REPORT ON PROCEEDINGS BEFORE

STANDING COMMITTEE ON STATE DEVELOPMENT

INQUIRY INTO URANIUM MINING AND NUCLEAR FACILITIES (PROHIBITIONS) REPEAL BILL 2019

CORRECTED

At Sydney on Thursday 26 September 2019

The Committee met at 1:30 pm

PRESENT

The Hon. Taylor Martin (Chair)

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

The CHAIR: Welcome to the first Standing Committee on State Development inquiry into uranium mining. This inquiry has been established to inquire into the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019. The object of the 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 in New South Wales. This inquiry is a fact-finding mission to consider if New South Wales should investigate the viability of nuclear power as an energy source for our State. Before we commence, I acknowledge the Gadigal people who are the traditional custodians of this land. I also pay my respects to Elders past and present of the Eora nation and extend that respect to other Aboriginal members here today.

Today the Committee will hear from a panel of witnesses representing NuScale Power, SMR Nuclear Technology and the Energy Policy Institute of Australia. Before we commence I would like to make some brief comments about the procedure for today's hearing. Today's hearing is open to the public and is being broadcast live via the 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 if they attend that they must take full responsibility for what they publish about the Committee's proceedings.

It is important to remember that parliamentary privilege does not apply to what witnesses may say outside of their evidence at the hearing here today so I urge witnesses to be careful about any comments you make to the media or to others after you complete your evidence here today as such comments would not be protected by parliamentary privilege if another person decides to take action for defamation, should that happen. The guidelines for the broadcast of proceedings are available from the Committee 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 Committee staff.

To aid the audibility of this hearing, may I remind both Committee members and witnesses to speak into the microphones provided please. 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 may have hearing disabilities. Finally, could everyone please turn their mobile phones to silent for the duration of this hearing. I welcome our panel of witnesses. Could each witness, starting from my left with Mr Pritchard, please state their name and position title and swear either an oath or an affirmation.

TOM MUNDY, Chief Commercial Officer, NuScale Power, sworn and examined

CHERYL COLLINS, Director, Sales, NuScale Power, sworn and examined

TONY IRWIN, Technical Director, SMR Nuclear Technology, affirmed and examined

ROBERT PRITCHARD, Executive Director, Energy Policy Institute of Australia, sworn and examined

The CHAIR: I invite the panel to start proceedings with their presentation to the Committee.

Mr MUNDY: My name is Thomas Mundy. I am honoured to be invited to appear before the honourable members of the Standing Committee on State Development. I reside in the State of Pennsylvania in the United States of America. I have 37 years of experience in the power generation industry and have been with NuScale Power [NuScale] since 2012. I presently serve as NuScale's Chief Commercial Officer. In that role, I oversee, among other things, NuScale's global business development activities.

NuScale is best described as a nuclear technology development company, specialising in the development of a 720-megawatt gross nuclear power plant based on NuScale's small modular reactor [SMR] technology. NuScale's mission is to provide scalable, advanced nuclear technology for the production of electricity, heat and clean water to improve the quality of life for people around the world. We will achieve this mission by providing smarter, cleaner, safer and cost-competitive energy. We aim to be the new nuclear technology of choice for the nuclear generation industry in the United States and internationally.

I have been invited to Australia by the Australian Nuclear Association to make a presentation on the current status of NuScale's technology development program at a conference to be held in Sydney on 27 September 2019. I understand that nuclear power generation in New South Wales is presently prohibited by State and Commonwealth legislation. My overall contention is that, should the legislative prohibitions be removed, NuScale's SMRs can provide safe, reliable, baseload electricity production that can be an integral part of the electrical power system. NuScale's SMRs can also be operated as a dispatchable, load-following source of electricity to complement and support power systems that have a high dependence on intermittent electricity generation.

NuScale's SMRs are also ideally suited to provide process heat for a variety of industrial applications including district heating, desalination, hydrogen production and refinery operations. I previously provided, with my written submission to this Committee, a presentation on NuScale's progress to deployment, and I seek the Committee's indulgence to present and speak briefly on this presentation, inviting the Committee members to ask questions as I proceed. If I am unable to answer any questions from the Committee from my own knowledge, I will be happy to take such questions on notice with a view to making a supplementary submission afterwards.

The CHAIR: Thank you.

Mr MUNDY: I would like to refer now to the presentation that is displayed on the wall and start by first acknowledging the United States Department of Energy. We have been and continue to be a substantial financial assistance award recipient from the United States Department of Energy and are obliged to acknowledge its support in public presentations such as this. As I mentioned in my opening statement, we intend to provide an energy solution that does more than just what traditional nuclear has done to date, and that is to provide large amounts of baseload electricity. We want to do that by providing smarter energy, cleaner energy, safer energy and energy that is cost-competitive. I will talk about that during the course of my presentation.

