are doing some tremendous work already. They will be the ones to lead this going forward and I am sure the same will continue in the renewable space. The key is: What can government do to facilitate that competition, to let it carry on and let it continue happening? The answer is: To treat things neutrally. If you are going to spend taxpayer money in the name of emissions abatement and in the name of funding research for emissions abatement, let that be neutral. Then whoever makes the better case for an individual project should be the person who receives that grant or receives that support.

The Hon. MARK BUTTIGIEG: There are two different approaches to that line of thought. Do the academic analysis upfront in terms of the model that compares both parts before we start spending the money on more subsidies to an industry that perhaps may not be efficient irrespective of what you think about renewables, or let us let the market try to work it out. We heard testimony earlier today which suggests that the experience in the Western Australian jurisdiction where there is no restriction on uranium mining has not led to a sprouting of a new nuclear industry there. The market is telling you it is not viable is what the argument would be.

Mr MARAR: Sure. Thanks for raising to that point. I recognise that in Western Australia those projects have, while they have been approved and while they are still slated to go ahead eventually, they are being kept dormant at the moment. In New South Wales I know that no mining licenses have yet been applied for although exports to South Australia have still continued as I understand. In the wake of the Fukushima disaster the uranium market essentially crashed. Prices are now very low. Mining in general, whether it is uranium, whether it is coal or iron ore, it is subject to massive fluctuations.

Western Australia's entire economy in some ways is heavily pinned to the mining sector. Over the current period, uranium prices being so low, mining is currently not competitive. I do not think that is an argument against allowing uranium mining so that in the future when the prices do pick up, things change. For example, in Japan in the wake of Fukushima, they scaled down nuclear power over time to where it is now only 3 per cent of the energy mix—

The Hon. MARK BUTTIGIEG: How much, Mr Marar?

Mr MARAR: Currently 3 per cent. The government's slated policy as of now is to scale that back up to 22 per cent in part because, firstly, their emissions have gone up rapidly and they are importing a lot of Australian natural gas which is expensive. Secondly, because their power bills also gone up significantly. These things do in fact change quite significantly over time and we need to be ready for that.

The Hon. MARK BUTTIGIEG: In terms of the cost of electricity, it has been raised prior today and seems to be a major factor in all of this debate in terms of stimulating the debate about sources. Is there much awareness of what contributes to the average New South Wales consumer's electricity bill? You touched on this before in one of your answers or your statement, that we have had an investment in the actual network, the poles and wires, which has by and large been scaled back now as a result of regulatory findings from the Australian Energy Regulator, and then you have the retail market which is essentially an oligopoly—two or three major players in the market gouging prices. Generation is ironically one of the areas where there is some competition, notwithstanding a move back to vertical integration so the generation companies own the retail companies. That is what is driving prices up from what I can gather, not necessarily the source of the energy. Have you got a view on that?

Mr MARAR: You are right about that. I did a submission to the New South Wales Government back in 2017; it was one of the first hearings I ever did. I think there needs to also be recognition of the link between certain sources and some of those factors that you outlined. One of the things that the Australian Competition and Consumer Commission found contributed to the cost stack in New South Wales was solar tariff feed-in schemes and environmental costs and things like that. Separate to that, we know that overinvestment in network assets, as you correctly pointed out, was a significant driver. A significant amount of investment comes from needing to make the grid reliable as older generation, coal fire generation moves into premature retirement.

A lot of that is because more renewables are being put into the grid because they need to be firmed up as time goes on. That is a concluding factor in terms of prices going up. There is a link over there. Also, by their nature, things like wind and solar are usually built in areas that are away from population centres where there is a lot of wide open space. It therefore costs more money to connect them up to the network. I do think that there is a link there, but as you correctly pointed out a number of different factors have made our prices as expensive as they are.

The CHAIR: Thank you very much for your time here this afternoon. The Committee has resolved that any questions taken on notice be returned within 21 days. If any questions were taken on notice the secretariat will contact you in relation to the questions. Thank you again for your time.

(The witness withdrew.)

The Committee adjourned at 17:08.