RESUMED **[10.02 AM]**

COMMISSIONER: Thank you very much for joining us this morning. We are looking today at low carbon energy generation and we are particularly looking at options that might provide that now and in to the future. I am particularly interested in the vision of small module reactors and your smart development. So I wonder if you wouldn't mind, just going through that vision statement and perhaps some of the principles of the smart technology.

DR ZEE: Okay. Firstly, I would like to thank you for this opportunity to introduce (indistinct) that we have been developing for the last 10 years. My name is, as introduced, Kyun Zee from (indistinct) I have my talk today under five subtitles.

MR JACOBI: Yes.

DR ZEE: Firstly, I would like to go through some of the SMR, small moduar reactor, some of those small and medium size we (indistinct) and is general (indistinct) The second title, I would like to introduce smart development history and what (indistinct) for the smart development and licensing activities.

MR JACOBI: Dr Zee - - -

DR ZEE: I would like to (indistinct) introduce our – as far as I understand, certain Australia has some sort of inland need for energy and water, or you know electricity. So we, in that case, the plant (indistinct) is very important, so I would like to introduce some of the dry cooling options that we think for the inland deployment of SMR. And my fourth talk is on recent information on collaboration of smart projects and smart commercialisation.

MR JACOBI: Dr Zee, if I could just interrupt there? Could I bring us to – I think we have a slide, slide number 5.

DR ZEE: Yes.

MR JACOBI: And I am just wondering about whether you could explain where you think the market for small modular reactors that you are considering development, where you think that market might be?

DR ZEE: Okay. My market estimation, as you know there are vast potential demand, that is most prominent international or the government agencies and international prominent institute estimated that by 2050 about 500 to 1,000 units will be needed. For the most recent US (indistinct) report, that was published in 2013, they conservatively estimated around 18 gigawatt (indistinct) in year 2013. In other words, if it is a 100 megawatt plus SMR like smart, that is around 180 units to cope with this demand. Or something, a smaller units it will be over 200 units. So in that case, if we assume that one unit cost about 1 billion dollars for the (indistinct) construction cost, then that will be over 300 billion US dollars by year 2035. And most recent estimation by (indistinct) as far as I understand it, they are assuming it is about 400 million dollars by year 2035. So it is not exactly to be (indistinct) proven market estimation but the amount of market size, I predict here is (indistinct) is about 200 units to 250 units multiplied by one million dollars, that will give you around 300 million US dollars.

MR JACOBI: Yes. Can I just – that is the total market. Where is it in the market that you think SMRs might have a market opportunity?

DR ZEE: The market opportunity we are looking for is a (indistinct) area, south-eastern Asia countries, also support of Australia probably, hopefully. The inland side, also UK is looking for SMRs too. US and Canada market, Canada is also – they have – they require large amount of energy for remote area, for the mining areas. So we think that there are plenty of sites, a sizeable, strong market and demand exists for SMRs.

MR JACOBI: Yes. Can I just take us from there to deal with what you see are some of the challenges in terms of deploying SMRs? We have got a slide for this; I think this is slide number 6.

DR ZEE: Yes.

MR JACOBI: Just wondering whether you might address the Commission on what you think some of the challenges in terms of deploying SMRs are going to be?

DR ZEE: We think – I listed here two different challenges and hurdles for – one is technical challenge, the other one is commercial challenge for deployment of SMRs in general. As you know, by nature nuclear requires every (indistinct) technology should be proven before it is implemented, actually implemented. So there are many fancy ideas of new concept for SMRs, especially SMRs these days. But those technologies, if it is really implemented to the plant, SMR plant, that should be in advance – should be proved and that is a little bit (indistinct) second regulatory licensing, unclear regulatory licensing hurdles. That is you have to – those meet licensing requirement which may not exist at this moment. So for the new design technology or new and best technology, they have to prepare licensing (indistinct) first. So there are large risk for those advanced technologies for licensing aspects. Another one is in general modular construction. I'm not talking about component level mobilisation but if it is a unit mobilisation that some of the (indistinct) companies are taking, that require – they have some contradict with the current licensing (indistinct) licensing requirement. So that there is existing – there exist those licensing issues for the modular concept.

Second part on the commercial (indistinct) as you know by the economy of scale, small modular reactors inherently disadvantage in plant economics when compared with the large scale nuclear power plant. At the same time, SMRs should compete with the other energy sources like gas-fired, coal-fired and those conventional thermal plants.