With respect to who NuScale Power is, the organisation was established by our Chief Technology Officer who did some work in the early 2000s when he was the head of the nuclear engineering department at Oregon State University. It was through that work, that was funded by the Department Energy, that the original underlying intellectual property was first developed. Subsequently, in 2007, the company was started and really did not take off in its design development program until two things happened. First, Fluor Corporation, a large multinational engineering procurement construction company, headquartered in Dallas, Texas, became our primary investor and, second, NuScale winning a very large, competitively-bid financial assistance award from the Department of Energy in the US.

Those two things allowed us to rapidly accelerate the development of our technology to the point now where we have actually invested more than $900 million in the development of our technology and program. All of the work that we are doing now is to ready for our first plant deployment for a customer who will deploy the 720-megawatt facility in the state of Idaho, with that project generating electricity in 2026. That is the timetable that we are on currently to meet that commercial obligation.

At the heart of our technology is our small modular reactor system. We call that the NuScale power module, which is displayed on the screen. That is what is referred to as an integral reactor vessel, meaning that instead of having a separate steam generator reactor vessel and pressuriser vessel, we have combined all of those vessels and the functions that they serve into one integral vessel, shown in the centre of that drawing. Instead of those components being surrounded by a very large containment building that you would find currently with large nuclear power plants, we surround that module with a high-pressure steel containment vessel.

The entirety of this system—and this system also includes other ancillary pieces of equipment, including decay heat removal and emergency core cooling systems—so this is the entirety of the nuclear steam supply system for our power plant design. It has been sized to be able to be completely fully factory fabricated, taking advantage of the benefits of repetitive factory fabrication and the savings in costs and schedule and less risk associated with that repetitive factory fabrication. So there is no field fabrication or construction of any kind associated with these systems. I think the next slide is probably the most telling. It differentiates our technology—

The Hon. SCOTT FARLOW: If I could just interrupt. What sort of size are each one of these vessels?

Mr MUNDY: They are roughly 76 feet tall by 15 feet wide, and those dimensions have been set so that we can ship them from the factory by rail truck or barge. It is the size that drove the actual power output of the technology, as well. This slide depicts what you would find in a typical, large pressurised water reactor nuclear power plant that is offered commercially for sale these days. It shows in blue individual steam generators which are roughly the same size as our power module.

In red is the reactor vessel and in purple the pressuriser. In green are the reactor cooling pumps. You see that all of those are surrounded by a high-pressure steel containment building—this is a very large structure—and then that building is surrounded by what is typically referred to as the reactor building. Within that building there will be additional pieces of equipment—high pressure coolant injection, low pressure coolant injection, auxiliary feed water. There are a number of systems that support the operation of that power plant.

We have taken everything you see there, and the equipment that would be found in that additional building and it is embodied within the entirety of our NuScale power module. The biggest exception is that we do not have that large containment building. The high-pressure steel containment is exactly designed for pressure ten times that of that large building. All that leads to an extremely strong safety case for the technology that I will mention in a moment.

This slide depicts that the technology has been specifically designed to come from the factory, to be installed in the facility itself, as opposed to being constructed or assembled in the field. As you notice, in the middle of that graphic is a cut-away of what we call the reactor building where these modules are housed. Notice that the technology is scalable, in that the building itself can house anywhere from one to 12 of these modules. So if all 12 are installed and operating at full power the total facility output is 720 megawatts. But you need not have all 12 installed. You can start with something less--anywhere from one to up to 12. It presents a compelling proposition to be able to add 60 megawatts of capacity each time you install a module.

These modules are connected to their own power conversion systems. That would be a steam turbine generator, condenser and other pieces of equipment that are also fully factory fabricated. They come to the site. They are wheeled into the turbine building and hooked up. Again it is a simplification of the construction of the facility and taking advantage of repetitive factory fabrication. When that reactor that produces 200 megawatts thermal of heat is directed to those steam turbine generators they produce 60 megawatts. But the technology is also well suited to direct that heat energy to something other than a steam turbine generator, and can be directed to any number of process heat applications, that I will mention in a moment.

We are often asked where our prototype will be? Where is our first demonstration plant going to be? The answer is that there will not be a prototype. In fact, under the United States Nuclear Regulatory Commission's [NRC] regulations we are not required to have a prototype for demonstration because the underpinning of the technology is based on well-known pressurised water reactor technology. That is not to say, however, that we did not need to do quite a bit of testing and prototypical demonstrations of the first-of-a-kind equipment associated with our technology.

