RESUMED **[9.46 am]**

COMMISSIONER: We reconvene at just after 9.45. Mr Jacobi.

MR JACOBI: Quantitative analyses and business case for establishing a nuclear power plant and systems in South Australia. Quantitative analysis will be undertaken to determine engineering, procurement, construction, life cycle, operating and maintenance costs associated with the possible development of three different types of nuclear power generation facilities in South Australia. The types of facilities to be considered are the small modular reactor SMR, the pressurised heavy water reactor and the light water reactor. Undertaking that work and to give evidence are Mr David Downing, Parsons Brinckerhoff and Mr Kenneth Green of Sargent & Lundy.

COMMISSIONER: David and Kenneth, a very warm welcome this morning.

MR DOWNING: Thank you.

MR GREEN: Thank you.

COMMISSIONER: All yours.

MR DOWNING: Okay.

COMMISSIONER: Please proceed.

MR DOWNING: Thank you. Good morning, thank you for the introduction and thank you for the opportunity to make this presentation to the Nuclear Fuel Cycle Royal Commission. Presentation will be focussing on the methodologies and assumptions that we have been developing over the last few weeks. We would ask you to bear in mind that the study we have been performing is still ongoing and that our work is still being reviewed and revised as we proceed. Next slide please. The brief we received from the Nuclear Fuel Cycle Royal Commission is ultimately focussed on developing a business case around the possible development of nuclear power plants in South Australia that might enter in to operation around about 2030. We were asked to focus on modern technologies that would be commercially available around 2030. The brief identified certain reactor technologies but it was essentially wide ranging in this regard.

We were also to consider what the infrastructure requirements of the plants might be. What additional road, rail, transmission, infrastructure, et cetera might be required? And we were asked to put all this in to a South Australian context. The business case will draw on the whole of life cost estimates and performance projections of the facilities in order to identify what commercial returns might be achieved versus what might be the expectations of developers and financiers. We are to identify what development risks might exist and what measures might be required to facilitate investors’ participation in a nuclear power plan project.

MR GREEN: We are aware that you have already received a considerable amount of information about the interest and technical aspects of the various facilities that could be built. We reviewed the potential available technologies in the market from a standpoint of how many unique cases we had to look at. In other words, we are not looking at specific technologies, we are looking at categories. So we started out with what are called the evolutionary designs. These are plants that currently exist, either in construction or in actual operation and in some cases; these are plants that have had a number of years of operation, ABWR for instance. These are usually termed as active safety plants and we will talk a little bit more about that as we move on. In looking at these, we have come to the conclusion that for the light water reactors; these will fit in to the category with the advanced reactors that have more passive design. Right now if you were buying one today, these would potentially have economic advantages but when the advanced reactors are in an enth of a kind situation, a lot of that economic advantage will probably go away. The exception here is the enhanced CANDU 6. We looked at that separately simply because it has a different size. It is the only reactor that we are looking at in evolutionary or advanced reactors that comes in in the mid-range, approximately 700 megawatt electrical. Because of that uniqueness we did include it as a separate case. The advanced reactors have – they are called passive reactors; they have some element of passive design and we have to remember that is a sliding scale. Now instead of having immediate active systems, these have active systems that come on days after an event. They are still not truly passive from the standpoint of what is called walk away passive but they do have an enhanced ability to wait until you have active design implementation.

In looking at these, we see three distinct types; two light water reactors, a pressurised water reactor and a boiling water reactor. Then we have a heavy water reactor. So we considered each of those as a category and again, the ones listed here are the ones we had most information available for. They will encompass other potential designs that may be in the marketplace in the future. In particular, the AP-1000 is of interest simply because of the amount of data we have and reliable information we have to set a benchmark for the cost of future plants. We will talk a little more about that but there is some real momentum. Eight units currently under construction, four in China, four in the US, a number more planned for China. At least eight more are in the licensing process in the US. So from a standpoint of momentum, there is a lot going on here and because of that there is a lot of information available.

Small modular reactors, this falls in to a little different category in that we do not actually have an active project being built in a small modular reactor. However, there is a considerable interest. We have listed four small modular reactors. We probably could have listed 12 or 15 if we had wanted to because there is so much being looked at out there. These four listed, NuScale smart, the Holtech SMR 160 and the mPower because these have a clear position in licensing. In other words, they have the potential of being licensed, being able to be ordered, so that they could be online before 2025 and so that is what qualified them. Again, they represent all the others that might come in, by 2030 it might be a different landscape. We chose to actually model this with two examples, the NuScale and mPower. And the reason we did that is because they represent kind of the end of the range, small modular reactors are not all the same size. NuScale is less than 50-megawatt electric per module, so we looked at combining six of those in to something that would approach 300-megawatt for an installation. On the other hand, the mPower is 180-megawatts per module, so we looked at putting two of those in to a facility that would give you 360-megawatt total. So we looked at those two cases.