MR JACOBI: Yes. Could I just stop you - - -

DR ZEE: So they - - -

MR JACOBI: - - - there Dr Zee.

DR ZEE: (indistinct) very important.

MR JACOBI: Sorry. Could I just interrupt there and just ask you, you mentioned the disadvantage as compared with larger scale commercial plants and I am just interested to understand about whether you think that that particular disadvantage in terms of scale can be overcome?

DR ZEE: Yes. We think it can be overcome, or at least we can close to the large-scale nuclear power plants. That has been addressed in the IAEA documentation on SMR, economic aspects of SMR. By multiple mass production of components and learning (indistinct) and (indistinct) of design and engineering. Those also we can short term the construction period so that those interest, that is compiling, doing the longer construction period can be used. But still there is a – we have to overcome those economy of scale – those economy of scale can be compensated partly, I will say partly, by if you think about transmission costs by locating these small modular reactors near the consumer site. And if you think about the savings in transmission, savings in power loss and by applying that diversifying the application usage (indistinct) like producing (indistinct) desalination, fresh waters, those will be the beneficial (indistinct) will improve your plant economy and thermal efficiency of the plant, even though it is a small unit. But in general, that commercial (indistinct) are talking about here is in general. We have disadvantage in economy, the plant economics comparing it with large-scale nuclear plant.

MR JACOBI: You mentioned mass manufacturing as something that has been identified with SMRs and the advantages that they might offer, and I am just interested to understand the extent to which there would need to be – or what are the scale of the sorts of orders that might be needed to begin to see effects or benefits associated with standardised manufacturing of large volumes of items?

DR ZEE: Yes, that is the mass production I am talking about for example, if you are installing one gigawatt with an SMR, with 100 megawatts you have .1 gigawatt size, that will require 10 units of (indistinct) like 100 megawatt (indistinct) And each 10 units will require eight steam generators and four small size pump, reactor cooler pumps, so if you multiply by 10, that will amount to 80 steam - small steam generators, 40 reactor cooler pump with a single verification and design and engineering component. The design engineering you can produce 80 units, 40 units of (indistinct) so that will actually lower the plant cost (indistinct) implement those (indistinct) costs. That has been addressed by the – in Westinghouse during the IAEA (indistinct) corporation work on SMR economics. They said more than 20 per cent will be saved if there is a mass production of certain components.

MR JACOBI: Can I just take you to slide 8, and I am just interested in understanding the sorts of applications to which the particular reactor that you are developing can be put?

DR ZEE: (indistinct)

MR JACOBI: Sorry. Could I just take you to slide – I think slide number 8?

DR ZEE: Eight. Yes.

MR JACOBI: Just hoping you could explain the sorts of applications to which the smart reactor that you are designing can be put?

DR ZEE: The smart reactor can be utilised for the – just for the electricity generation or a combination of electricity generation as well as desalination. Or it can produce electricity and also the hot water, so the plant itself is a 100 megawatt electric plus the thermal energy output from reactor is 330 megawatts. But if it is converted to electricity, the efficiency will be a while (indistinct) one third, so that is 100 megawatt (indistinct) Now if it is combined with the desalination plant, we utilise around 10 per cent of the heat source which is (indistinct) the waste heat plus some of the high quality steam from after high pressure turbine. So if in that case we can produce 40,000 tonne per day of water as well as about 90 megawatts electric, or electricity. If it is utilised for the (indistinct) heating and also electricity supply then we can produce around 615 gigajoule per hour of 85 degrees Celsius hot water to the consumer and also electricity about 80 megawatt (indistinct) Those population are listed here, 100,000 to 500,000 population is majorly based on Korean, foreign Korean consumption with electricity per capita and water consumption per capita.

We utilise - we consume around 400 litre per capita these days, slightly over that. I know that Australia is 650 something, about 1.5 times more water is consumed per capita by Australian people. Also electricity, I think are very close to ours. We utilise around 10,000 kilowatt an hour per capita. Australia similar, a little bit more than that I know. So as far as electricity is concerned, pretty close. If it is water you consume more than in average than Korean people do. So if it is 100,000, a city of 100,000 population, we require around 100 megawatts electric as well as water of 40,000.

MR JACOBI: I was just wondering whether we might go to the development history and the time frames in which this particular reactor has been developed and I was just hoping you might take us through that.