This slide lists a number of the tests that have been conducted. This is only a subset of the testing program. In fact, to date we have spent over $120 million in producing the information that was needed not only to satisfy the NRC's review of our technology, but also to ensure that we could effectively manufacture the equipment that will be installed in our power plant facility. I mentioned that the technology is well-suited for base load electricity production, which large nuclear plants have done well for the last 60 years, but we have also developed and built into the design many more features and capabilities that you will not find in those currently readily available—large plants or even our small modular reactor [SMR] competitors.

For one, we have specifically developed the ability to "load follow"—that is, changing the electrical output of the facility so that it can complement and support the grid stability and the capacity needs of the system as typically renewable energy sources and their outputs increase and decrease. So the technology has been designed to significantly load follow. It is also well suited to use that process heat to provide that heat for industrial applications that need heat and, in fact, many of which use thermal generation. Generation heated by coal or natural gas in those processes. Our technology can be used to replace that carbon based generation, reducing the carbon footprint of those processes.

We also have, because of the strong safety case, and the design itself, a number of features that I will mention that you also will not find in other nuclear plants today or that have been proposed. This slide depicts the capability of the technology to change the electrical output of the facility. We can do that in one of three ways. We have what is called a steam bypass. Instead of the steam being directed to the turbine you can bypass it variably from 100 per cent to nothing for rapid changes in the output of the generator if that need arises. You can also up- and down-power the reactors themselves, with the use of the control rods at the rates that are set forth in the table.

You can also take modules in and out of service, depending on time duration—so, steam bypass for rapid power changes, module manoeuvring for changes in power when you have more time, and then dispatchable modules where you are talking about the reduction of increments of 60 megawatts of capacity over a 12-hour period, essentially. This slide just highlights some of the studies that we have conducted and published—they are available on our web site—on how we would effectively and economically use our technology and the process heat for a number of industrial applications, including the production of clean water. This slide talks about the new level of plant resilience associated with our technology.

The safety case for our technology is really second to none. It allows our technology to be approved to operate in what is called island-mode operation. So we do not need to be connected to an off-site power supply in order for the facility to be allowed to continue to operate. The actual power that the facility itself produces can be used for the electricity needs of the facility. It can also then provide first responder power. So when the transmission system grid is restored this facility can be a first responder, providing power back to the grid to enable the grid to be restored and provide the electricity sources needed to start up other generation sources.

It also has black start capability, meaning that it does not need off-site power in order to start itself up and then provide that power back to the grid. These are capabilities that currently do not exist for any nuclear plant that is running or being offered at the gigawatt size and for other SMR technologies that are out there. The resiliency of the facility is extremely high. The reactor building where these modules are housed is a seismic category 1 structure, and it is built to very high, robust standards, allowing it to withstand very high levels of ground motion. In fact we have designed it to a level of ground motion that is typically much higher than other nuclear plants.

The building above grade is designed to aircraft impact resistance. It is able to withstand the impact from a large commercial aircraft. That is required by regulation, but it is one of the resilient elements of the technology. Suffice it to say that it is a very robust structure. Our reactor protection system—that is, the electronics and the system that is associated with it—that is intended to control the reactor and other systems is highly cyber resilient. It is resilient to cyber-type intrusion events based on the nature of the technology that we have selected for that system. It is based on non-micro processor technology called field programmable gate array technology. Suffice it to say that it is also very resilient to cyber-type intrusions.

Lastly, through studies that we have done with the United States [US] Government, the technology—the power plant—is resilient to electromagnetic pulse and geomagnetic disturbance events. These are all features and capabilities that you are not going to find in other nuclear technologies that are available today. It also provides highly reliable power. In fact, we can show that a 720 megawatt facility can provide, over the lifetime of that facility, 60 megawatts of electricity at a reliability of 99.98 per cent. What does that mean over 60 years, or the life of that facility? The facility is always, with the exception of about a week, going to be providing around 60 megawatts of electricity.

For those who need that kind of highly reliable power and who are currently obtaining that reliability through expensive diesels or batteries, this is a very attractive feature of our technology. You only get that because we have these essentially individual power supplies. We do not have what is called a single shaft to the turbine, because when the turbine goes down, so does the total output. There is only one turbine and so the total output of the facility goes to zero. In our case, we have individual modules, so when you take a module out of service, say to refuel it, you only lose 8 percent of the capacity of the facility. The remaining 92 percent of the facility continues to operate, so you are always generating some amount of electricity.