I guess we are back to David on this.

MR DOWNING: Yes. No problem. So anyway, having reviewed the available technologies, the next part of our brief was to assess the information we were able to compile and to model the whole-of-life costs of the development of these nuclear power plants for South Australia. The outcomes of the modelling will flow in to a business case that will demonstrate whether or not there is an economic viability for the projects. To perform the modelling we have to develop a range of economic cost revenue, performance and schedule assumptions for the whole of the life of such a facility; from design and development, through construction and operation to decommissioning and final site remediation. The economic model will calculate the net present value of the facility’s cost and revenues to determine the levelised cost and levelised price of electricity. Economic assumptions range from macro economic assumptions on cost escalation and foreign exchange rates through assumptions specific to the assumed nuclear power plan business model, to assumptions on revenues to be generated based on wholesale electricity pricing. Escalation of operating costs has been assumed to be consistent with that used in the Australian electricity technology assessment at 2012. As much of the reference data we have been using is expressed in US dollars, we have used an interim assumption on exchange rates pending confirmation of forecast rates for economic modelling.

Wholesale electricity pricing is being forecasted by another adviser to the Royal Commission, taking in to account the forecast changes in South Australia’s generation mix in response to international and Australian climate change obligations. The weighted average cost of capital is frequently used in net present value analysis to identify the break even internal rate of return of a project. For the purposes of this study, a weighted average cost of capital has been estimated based on what is considered to be a reasonable business and financing model for a nuclear power plan in South Australia. In making this assessment, we have assumed some significant de-risking measures would be addressed. For example, recent nuclear power plant experience shows that investors want to see long-term revenue certainty. The US AP-1000 project and the UK’s Hinkley Point project all show strong elements of revenue certainty in their financing by way of long term PPAs and in the case of Hinkley Point, a government sponsored contract for difference. Similarly, the same projects have strong loan guarantees to give lenders further assurance of the soundness of their investment. On this basis, we have assumed a model that resulted in a pre-tax real WACC of 10.47 per cent. This compares favourably with the range of discount rates used in other studies such as the Imperial College study of 2012.

MR GREEN: As I said, we heavily depended upon the information from the Westinghouse AP-1000 projects to provide essentially a benchmark. At any point in time, whether it is 2020, 2025, 2030 it will be a competitive market and the AP-1000 because it is an actual project that is being built will, I think, set a benchmark that if someone cannot compete with that, they won’t end up in the market. The other issue with the Westinghouse AP-1000 that makes it attractive is that the information is a very high reliability. The two projects in the US, the four units, the Vogtle and Summer projects are being built in a regulated environment. By that we mean that the cost of a plant has been approved based on being able to recover the cost in a regulated electricity market. So the costs have to be publicly reported and they are actually broken down. The costs that are reported are the original contract costs, the escalation that is allowed for under the contracts and they even report a certain quantity of the cost that is under dispute currently between the supplier and the owner. But with all that information, we have got a very reliable basis for what those plants are actually going to cost.

Those plants are first of a kind plants in the US and China, however they are being built on existing sites, so we factored that in to what we believe the enth of a kind cost would go to that would be applicable to South Australia but of course there would be first of a kind cost with being the first nuclear unit. Extrapolating that information to the other options, the boiling water reactors historically have not been greatly different in price. There has been a certain window of pricing and boiling water reactors and pressurised water reactors have fallen in to that window, one being more competitive than the other depending on the particular situation. So we did not differentiate in capital costs between those. The heavy water reactor is a little different situation. The historical experience in Canada is that the heavy water reactors that had been built there have cost more than corresponding plants in the US that would be of similar size. There's actually a reason for that. As we look at it, part of the heavy-water cost, the heavy-water management systems, the relatively large size of the plants – so it is logical that there is some increased capital cost with these heavy-water reactors. So we've factored that in. Because there are no current firm orders for heavy-water reactor we have no way to verify. However, the only thing we have, the EC6, the smaller CANDU, has been proposed for Romania and what has been reported in the press is the costs of that project are relatively high. Again, we don't know too much about the details of that but that's being proposed, I believe, by a Chinese organisation working with the Canadians. Still, it looks like a fairly high capital cost. So based on that we did estimate a higher capital cost for that.