DR ZEE: Okay. Our SMART development dates back to 1997 when we first started the conceptual design and basic design. Year 20 - only year 2000, year 2002, we started a one-fifth scale, what we call SMART pilot plant. Instead of going through 330 megawatts class or 100 megawatts electric class large size, actual size restructured with a one-fifth scale. Right. From that development we tested some of the components, you know, steam generators, we produced prototypical steam generators and also reactor coolant pump and other major (indistinct) with a small size boost. Okay.

After that SMART-P development period we started our actual size which means a SMART 330 megawatts thermal (indistinct) which is 100 megawatt electric, it's current design. So we did spend around two and a half years of pre-engineering period and then we go for the three years of tender design approval project. So during that period we produced all the, you know, licensing documents. We verified some of the important technology that should be validated by executing separate (indistinct) test (indistinct) test and, you know, component test, blah, blah, blah.

But the problem was when we were doing standard design approval, in the middle of the standard design approval , Fukushima accident occurred. So there, you know, just after one year after the Fukushima accident our regulatory requirements was asking us to take some more additional actions or design improvement for the cost of Fukushima action items. So after we get standard design approval in year 2012 we immediately started design improvement and the cost of Fukushima action item implementation projects, and that project will end next coming February, next year. So we have almost completed all the additional test experiments and, you know, design rectification.

COMMISSIONER: That might be a very good time for us to look in a little more detail of what you have done since Fukushima. Perhaps you might like to walk us through the activities that were taken following the accident in your design, and perhaps starting at slide 15.

DR ZEE: Okay. The recent development activities immediately after the SDA approval, I mean standard design approval, was the first implementation of post-Fukushima action plan. Our government required around 22, as far as my memory is correct, 22 - over 20 additional design changes or back fitting of the existing large scale operating   PWRs in Korea. But some of them are not quite relevant to this SMR, like SMART like SMR. But some of them, I'll say five, six items, we were asked to improve even after the standard design approval. That was the full passive safety system, if it is a new SMR, they want to have some initial provisions for the SMART to cope with the Fukushima-like accident. There was some additional provisions for our past existing passive systems. Right.

So what they did was we designed and test for three years full passive safety systems in addition to the existing passive safety systems with the SMART and licensed by standard design. We add some more passive safety systems and we add some more provisions, for example, adding of the water and fuel provisions for the ECT tank which is already existing. So we add some additional water resource to them like that.

COMMISSIONER: Can we go to the next slide?

DR ZEE: That is design and test of a full passive safety system is undergone with requirement by the existing, our integral testable specifically designed and constructed for the SMART.

MR JACOBI: Dr Zee, perhaps could we go to slide 16.

DR ZEE: Yes.

COMMISSIONER: Perhaps you would walk us through each one of those particular activities that have been designed back into the SMART reactor.

DR ZEE: Okay. There is the safety SMART plant is, for example, a passive residual heat removal system, it is a 1T called a long-term (indistinct) and for the, you know (indistinct) removal after reactor is shut down, even without any electric source because it is passive, it utilised the natural circulation to remove the k heat from the reactor core. The k heat is dissipated to the steam generator and then our passive residual heat removal system works on steam generator. So there are only two closed room operating in natural circulation, primary site is also natural circulated without any pump or force of the circulation.

Secondary site, the passive residual heat removal system is also operating with natural circulation. So our design requires two different natural circulation (indistinct) and we believe that by many simulation and also through our testable with the actual height, one to one height design, we verify and validated our (indistinct) the heat (indistinct) steam, pure (indistinct) under emergency (indistinct) And that is what (indistinct) effectively (indistinct) as our design. There will be no concern about under these (indistinct) SV or accident occurs. Also we utilise hydrogen (indistinct) system, is also passive, so there will be no concern about local hydrogen exposure, even under there is a (indistinct) hydro (indistinct) produced. The other one is this containment and steel lined concrete (indistinct) containment is the (indistinct) is very large we design. So that even though there is a (indistinct) explosion, it can accommodate whole expanded volume of the steam inside the containment. That is also, we satisfied the (indistinct) EUR requirement where aircraft crash by terror, whatever reason, the aircraft is impact on the containment building, that will withstand the area impact.

The minimise fuel failure means that we simulated every design basis accident, that during all those design basis accident, the fuel and the reactor core is submerging under the (indistinct) coolant water. So that that is because our volume of (indistinct) comparing with the power ratio is very large, so that there are plenty of waters in there. The other one we minimise the penetration piping size under two inches which is in the pipe way that is a (indistinct) accident of loss of coolant by pipe breaking, the water will – the metacore will not be (indistinct) uncovered.