The construction time frames, because of the simplicity and the fact that the entirety of the nuclear supply system and containment are made in a factory, the construction duration and the schedule are much shorter than you find for current big plants. We are talking about a 36-month construction period as opposed to five, six, seven, eight years that some of these bigger plants have taken to build the facilities themselves. In the licensing space we are the first advanced nuclear reactor to submit an application to the US Nuclear Regulatory Commission to have them approve our technology. It was the first advanced technology of the small modular reactor variety to have done that. That review is going extremely well.

It is basically a four-year process and we will receive the NRC's approval next year. In about a year from now the technology will have been approved by the NRC. As I mentioned with respect to the safety case, a separate application is being pursued by a nuclear utility, the Tennessee Valley Authority in the US. Under their application to approve a particular site for the future deployment of small modular reactor technology, we have been able to show that we can satisfy the criteria that would allow the NRC to approve an emergency planning zone that is substantially smaller than what is currently required by regulation. US nuclear plants have to have a 10-mile emergency planning zone from the centre of the reactor building.

Our technology can demonstrate, because of that extremely strong safety case, that the emergency planning zone could be limited to essentially the owner-controlled area, the site boundary of the facility. One last point on the safety case is with respect to an event that happened in Japan at Fukushima where they talk about how long a nuclear facility can cope with a situation where the facility loses all electric power. In the case of the plants in Japan, they had roughly 72 hours before they needed to do something to essentially inject water into the reactor cores to keep them cool. They needed to start a pump, they needed to open a valve and they needed to move water from somewhere into the reactor vessels to keep them cool. They were not able to do that and, as a result, there was damage to those reactor cores.

They had 72 hours to deal with that. For our technology, our coping period is not 72 hours but an unlimited and indefinite period of time, meaning that when the station loses all power to it, all of the 12 modules will safely shutdown and they will self cool for an indefinite period without the need to add any water, without any operator action and without the need for the restoration of AC or DC power. That is a capability and a feature that is second to none to any nuclear light-water technology that is available today. Coming from the utility business as I do, the question of cost is of paramount concern.

Certainly the safety case is second to none and the customers have the ability to examine the details of that safety case through the materials that we have submitted and are available on the US NRC's website. But for many of the customers it certainly comes down to the commercial aspects. We were probably the first SMR that produced and published a cost estimate based on a very detailed and robust cost estimating and project delivery activity. We first had that in 2014. We updated it in 2017 and we are in the process of doing it again for our client's first project. Basically what that work does—and it conformed to the American Association of Cost Estimating at what is called a level four cost estimate—is that it was based on a very detailed design.

As I mentioned, we are not in the conceptual phase of development. We are not still developing the design; we are readying the design for construction. We are producing the last pieces of information that are needed to fabricate the modules and construct the facility. We have been able to produce, with a high degree of fidelity, these cost estimates both on a first-of-a-kind basis and on an nth-of-a-kind basis, meaning the subsequent costs of the facility after we have had the learning from having made these modules—in this case, about 12 of them in the first instance—and have constructed a couple of these facilities and we have learned to reduce that cost even further. It is similar to what has been seen in the US submarine construction program. The cost of the first submarine is much, much higher than the cost of the last sub because of that learning and how they improved on reducing the cost from the first one to the nth submarine manufactured.

These numbers are premised on deploying our technology in a generic south-eastern US site. This is all based on US costs using US supply chains, US-sourced equipment on a US site. This number will vary in other parts of the world, where the supply chain varies. If we use international best pricing on the supply chain and a different source of labour, in many places around the world labour is less expensive than it is in the US. I stress that these numbers are US-based. The first-of-a-kind number, the $3 billion for essentially 720 megawatts or $4,300 per kilowatt, is around the price that our first customer will be paying on an overnight basis. But these numbers are very competitive to gigawatts size nuclear facilities, which have been averaging well above $5,000 per kilowatt on their construction programs, many approaching $9,000, $10,000, $11,000 per kilowatt.

Our program schedule right now supports our client's desire that it be operating and generating electricity in this first facility in 2026. Everything that we are doing now supports that time line. The customer is a municipal power company headquartered in Salt Lake City, but with a generation portfolio across several States in the western part of the US. It intends to deploy this facility on property actually owned by the US Department of Energy, at its Idaho national lab site, another one of the incentives and benefits that the Department of Energy has made available to this first-of-a-kind deployment in the US with our technology and our customer. What is interesting about that is, because it will be on an Idaho national lab property site, the Department of Energy intends to use two of the 12 modules, one to be used for research and development activities associated with probably the production of hydrogen and looking at advanced processes to do that.