Next slide, the small modular reactors. Of course, again we're dealing with situations where we don't have any contractor to look at. We don't know what the actual offering will be when these start to be built. We've seen reports over the years, this $5000 per kilowatt electric capital cost thrown out there. We don't know what scope of supply that would actually cover. We don't know what point in time those dollars are relevant to, US dollars of course. So we kind of discounted that as being a number. We did notice in the earlier information and a presentation you had on the smart reactor that they were quoting prices in the $US9000 to $US10,000 per kilowatt. We think there's a reason for that and the reason is they're talking about the Saudi project which is very much a first of a kind.

They're also talking about stand-alone designs of 100 megawatts, whereas in looking at others like the NuScale, the Wholetech, the mPower, we're talking about putting multiple modules together to get up in the 300-megawatt range. So there's some economies there. So we don't know that that's inconsistent with what we're predicting which are slightly elevated numbers. There's the very excellent study done last year in the UK on small modular reactors that came up with a range of estimates of $US6400 to $US8900 and we think that is fairly consistent with what we're seeing. So we've got some good information there.

Will they be successful with a larger cost than the larger plant options? Obviously they're aiming at a market that the larger plants can't go into but we think they have some chance of being successful, even competing head to head, simply because of the potential advantages in the less infrastructure costs required to support it and also the ability to phase in generation to more closely match the load growth. So we do think part of the success of the SMRs will depend on there being able to succeed in a large market also because they need to get the volume up.

MR DOWNING: So if we move onto the capital cost assumptions that we've made, what we've put in here in our capital cost assumptions, the light-water nuclear power plant capital cost therefore are estimated from the reported experiences with the recent AP1000 projects. Heavy-water plant capital costs have been estimated to be higher than those of the LWR plants, reflecting the Canadian versus US cost history. Additionally, please note on the CANDU plants there's a significant life extension refit cost that has to be factored in after about 30 years of operation. That's not just a capital cost. It's also about two years off. So that has all got to be factored into the modelling.

SMR costs have also been factored to be slightly higher than the large-scale light-water reactor plants, though not as high as some reports have been suggesting, owing to, as Ken states, our belief that they need to be cost competitive with the large-scale plants to be successful in the market. These costs are all expressed in US dollar terms and what we have done for the CG modelling that has been done by others, we're separating out the local components of these costs and modelling those separately in order that the economic impacts of the developments can be modelled by the CGT.

To infrastructure requirements, every power plants needs support infrastructure, the scale of which can be highly site specific. Now, numerous submissions to the Royal Commission have suggested locations for a nuclear power plant in South Australia. Other submissions have dismissed or debunked those sites. Location obviously is a contentious issue. So what we have done is we've – for the purpose of this study we are not focusing on any particular site, any particular location. We're considering generic greenfield and brownfield sites. The descriptions have been supplied to us, agreed with the Royal Commission. For these locations we've identified appropriate high-level scopes of supply and, therefore, costs of infrastructure that can be used as building blocks with the power plant costs to estimate the total project costs.

Road and rail infrastructure is basically independent of power plant size. The greenfield concept assumes that the plant will be 50 kilometres from the nearest appropriate infrastructure. So we've estimated the cost of 50 kilometres of roads and rail links together with the works required to connect to and refurbish any existing infrastructure around the connection point. For the brownfield concept we've basically done the same thing but we've just estimated the cost of short spurs from the infrastructure into the power plant itself. In all cases we've assumed that the infrastructure will be built to the appropriate local and national standards.

Nuclear power plants, like all thermal power plants, use steam turbine generators to generate power. Steam turbines, whether in a nuclear or a conventional power plant, nearly always require significant quantities of water, primarily for cooling the steam exhaust in the steam turbine. If a plant is located close to open water, such as on a coast or a river, water is often pumped directly from the source, through the condenser and returned to the source, so-called once-through cooling, but this requires a significant volume of water to be used. Alternatively, if sufficient water is not available for once-through cooling a closed-loop system with cooling towers or cooling ponds might be used. Water that's lost by evaporation in the cooling towers or the ponds has to be made up by adding water to the cooling water circuit but the net consumption of water is much less than in a once-through system.

We've estimated the water quantities required in order to define the water supply systems necessary. Water consumption, therefore, on whatever scale is clearly a challenge. Pumping water over long distances can incur significant costs. The higher the volume, the higher the cost. We believe that the volumes required for large-scale plants would be impractical to supply over any distance and that once-through cooling from a nearby source would be required. Similarly, the volumes required for once-through cooling of SMRs would be impractical, but SMRs equipped with cooling towers would be more flexible. The cost of once-through cooling facilities has been accounted for within the capital cost estimates of the plants themselves. We've estimated separately the cost of raw water supply systems for SMR power plants using cooling towers for cooling.