COMMISSIONER: Okay.

DR ZEE: So that no fear of failure is expected. As far as the (indistinct) covers the metacore, the heat removal is consistent, so that there will be no concerns about (indistinct)

MR JACOBI: In terms of - - -

DR ZEE: The other (indistinct)

MR JACOBI: In terms of the - - -

DR ZEE: (indistinct)

COMMISSIONER: In terms of the passive residual heat removal system, the period of grace, I think you have got another slide which gives us an estimate of the period of grace under the smart reactor in comparison to Fukushima Perhaps you could walk us through that?

DR ZEE: Yes. Fukushima actually that the earthquake, after the earthquake (indistinct) earthquake (indistinct) successfully shut down. The problem was – their problem was there was a transmission line coming from the outside of the plant, Fukushima plant, that transmission power was toppled down and there what happened, the off site power loss. So that emergency diesel generator started but because of the tsunami the emergency diesel generator was flooded and it died, it shut down. So the battery (indistinct) battery operated for – it lasted more than eight hours when eventually they lost every single bit of electricity to (indistinct) to remove the casings. So that the reactor was overheated and they released some out the over pressure protection system, like a valve is opened and they release the steam, high pressure hot steam to the confinement building which is not containment building. This is just a panel of steel panels and there was a hydrogen explosion. On the other hand, smart even though the scenario (indistinct) is lost, blackout, our (indistinct) our system, automatic cooling starts because it’s a fail system. So the (indistinct) in (indistinct) case closed position and if electricity is out, it will open the circuit and our (indistinct) system as you know is a passive, natural – by natural circulation. It removes the (indistinct) from the reactor core to (indistinct) generator, steam generator to (indistinct)

So our core cooling ability is maintained for three weeks. If (indistinct) is properly filled with water, or even the water is dry out, we think about the air-cooling of the ECT, heat exchange, so that we can maintain the core status as required. The – normally – the every requirement on the passive system is you have to (indistinct) time (indistinct) grace time means that the time that required without any operator action. They require (indistinct) about 72 hours but the smart, if it is more than three weeks, I think it is – we can (indistinct) because we have separate provisions to supply water to the ECT (indistinct) of the (indistinct) RS system. And there will be plenty of time to cope with the – any accident, even severe accident event.

COMMISSIONER: Thank you.

DR ZEE: (indistinct)

MR JACOBI: Can I take us back – I am interested in understanding the extent to which prototypes or the particular technologies being integrated to be tested? That is, I am interested in understanding how far the particular technology has been demonstrated or tested and I think perhaps that might bring us back to slide 10.

DR ZEE: From (indistinct) yes. Okay, technology validation. If you – please refer to page 12 - - -

MR JACOBI: Sorry.

DR ZEE: Okay. In parallel with the standard design activities on the right hand side, (indistinct) design and engineering activities, they produce design better. And then that should be verified and validated. Also those design tools should be verified and validated. So what we did was we (indistinct) what they call (indistinct) which is most important for the verification and validation for safety system validation. That is the normal way. We brang the sequence of accident or operational procedures, so that by that we can table – we selected the most major test activity for experiments that we have to validate and verify. The verification of two is also done during that SDA period, so these codes, computer code system, utilised for the design and analysis activities all should be verified and validated with the safety test and separate prep test.

So a safety test is majorly required for the safe system, right, and the performance test is required to verify the performance based design. So there are two different tests and experiments at the same time we have to show it to our regulatory body that our design actually is correct and accurate so that it can be utilised for the standard design. Also, our system design tool should be verified by separate different tests and all those either for (indistinct) test.

So safety tests are listed. Major safety tests we've done are listed here. On the right-hand side, those performance tests are listed there. But as you know, the response reactor has been - the history of development is 1997 we started. So there are many different tests and experiments. If we add all these, they will amount to 15. So instead of these 22 that was performed during the safety of our standard design (indistinct)

MR JACOBI: I'm interested within Korea have you developed a demonstration plant or how much of the particular technology has been demonstrated?