The last module will be used actually for electricity production for the laboratory itself. And then because of where we are and the state of the program, the fact that we are almost finished with a major regulatory review from a top-tier nuclear regulator and the fact that, other than the US where natural gas is very inexpensive, for the rest of world natural gas is usually at a pricepoint that is much higher than it is in the US. In some places carbon is taxed and increases the cost of generation from thermal generators involving carbon. We have a lot of international interest in our technology both from the processed heat perspective, whether that is for district heating or desalinisation, say, in the Middle East, or to replace retiring coal, say, in the region of Eastern Europe where they have very strict low carbon objectives and our technology is an excellent fit to replace retiring coal generation. With that, I am happy to address questions you might have about our technology or our program.

The Hon. MARK BUTTIGIEG: Those cost comparisons you had where you had the overnight and the nth, they are in US dollars in 2017?

Mr MUNDY: Correct.

The Hon. MARK BUTTIGIEG: Have you done any cost per kilowatt comparisons with Australia?

Mr MUNDY: We have not developed those estimates yet for Australia. In many countries we have been able to rely upon the database that our engineering, procurement and construction company Fluor has by having done major infrastructure projects around the world. We have been able to adjust our price because it is all in their cost estimating system and they can easily convert, "What does two inches of pipe cost here and what is it cost here". We have been able to do that but we have not yet been able to do that for the Australian market.

The Hon. WES FANG: Thank you very much for coming in. Fascinating to learn about the technology and I have a number of questions about it if you do not mind.

Mr MUNDY: Sure.

The Hon. WES FANG: The first one is: We saw your estimated costing for the 12 module reactor building and you spoke earlier about how the system can start with one modular reactor and then you can scale it up as required. Have you estimated what the cost would be if you want to start with just one reactor? I would imagine that there is a base cost for the building and infrastructure and then the modular reactors add into that. With the economies of scale, have you worked out how much you would expect an initial base cost with a single reactor would be?

Mr MUNDY: We certainly know what those costs will be. The cost numbers that I presented are based upon a 12 module facility. Like you said, if you build a facility and spend the capital that can house a 12 module facility and you do not ultimately install all 12, you have paid for more building and structure than what you need and the economics are not as favourable. Usually customers intend to buy at least our reference plant design and that means the first version of the design that we intended to have licensed is the 12 module.

Certainly, we have contemplated and customers have asked us," Can you build me a four module facility?" The answer is: Absolutely we can. The economics will probably not be as good, in fact, we have done some parametric analysis that would suggest it is not. But for some markets, for example, where their source of fuel is expensive diesel fuel, even though not as good economics that I show here, in that particular market a four module NuScale facility is a great option. We intend, when we get past the licensing of this reference plant design, to examine—

The Hon. WES FANG: Scalability?

Mr MUNDY: —should we offer a second design that is specifically intended to house fewer than 12 modules.

The Hon. WES FANG: Leading on from that, what options do you have for multiple buildings? Do you think this building can be scaled to install, say, 24 or 48 or would you be more looking to install the reference building three or four times? How do you see the benefits of that scalability?

Mr MUNDY: We arrived at a facility that has 12 modules based on the input that we received from the customers who participate in what we call a "NuScale Advisory Board". It is comprised of utilities that are interested in ultimately deploying our technology. There was two things that we were looking at, one is a certain size output. In the US, between now and 2040, 80 per cent of the coal generation will retire. Those plants are somewhere between 300 and 600 megawatts on average so having a facility in the 600 to 700 range was a good repowering option. Twelve modules also gives us the economics back and we were looking at this in the 2007 to

2008 timeframe. We were trying to hit a pricepoint on an overnight basis of around $5,000 per kilowatt because that is what the big plants were advertising.

We settled on, in the first instance, a 12 module facility. We have looked at, "Why not make it 16 or 18". For one, you do have to do move these modules around every two to four years depending on the refuelling cycle that it will be on and there is only one overhead crane. As you get additional modules beyond that you would have to install a second crane and we did not feel that was cost competitive to do. It would be more cost competitive to build a second facility adjacent to the first one if you wanted to add more modules. That is really how we got to where we were on the 12. We have customers. It is very attractive because when you do not start with all 12 you are obviously not paying for those modules that you do not have installed but you are also not paying for the power conversion systems as well.

If you start with six modules you also forego the cost of a second—we have two turbine buildings, each one houses six of these power conversion systems. If I start with six modules, I start with one turbine building and install all six power conversion systems. I do not build a second turbine building and I do not pay the cost of those power conversion systems or the six modules until I intend to start installing them. You can add 60 megawatts of capacity on a very inexpensive dollar-per-kilowatt basis each time you incrementally add one of these modules. That is very attractive from a cash flow perspective and also from a project financing perspective.