On electricity transmission South Australia, ElectraNet, has a very mature transmission network. It's appropriately sized with the demands imposed on it and it has existing generation units connected which range in size up to the 260-megawatt units at Northern. Most generation is connected to the 275-kV network which interconnects with Victorian network down at Heywood near the Portland smelter. For the estimation of the cost of transmission infrastructure assets we've adopted a building block approach using cost estimates developed for the electricity transmission cost assumptions component of AEMO's 100 per cent renewable study in 2012. We've continued with generic greenfield and brownfield assumptions associated with the distance from the plant to the nearest infrastructure. The nearest shared infrastructure we've assumed for transmission purposes will be rated at 275 kV for the SMRs but 500 kV for large-scale plants.

Part of a requirement from the Royal Commission was to develop some additional electricity transmission building block costs. The brief from the Royal Commission provided descriptions and a selection of electricity transmission assets for consideration in parallel with the nuclear power plant assessment. These costs have not been included in the nuclear power plant modelling itself but can be used to estimate the effects of variations in the connection options. These asset descriptions cover the cost of constructing new 500-kV and 275-kV transmission lines and substations as well as the cost of HVDC interconnectors for a range of capacities.

So apart from capital costs we have operating costs. The operating costs of a nuclear power plant are largely fixed. Operating costs that are actually variable with output are very low and not material in relation to the whole. The US Nuclear Energy Institute routinely collects operating cost data on the US fleet of nuclear Power plants which allows us to be reasonably assured of the operating cost estimates we are making. Operating cost data is often, even routinely, published as dollars per megawatt hour or cents per kilowatt hour. This can give a false impression that the operating cost is variable, however costs are expressed in this way so that they can be compared more easily with benchmark retail costs, for example. Importantly, these costs are based on the premise that the plant operates on a base load.

Decommissioning costs are treated as an operating cost. A fixed annual cost is allocated to fund a reserve account that accumulates the amount estimated to be required for the 60 year care and maintenance, and the decommissioning period after operation ceases. The nuclear energy institute also maintains good reference data for nuclear power plant fuel costs. Again, fuel cost is usually expressed as a variable cost, however unlike conventional fuels, nuclear fuel and spent fuel costs are not truly variable. Nuclear fuel has a limited life and it is routinely moved around the reactor and replaced according to a regular schedule.

The rate at which fuel is used by the power plant is therefore time based, not output based, so the cost of fuel and the cost of dealing with the spent fuel are essentially fixed. Transmissions costs are expressed as a use of system charge and they're a culmination of fixed and variable components. These again are published by AMO and we've taken those numbers from the latest AMO reporting. For technical assumptions we've taken representative examples of each technology to model. For the live scale reactors, we've assumed single unit power plants. For the small modular reactors we've assumed a number of units that result in a power plant in about 300 megawatts.

One of the major assumptions deals with the capacity factor of the power plant. Capacity factor is a measure of how much energy a power plant actually produces over a period of time, in comparison with what it could produce if it were running 24/7 at (indistinct) capacity. It takes into account allowances for unplanned forced outages and planned outages such as those for core refuelling. It also takes account of those occasions when generation can accede a plant's nominal electrical output because the plant's normally rated on a thermal basis for the reactor output.

Capacity factors have consistently improved in recent years. Capacity factors of 96% excluding the refuelling outages are now being achieved. A long term average in the low 90s, including an allowance for refuelling is a realistic and prudent based case in new third generation plants. On the schedules, the fundamental assumption that we have is that the nuclear power plant will enter into operation around 2030. This will be preceded by pre-construction for site assessment, licensing, permitting et cetera and construction periods which are appropriate to the technologies. We've assumed that SMRs will be subjected largely to the same regulatory process as large scale plants.

It may be possible that the regulatory frameworks and assessment regimes might be relaxed somewhat, but this is far from certain. So we've taken the prudent view that similar requirements and therefore schedules will apply. We've assumed a 60 year operating life, which is the planned life for all modern designs, and we've assumed that there will be up to 60 years of care and maintenance of the inactive power plant, which is required to allow the installed components to cool down prior to them being safely dismantled, disposed of and the site remediated.