DR ZEE: Normally reference plant or the first ever kind plant should be - you know, that is a normal - until now, when the US Westinghouse built their first AP1000 unit in China, right, my personal opinion is that because smart - even though we adopted some of the innovative concepts and systems, it is basically based on the already proven pressurised water reactive technology. So cool vapour is where the technology base is based on current operating (indistinct) technology. So what we did was we did some - if it is innovative or an innovative concept like a steam generator that has not been utilised in a commercial basis. We test in Montreal. Through Montreal we tested the performance of the helical coil steam generators. We tested those in services (indistinct) tools that will be utilised during the reactor operation for the helical coil steam generator tubes.

So those things were done by separate different tests and component tests, right. All of the hydraulic safety system tests was done with the scale bar of 1.8 with the ATR. That is over $US 20 million we invested to build that testing and as a reference I think the first ever kind SMART unit 1 and 2 will be built and operated in Saudi Arabia first. So I think combining all these separate impact tests, component tests and performance tests and infrastructure tests plus actual plant, that will verify and confirm the associated technology we implemented into the SMART plant.

MR JACOBI: Can I come now to the design approval and I'm just interested in that I understand that the SMART has received design approval in Korea.

DR ZEE: Yes.

MR JACOBI: The Commission has heard about the effects of design approvals outside jurisdictions and I'm just interested to understand the extent to which the design approval for this plant in Korea might assist its licensing in other jurisdictions.

DR ZEE: That is a difficult - I think Australia, if you are going for nuclear power you will definitely have a regulator because you have already the research reactors in operation.

MR JACOBI: Sorry, can I interrupt.

DR ZEE: Sure.

MR JACOBI: I'm not so much interested in Australia. I'm interested to understand the effect of if one obtains a design approval in Korea, does that mean that that would assist the licensing in the United Stated or in Europe?

DR ZEE: We believe that the Korean regulatory (indistinct) reactor requirements are equivalent to the USNRC's, the US requirement, because our regulatory system is majorly based on the US regulatory system and all the technical requirements can be one-to-one match to the NRC's, you know, Red Guide or the regulation of - what was it - standard. So that is we think we are very much compatible with our regulatory system - compatibility of our regulatory system. But as for your question do you accept it or not, I cannot say to you immediately but for our PPE agreement with the Kingdom of Saudi Arabia we agreed to follow Korean regulatory requirements.

MR JACOBI: Can I come now to deal with that arrangement. I'm just interested, first of all, in dealing with the project time frame and I think that slide 19 - - -

DR ZEE: Yes, the project time line. I listed in here until we achieve the construction permit, assuming that we have a two-step licensing - the first step for a construction permit and the second step for the operation licence - until the CP, construction permit, we think it will be around four years. That will include the site arrangements and the documentation for CP application and also licensing review of two years. That is normal. We, in Korea, a licensing review period is about two years for the preliminary safety analysis report for the construction permit. After the CP is issued, we think four years. If it was a new plant, it will take around four years of actual erection, system implementation and construction of the buildings and the last one year is on the initiating tests, start-up tests. So that will give you five years plus three years plus one year of site arrangements, that will give you a total of nine years, conservatively I think.

DR KIM: And it is very conservative.

DR ZEE: It is very conservative. What we say the final goal once it leaves the - after three, four units of construction, we expect that from the first concrete of main building to the COD, which is the completion date - commercial operation date - we think it will be three to four years.

MR JACOBI: Do you have a view as to the sorts of time frames that you expect on nth of the kind build overall?

DR ZEE: Yes, by - - -

MR JACOBI: How much - by what sort of period of time do you think that the nine years might be reduced?

DR ZEE: So once you have a site we think that the environmental report (indistinct) that, you have to collect, if the site is available, potential site is there and we have to collect all those geological data and, you know, meteorological data, you require around two years. But what I am saying here, 12 months, a one-year period is, assuming that you have a potential site, candidate site, and assuming that those datas are available, and what I'm saying here is we have to prepare - if it is a - I don't know, if it is a seashore site much easier. I mean, you have a very accessible (indistinct) is there, but if it is an inland site with transportation of heavy equipment you need to figure it out. You have the ground, you have to dig. That will give you approximately one - I think a 12-month period for the site arrangements. So normally in Korea we do it at the same time.

So until the CP, it takes about two to three years in Korea because already they are managing the site area and they, you know, collect all those potential sites, meteorological data and geological data and everything. What we did with Kingdom of Saudi Arabia is we utilised first abounding site values, assuming what we call generic site values, right. Then we will correct or optimise later on, once the site is completely fixed then we will back feed the site data and check whether our engineering data is within that boundary, that site (indistinct) in our. By doing that we can, you know, sometimes take some of the disadvantage in economy side, it will increase because the plant is not only optomised for the site. But still we have reduced the construction period by doing that. That's my general concept of the site preparation.