The Hon. WES FANG: The last question I have is—and you sort of answered this during the presentation—where the first facility is going to be located you mentioned that one of the reactors is going to be used for heat and the other one for generation of power. How easy is it, say, if you had a reference building with 12 reactors, to multi-use those reactors? For example, you would be aware that we are in a drought. We have desalination—water supplies that will supplement our dams. I note that you said that you could use the heat sources in order to desalinate water. What is the ability of the system to be used to produce heat and then when we have full dams, be reverted back to electricity? Can it be scaled in that way?

Mr MUNDY: Very easily. In fact, we are talking to a potential customer in the Middle East that finds our technology very attractive. They use thermal distillation there so they need a heat source. They need the heat from our technology as opposed to using, say, reverse osmosis which you just need electric power essentially for. They are looking at us to make water during the day when solar is predominant and then switch over to electricity production when the sun sets and solar generation goes down. Water in the day, electricity at night. We can very easily switch from one to the other; it is just a matter of directing that steam either to its power conversion system or to an industrial process.

The Hon. WES FANG: Thank you very much.

Mr MUNDY: And any combination that you want, any modules.

The Hon. SCOTT FARLOW: Thank you very much for your presentation. I am just interested, 2026 is your timeline for the first operational plant in Idaho. What does your order book look like from there? What sort of timeframe would it be theoretically for somebody to place an order to then have a system up and running after 2026?

Mr MUNDY: We are talking to a number of companies, that last slide identifies some of the markets that we are in. They are all looking, the follow-on projects, are contemplating commercial operation dates in 2027, 2028, 2029, 2030. They all vary depending on where they are in their study of nuclear deployment. There are many companies that are interested in our technology and, either by policy or mandate, cannot be the first mover on commercially demonstrated technology. As we say, there are many that do not want to be number one but they clearly want to be number two. We expect to be working on very close follow-on projects from this first one in Idaho.

The Hon. SCOTT FARLOW: Effectively, in 2026 Idaho is up and running and then you would expect orders to be confirmed following 2026 to then be operational.

Mr MUNDY: To me, commercial operation dates are 2027, 2028, 2029. We are going to have projects working in parallel, essentially. And that is why one of our focuses now is to build out our supply chain. We have been going through the process of identifying companies that, as strategic suppliers to the program, produce the power modules for our technology. We need to make sure that we have sufficient supply chain capacity to be able to satisfy this customer interest that we have.

The Hon. SCOTT FARLOW: For assembly or construction of the plant, what sort of operational cost do you look at in terms of kilowatt hour costs?

Mr MUNDY: In terms of the operational or on a levelised basis?

The Hon. SCOTT FARLOW: Yes.

Mr MUNDY: Our levelized cost of electricity [LCOE] for the first project is $65 per megawatt hour.

The CHAIR: In the United States, of course?

Mr MUNDY: Yes. I am hesitant to talk LCOEs because it is very heavily driven on the financial structure of the client. Our first customer is a municipal power company, meaning they are an instrumentality of the State. They do not pay taxes and they are able to acquire much more debt financing at a much lower cost of capital. Our target for them, for that project commercially, is $65 per megawatt hour. We think we might be improve upon that but that number is based upon a competing combined cycle gas project that has an LCOE of $65 per megawatt hour. If you are an investor owned utility in the US, your financial and cost to capital is quite a bit different than a municipal power company, you are probably looking probably $15 or $20 more depending on your cost to capital, tax rates and some other things. Again, it all depends on generally what is the competing cost of technology and what is the customer's need for a diversified portfolio. A number of the considerations go into what they will select and what the market is.

The Hon. SCOTT FARLOW: I take your word for it but walk me through the process. Without any electricity or without any water how do the modules cool themselves down?

Mr MUNDY: Every nuclear plant has what is called an ultimate heat sink, meaning it is an ultimate source of water that is used to cool the reactors when needed. Usually, that source of water is somewhere—it is in a tank or a pond and there usually has to be some means of getting that water from where it is to the reactors when needed. We have simplified the design by putting the modules themselves in that pool, in that ultimate heat sink of water. What happens is that when the reactors shut down, the nuclear fission process stops but there is still what is called decay heat that is generated where the fission products continue to decay over time. As they do, they generate heat. You must have the means of removing that heat.