So what are we looking for from the modelling? The modelling outputs focus mainly on the net present value of lifetime costs, lifetime revenues and lifetime generation. Using those, we can develop the associated levelised cost and levelised prices of electricity. Based on the assumed weighted average cost and capital which is used as a discount rate in the calculation. We also break out constituent components of cost to identify those which have the greatest effect on the total, and therefore those on which to focus our sensitivity assessments.

Modelling outputs will also include aggregated costs over the life of nuclear power plants to be used as inputs to the CGE model. The detailed business case will then build on the modelling outputs to assess the nuclear power plants commercial viability, and to identify any funding gaps. It will consider the sensitivity of the modelling to variations in a range of factors and the impact that these might have on the facilities' commercial performance. The business case will also describe the developmental risks to a nuclear generation facility. It will describe what matters and central financing partners will consider it important to address, to facilitate their participation in the project.

That basically concludes our presentation. As we said at the beginning, please bear in mind that this is still an ongoing piece of work. We continue to review and refine our assumptions. We will continue to do so within the next few weeks before our final report is presented to the Royal Commission at the end of the month.

COMMISSIONER: Dave, can I just get an idea of the sensitive analysis that you are going to do around pre-construction and construction in terms of time frames.

MR DOWNING: Basically the time frames we're looking at, basically are plus or minus one year at the moment and the associated costs plus or minus, because the time frames would be slightly longer or shorter. There'll be slightly more or less cost associated with that.

COMMISSIONER: It seems not as conservative as I might have expected with the construction of the first one, so I wonder - - -

MR GREEN: I think one of the difficulties in this is that the - you know, the real cash flow starts when the order's placed and you can do a lot of preliminary work that may seem very expensive on the assumption that you might never have a power plant, but in comparison to the actual capital cost that you're going to invest once you have a contract, it's relatively small. So the real factor is going to be that once you reach that point where a contract is set, all the preliminaries have to be in place so that the project can go forward on a schedule.

MR DOWNING: I think what the - the premise we've come with is that the - this will not be the first of a kind of the technology. The technology will have standard design - - -

COMMISSIONER: I understand that.

MR DOWNING: - - - (indistinct) there will be some plants out there already in process.

COMMISSIONER: It will be the first of a kind, yes.

MR DOWNING: In Australia.

COMMISSIONER: In Australia. I think we'll come back and have a little discussion about that. I'm not convinced about the construction time frame of that and I'd like to set a broader sensitive analysis or in time, I think. But thank you both for a very clear presentation. We will now adjourn until 10.30 when we will have an examination of analysis for radioactive waste storage and disposal facilities.

ADJOURNED **[10.18 am]**

RESUMED **[10.29 am]**

COMMISSIONER: We reconvene at 10.30 and I welcome Dr Tim Johnson from Jacobs. Mr Jacobi.

MR JACOBI: Quantitative analyses and business case for radioactive waste storage and disposal facilities in South Australia. Quantitative analyses will be undertaken to determine engineering procurement, construction and life cycle, operating and maintenance costs associated with the possible development for hypothetical types of radioactive waste management facilities in South Australia. The scenarios to be considered are surface, near surface low-level waste management facility, a tunnel blow and intermediate level waste management facility, a centralised dry cask spent fuel storage facility and a deep geological disposal facility. To provide a presentation in relation to that matter is Mr Tim Johnson of the Jacobs Engineering Group.

COMMISSIONER: Dr Johnson please proceed.

MR JOHNSON: Okay. Thank you very much. Well, I am presenting on behalf of Jacobs and the actual presentation was put together with my colleague (indistinct) Cook and our subject matter experts, NCN and Geneva. The approach that we are taking in this analysis aligns with the request for proposal which we initially responded to and we are looking at four generalised types of waste storage and disposal facilities. As identified a moment ago, these are – this is terminology we have chosen in agreement with you because internationally there’s quite a lot of disagreement about the terminology in this area. Interim storage facility for high and intermediate level wastes. This will be a surface facility. A geological disposal facility (GDF) for high-level waste and this will be a deep underground facility. An intermediate depth underground repository which will probably be co-located with the GDF and I will come on to that a bit later. For intermediate level wastes and finally a low-level waste repository (LLWR) which is a near surface facility.

Our investigation will look at the business case to manage international waste which does not have a local solution, as well as potential Australian waste from a nuclear power programme. So what types of waste are we actually considering in this study? Well, we are going to be looking at the following, and again, it’s to simplify the following of three waste streams. The first waste stream we are calling high-level waste and mostly the high-level waste is spent nuclear fuel. Potentially with some stabilised waste in the reprocessing of spent fuel. This waste we assume will be delivered in casks