MR JACOBI: Can I come now to deal with the arrangement that KAERI has entered into with the Kingdom of Saudi Arabia, and I think perhaps if we can pick up from about slide 27. I understand that an agreement has been entered into because - sorry, slide 29, that an agreement has been entered into between KAERI and Saudi Arabia with respect to planning construction. I am just wondering whether you could explain that.

DR ZEE: Okay. The pre-project engineering agreement is the first implementation - first stage implementation of our government to government MOU or SMART partnership. It is during that PPE agreement we will do first of a kind engineering specifically designed into the Saudi environment. Okay. Because there the plant cooling options should be the dry cooling options, if it is the inland site near the consumer site we need to prepare a water resource even though it is not a huge resource but we need to have some additional water resources so that it can - we need to optimise the balance of plant site because the ambient temperature and plant cooling is different from the current standard design ,and also we need to - even though the test of our full passive safety system is there, we have to add onto the standard design approval, design features, plus those additional post-Fukushima actions items.

So those are the important areas for the SMART units 1 and 2. During that period they wanted to participate in the SMART nuclear steam system design, right, which normally KARI is performing. So by CRT, OJT and OJP for two and a half years we will repost more than 30 Saudi engineers to KARI site design centres and we will, you know, give them training, starting from the general training to the specialist job Korean team training and we will have them participate in selected parts of the design activities together with the KARI engineers and scientists and whilst that - we will prepare the supply proportion for the SMART units 1 and 2.

That was the first part in the PPE agreement as well as the government to government MOU. So all these activities will be done within a three-year period together with the government, the KA CARE which is a Saudi government agency.

MR JACOBI: Do you have a view as to the time frame, assuming there was a decision to proceed, the sort of time frames that will be involved in potential construction before any potential operation of those plants?

DR ZEE: So the previous slide, starting from 1 December this year, our PPE will last three years and then at the end of November in year 2018, then we think that about six months to a year for the construction, preparation of construction in Saudi Arabia and, as I indicated, about five years will last for the actual construction and operation for first one and two units in Saudi. So that's the current agreed time schedule with the Saudi side.

MR JACOBI: You referred to some modifications to the cooling system for a potential inland site.

DR ZEE: Yes.

MR JACOBI: I am just interested, you might be explain the implications or first the technical nature of dry cooling and then the potential implications of that for the operation of the plant. I think slide 25 might be helpful.

DR ZEE: Yes. We studied some of the - whether we can deploy SMART's reactor and SMART's plant in inland sites. Inland, I mean if you have plenty of water source plant cooling is no problem, like if you have a large, you know, river or lake, then you can utilise those secondary water for measured cooling. But if you don't have, we searched many different cases of thermal plant which is operating in (indistinct) area and some Utah and New Mexico in the US where the water resource is sparse. We are utilising some of the dry cooling, bad cooling, sort of.

But what we did here is we searched how large or how we can design the back pressure of the condenser because normally when there is a back pressure is very important for your secondary site efficiency, plant efficiency. So by properly adjusting those design requirement as for the condenser site and these dry (indistinct) units, we think that we can have a proper plant cooling. Our conclusion was that indirect dry cooling which is not direct cool be – the turbine condensers but we will have – because it is a – in case there is a (indistinct) holes or any (indistinct) or failure in the condenser site, we do not want to pass over any small amount of radioactive material through condenser to the atmosphere. So we selected – even though we sacrifice some of the fuel of the thermal efficiency, I think indirect cycle will be proper. So that is the improved indirect dry cooling. Depending upon your site conditions, if the ambient temperature is very high, you may require some of these (indistinct) temporary (indistinct) to the fan cooling to maintain the condenser temperature evaporation.

MR JACOBI: The slide refers to there being power loss, or in effect – and I think you have referred to there being thermal efficiency loss. What is the extent of the thermal efficiency loss estimated to be for dry cooling?