What we can show both through our thermal-hydraulic test facility and the computer codes is that when they shut down, they will start dispelling that heat to the water that is in the pool. Over time the water in the pool will begin to heat up to the point where it will start to boil. The water will boil out of that pool. At the same time the amount of decay heat being produced in those cores is rapidly decreasing. After a period of time—30 days or so—even if all of the water has boiled out of the pool, the amount of decay heat is so low that just the convective air circulation around the outside of those vessels is enough to remove the remaining decay heat. That is an extremely conservative analysis but it does demonstrate though the extreme safety case that we have and the fact that we have this indefinite coping period.

The CHAIR: Is it what you would call an inherently safe design? Is that what it is referred to as?

Mr MUNDY: To some extent. It is fully passive in its safety systems and we do not rely upon any direct active system components. In fact, the fact is that currently operating nuclear plants and the large ones that are being offered need a source of emergency power, especially when they lose off-site power, like in Fukushima. They usually do that through emergency generators. We do not need any what is called Class 1E power. That gives us a safety case. It gives us the ability to run in island mode. It allows our technology to be placed at end-of-the-line-type scenarios or in a transmission system, where it is not as robust and cannot provide a very stable, dual-circuit-type connection to the power plant.

All of these things make our technology being able to be sited in many more places. It also eliminates the need to have, in some cases, a very large build-out of the transmission system to support the nuclear generation that may exist at a particular location. But passive means we rely on the immutable laws of thermodynamics and physics—buoyancy, heat transfers and those things do not change and everything acts upon those laws. Natural circulation is a good example: Hot water rises, cold water falls and that creates a path or a flow of liquid. If that flow of liquid is across a heated medium, either a heat exchanger or a heated core, it removes heat as it does that. That is what it is based upon.

The Hon. SCOTT FARLOW: Thank you very much.

The CHAIR: Mr Mundy, what is the life span of one of these modules?

Mr MUNDY: They have been designed for 60 years.

The CHAIR: How much maintenance would they need in that time? Does it end up a bit like grandfather's axe where, at the end of its life cycle, it has had almost all the components replaced?

Mr MUNDY: For the balance of plant equipment, that equipment is not designed for the life of the plant. Over time ordinary valves and electrical equipment will have to be replaced. But you do not want to have to replace the power module itself, the reactor vessel. That has been specifically designed for 60 years of life.

Other pieces of equipment are going to be either obsolete or need to be replaced. As I mentioned, the system and the technology is based on simplification.

We have eliminated many of the components and things that you find in other plants. For example, our refuelling outage, where we have to put new fuel and move the fuel around that is in there, is more of a repetitive maintenance activity than it is in comparison with a refuelling outage that would occur, say, in a large nuclear plant where they have to do a lot of work inside containment when the reactors are shut down. Typically, they bring in a lot of workforce to do all that. They move a lot of fuel. They work on their turbines and those sorts of things. Our turbines are industrial-grade steam turbines. They are inexpensive and very easy to maintain. The refuelling is accomplished by a dedicated refuelling team of 22 people in a 10-day period. It is more of a repetitive maintenance activity that anything else.

The Hon. MARK BUTTIGIEG: I have a couple of follow-up questions on my colleagues' questions in respect of cost. Obviously, one of the things that will be looked at in this market—leaving aside for a moment all the ideological debate over renewable versus nuclear and baseload and whether or not you can actually have dispatchable power—on pure cost comparisons, have you done any cost-benefit analysis for the Australian market of, say, building more coal-fired plants or renewable sources as opposed to this?

Mr MUNDY: Not for the Australian market. We actually are participating in a very detailed study that is ongoing in the western part of the US because it is that area where they have had State legislation that is mandating significant reductions in carbon. There is a much more heated examination now of the whole mix between, say, small nuclear—our technology will be examined under this analysis that is going on—and renewables that are in their market. But we have had many customers come to us recently from power companies who a year ago said, "We are going to stick with wind for the time being." These State mandates have come out and they have come back to us and said, "We cannot meet our system needs or our customers' needs without small nuclear being part of the equation." Now they are talking to us as possible deployments in their markets.

The Hon. MARK BUTTIGIEG: You referred to that cooling source—intrinsic or sort of resident. Do you create an artificial reservoir or something and then plonk it in? How does that work?

Mr MUNDY: I will go back to a slide.

The Hon. MARK BUTTIGIEG: I was not paying attention—clearly.

Mr MUNDY: This is the reactor building. The modules themselves and the reactor cores are well underwater.

The Hon. MARK BUTTIGIEG: It sits in water.

Mr MUNDY: This, in fact, is the ultimate heat sink. Other power plants might have this in a pond out here or in a tank above their containment. We simplified it by just putting the modules themselves.

The Hon. MARK BUTTIGIEG: It is all fully self-contained.