DR ZEE: Dry power loss, we estimated that would be around seven megawatts (indistinct) to cool down the (indistinct) plant and also the in-house – other in-house load will be around five megawatts, so total of 12 megawatts will be gone – will be lost if you apply these dry cooling units. And then we think that (indistinct) megawatts electric is normally it will be 103 megawatts electric but it will be changed depending upon the plant design for the actual site. Could be 95 to 100 that is my estimation of what will be the actual electricity to the grid. So if you search for the reference, there is around 12 per cent downgrade of your electricity to grid. Nominal value. That is because your in-house load is increased due to (indistinct) and secondly, your back pressure is a little bit higher than the sea water cooling, so that your thermal efficiency is degraded, so that your electricity to the grid, actual grid, you will lose around 10 to 15 per cent and that is what the normal (indistinct) are estimated. But in this case, we’ll lose about 12 per cent.

MR JACOBI: And I think perhaps one last question, with respect to that, to what extent is that particular dry cooling technique, or plant, been tested with your smart system?

DR ZEE: To me, I think there are many thermal plants. We already utilise this in direct – direct dry cooling for the thermal power plant. So that condenser site (indistinct) is totally different from the primary site, nuclear (indistinct) Secondary cooling, secondary site cooling and it doesn't matter whether (indistinct) say thermal plant or it's a nuclear plant. There exists already technology and already thermal plant up to even 500 megawatt electric plus. Thermal plant is equipped with these dry cooling, fan cooling units. Of course, 100 megawatt, 400 megawatt (indistinct) in China, in (indistinct) in the US they utilise some of the dry cooling units for the plant condenser (indistinct) So I think there will be no technique (indistinct) for these dry cooling units. Why then they did not utilise this dry cooling for the nuclear plant because nuclear plant if there is a 1,000 megawatt electric class, the water resources (indistinct) is enormous so we cannot utilise this dry cooling. But I think for the smart – for SMRs we can (indistinct) this dry cooling units if it is in that site.

COMMISSIONER: Do you have a view about the increase in costs with the dry cool?

DR ZEE: Yes, I think it will be increased, I mean (indistinct) cost – construction cost will increase (indistinct) is dry cooling units because you need initial unit for the – you may require some of the certain cooling towers, the chimneys to increase the air cooling capacity and also – but still there is a advantage and disadvantage. Even though it is a (indistinct) plant in the huge pump house for the secondary cooling, you need protection walls that goes to the (indistinct) 100 millimetres large structure, waves protection structure. So – but still we estimate about 15 to 20 per cent increase (indistinct) inland site because you need to pay additional transportation of everything and additional (indistinct) for this dry cooling units and so on. So we estimate about 20 per cent of (indistinct)

MR JACOBI: Just one last matter, I'm just interested in the extent to which it's possible to ramp this particular plant, or the extent to which this plant might be able to follow load demand?

DR ZEE: I'm sorry, the connection is (indistinct) we lost (indistinct)

MR JACOBI: I'll try again.

DR ZEE: Okay. What was your last question?

MR JACOBI: I'm just interested to understand the extent to which this plant can be ramped or it's capable of following load?

DR ZEE: You mean the (indistinct)

MR JACOBI: No, sorry. I will take a step back. The Commission has heard that some plants have the capability of following load, that is peaking style plant such as combined cycle gas turbines and I am just interested in understanding the extent to which this particular nuclear plant can follow the load, or follow demand from the grid.

DR ZEE: You mean the grid?

MR JACOBI: Yes.

DR ZEE: You mean load following capability?

MR JACOBI: Yes.

DR ZEE: Okay. Well, load following capability, I think we can cope with conventional load following and even if it is a – be normally - - -

MR JACOBI: Connection has failed.

DR ZEE: We've done several different scenarios of load following. We haven't done frankly speaking, the frequency control of load following but we think that these smart reactor can cope with a daily load following that conventional reactors. We have a very wide operation range because this reactor the – was designed to - with a wide operation base as a ORSD, we have a (indistinct) margins. The solo margin is rather large. Larger than the (indistinct) so that, you know, range of (indistinct) is wider, okay? So we can move around. Even though it is not good for the reactor, for the nuclear plant, I think we have more flexibility than the larger, to be honest. In fact the height - the core effective height is about two metres, so the actual (indistinct) oscillation is not - naturally there is no actual (indistinct) all right?

All that stuff, I mean, all the margins, the wide operation range, it will cope with both followings much easier than the conventional (indistinct) we get done in our 12, 6, 12 (indistinct) 242 (indistinct) so they are - I think technically it is very compatible with - to deal with. Those are very small problems.

COMMISSIONER: Gentlemen, thank you very much for joining us this morning. we very much appreciate your time and your evidence. We'll now convene again at 12.00. Thank you.

ADJOURNED **[11.12 am]**