Mr MUNDY: In fact, the outer surface of the containment vessel is a heat transfer surface area. It is specifically intended to be able to, under certain scenarios, remove the heat from the core through this annulus region out through the wall of the containment and into the pool water.

The Hon. MARK BUTTIGIEG: Where are we up to with this debate on nuclear waste products being left over from this process as opposed to what they were in the 1970s and 1980s? Where is that up to?

Mr MUNDY: Everything that we have done in this design in the context of the NRC, the US Nuclear Regulatory Commission's approval, is premised on the US regulations. Right now the US's decision is to move to a long-term, deep geological repository for the long-term storage of used fuel and high-level waste from nuclear facilities and from government processes. That facility is not yet open. In the interim, the NRC has approved long-term dry storage for 100 years on the site of the nuclear facility until such time as the government resolves the issue of long-term waste disposal.

In terms of used nuclear fuel, or it is called spent fuel—I hate to use "spent" because there is still a lot of energy left in those fuel bundles despite the fact that they are taken out—there is the ability to extract that energy and use some of that energy again. Right now we have designed—this is the pool here, what is called the fuel pool and that has been sized to be able to hold 10 years of used fuel produced from the operation of the facility. After around five years of operation, or of the bundles being stored in here, the system has been designed to be able to accommodate dry cask storage. You take these bundles and put them in these large vessels, high integrity casks, that are intended to allow you to store the bundles onsite.

We have set aside 2½ acres for dry cask storage within the protected area of the facility itself, because this was an add-on to current plants that are operating. This was never intended for the current fleet in the US, everyone assumed that ultimately this repository would be available and when this fuel needed to be removed from site it would go immediately to that repository. In the interim now, for up to 100 years, the fuel will be stored onsite. We produce no more—we use standard, pressurised water reactor fuel that is currently run in large pressurised water reactors [PWRs].

The only difference is that the fuel height is half the height of a normal, large plant bundle. We produce the amount of fuel that is on a pro rata basis, no more than what is produced in a current large PWR. However, we have implemented a design that has best practices for the minimisation of liquid and solid waste from the operation of the facility. You do create solid and liquid waste during the operation of the facility and we have implemented systems and practices that are better than top quartile performance from the US nuclear fleet. That is very small quantities of that kind of low-level waste.

The Hon. NATASHA MACLAREN-JONES: I am interested in what needs to be considered when you are choosing a site. In your submission you mention that you received an exemption in relation to emergency zones because of your safety. When you are looking at sites what needs to be factored in, or is there nothing much that you need to think about?

Mr MUNDY: We, as the technology provider, do not evaluate the site. The customer who intends to deploy will pick a location and then they have to go through a very rigorous examination. The particular site that I mentioned is a site that the Tennessee Valley Authority intends to, at some point in the future, deploy SMR technology. Under the NRC's regulations under 10 CFR part 52 they call it an early site permit, which examines and approves the suitability of the site, technically, geologically and those kinds of things, the environmental impacts and the emergency plan associated with the particular location of intended nuclear generation, a plant being deployed there, and you can bank that for up to 15 years.

The findings that the NRC makes are final. They cannot be re-litigated subsequently when they intend to actually deploy. They created an application, it was a bounding application in that it did not consider one technology, rather an assortment of technologies, and they created a bounding parameter of metrics associated with each power plant so that in the future they could pick any one of those and know that the site was approved for any one of those technologies. They also, as part of the emergency planning elements of that, knew that some of those technologies would allow them to reduce the size of the emergency planning zone, so they sought two exemptions. One is, identifying the conditions that must be satisfied at 2½ miles, and one for a technology they might pick satisfying a site boundary.

What we have been able to show through an audit that was conducted, that if we were the selected technology we could satisfy the conditions that have to be met to be approved for a site boundary emergency planning zone at that location. Nothing has been approved yet because they have not gone forward with the next step, and that is identifying the technology. In terms of what is examined, the site suitability looks at things like geotechnical, geological, seismic, those kinds of issues associated with the physical aspects of the site itself. Then the customer must examine the environmental impacts associated with the placement of nuclear technology, and it is very prescriptive in how they go about doing that. They also have to, at least under an early set permit process, identify either the major features of an emergency plan or a full and complete emergency plan for that site. It is in the customer's interest to try to make sure that the emergency planning zone has been right sized for the technology, and that is what this particular potential customer has done in this early site permit application.

The CHAIR: Thank you very much for making time for us today. I do not believe any questions were taken on notice. They usually need to be returned within 21 days.

Mr MUNDY: It is our pleasure to be here. Thank you for your interest.

(The witnesses withdrew.)

The Committee adjourned at 14:26.