COMMISSIONER: Good morning. Welcome to session four. This week the topic is low carbon energy generations and I welcome Donald Hoffman from the US. Thank you for joining us this morning Donald.

MR HOFFMAN: My pleasure, sir. Thank you.

COMMISSIONER: Let’s move straight in to this Mr Jacobi.

MR JACOBI: Against the backdrop of the evidence emerging from the Commission’s initial public sessions it is clear that Australian electricity generation and distribution systems are undergoing, and will continue to undergo a considerable change as they adapt to a need to meet emissions targets and sustain livelihoods and prosperity. On some of the evidence that change will need to occur much faster than it is at present. That background calls for careful consideration of a range of low carbon energy generation options available to meet those challenges, including nuclear renewables and energy storage. A critical part of that discussion requires consideration of their state of development and readiness to meet the challenges faced by Australia and the rest of the world in curbing emissions. The Commission has already so far, in its public sessions, received evidence about the now mature technologies of solar PV both on rooftops and on the commercial scale and wind and the contribution they are already making and which they might continue to be expected to make. It has also heard about hybrid systems and the potential to integrate combustion and other forms of generation. That discussion will continue in these public sessions; however the focus is to shift to a range of other options.

Under the heading of low carbon energy generation options, the Commission will receive evidence concerning nuclear power plants, currently in operation or under construction, the advantages of disadvantages of relevant designs and the likely timeframes for the future development of a range of new technologies said to have advantages over existing designs. As part of these sessions the Commission will discuss the state of development of so-called SMR reactors with nuclear engineers working as part of committal operations in the United States and Korea. The Commission will, as part of these sessions, extend this discussion concerning geothermal energy that it commenced with Professor Heinson, given the prominence of that technology and the promise it represented over the last decade in South Australia. It will also deepen its understanding concerning the prospects for the deployment of storage technologies both on grid and at the premises of end consumers. It will do those with those intimately involved in the commercial development of on grid thermal storage and both generation connected and consumer level battery technology.

It must consider the potential for carbon capture and storage including its state of development and its ability to be integrated in to existing plants fuelled by coal and gas and that technology has been said to offer promise, particularly as a transition technology to further commissions in an efficient combined cycle gas generation.  In these sessions the Commission is conscious that it is speaking to vendors of technologies with commercial interests.  Determinations as to the appropriate weight to be attributed to evidence from any witness will of course fall to be determined, taking in to account the witness's expertise, affiliations and interests.  However the Commission must understand and would ignore at its peril, the valuable source of information able to be provided by the developers of and investors in relevant prospective technologies and therefore has appropriate sought that information as part of the public sessions on this topic.

The Commission calls as its first witness Mr Donald Hoffman. Mr Hoffman is the President and CEO of EXCEL Services Corporation which he founded in 1985.  EXCEL Services Corporation provides specialist advice and support services to nuclear facilities in the United States and internationally with respect to operations, engineering, safety, licensing and regulatory issues. Prior to this Mr Hoffman was a branch chief and lead reviewer at the US Nuclear Regulatory Commission, the NRC, and an engineering officer on a US Navy nuclear submarine.  Mr Hoffman has served as a president of the American Nuclear Society from 2013 to 2014 and he currently provides presentations on the benefits of nuclear science and technology to the United States Congress.  The Commission calls Mr Donald Hoffman.

COMMISSIONER:  Mr Hoffman, thank you very much for joining us this morning.  Can we briefly skip through the evolution of nuclear power plants and then move on to the characteristics of Gen III and III+ designs?

MR HOFFMAN:  Certainly sir.  While there is a long and storied history related to how these evolutions have all evolved and where they have come to today, there are a number of common characteristics that exist in Generation III and III+  designs.  And those are sir, improved safety, where we actually have more safety trains in the vast majority of the design activities.  We also have aircraft crash protection, where we have either double containment or other mechanisms to ensure that we are capable of withstanding the impacts of an airplane crash.  We have severe accident mitigation which may also include in many designs, a core capture related to ensuring that we have mechanisms to address the most severe of accidents.  We have digital instrumentation and control systems and other enhancements and improvements in the actual control and instrumentation, and for that matter, the actual monitoring of all of the parameters related to the safety of the operation of the nuclear facility.  We have significantly lower, what we call, core damage frequency in large early release facilities and we have passive design safety features.

MR JACOBI: Perhaps if I can just come back to a number of the aspects that you have just identified? Perhaps if you could explain the distinction between what I understand are active design features and passive design features?

MR HOFFMAN: Active design features are those which require an actual action. Whether there is an energy source, whether it's alternating current or direct current AC or DC power and/or a pump starting to actually cause flow to occur, valves opening to facilitate that flow to go in to the containment, or through containment spread or in to the reactor vessel itself to provide a flooding mechanism or a recovery of water to keep the core cool. That is what is called an active feature. A passive feature is where there is no requirement whatsoever related to any valve movements, any operator action or any electrical power supply. These are the kind of things that rely on solely those laws of nature such as natural circulation and other gravity flows that will occur to ensure there was continuous flooding and/or flow to maintain the fuel cool and to preclude melt.

MR JACOBI: Now you referred to other – I think, in your list, to other improved safety features. I was just hoping you might be able to outline those just in broad before we come to address the characteristics of some specific designs?

MR HOFFMAN: Well, each of the designs vary somewhat. None of the designs are exactly all created the same. They have variances, pros and cons that have varying impacts on them, depending upon how you look at the design and its application. But indeed, these are common characteristics on all the Gen III and Gen III+ designs. Does that answer your question sir?

MR JACOBI: Yes. It does. What I think we might do is I think on that basis we might pick up and work our way through and perhaps if we can pick up with you an explanation of some of the concepts as we go. Perhaps if we can move first to the advance boiling water reactor type and I think we have got a slide for this, which I think is slide number 6. Do you have that in front of you?

MR HOFFMAN: Yes, I do. But I'd like to, if I could, there are certain other characteristics that I only talked about the improved safety. There is also improved licensing if I may.

COMMISSIONER:

MR JACOBI: Yes.

MR HOFFMAN: That is, we have design certifications and also combined operating licences and the actual design approval process in the UK and other mechanisms where we actually found ways to enhance and improve the licence - ability of these particular designs through generic reviews by multiple regulatory authorities around the globe to facilitate a common understanding of how they work.  We have also streamlined the licensing process to find mechanisms to actually get to where we need to go to facilitate an actual construction, whether it's a construction licence, an operating licence or just a site licence to facilitate further investigation.  In addition to those two that were previously mentioned, improved safety and improved licensing, we also have what we call improved economics.  We have made the design more standardised, more simplified and we have made it more robust.  By doing so, we found ways to enhance and improve and leverage our current knowledge and history related to those kinds of things that were experienced on previous designs, to enhance and improve and build on those.

This actually facilitates an acknowledgment and recognition that there is much to be learned.  So we have improved the materials, we have improved performance, we have improved mechanisms, we have improved the size, the applicability, so many things have gone in to that activity.  We have also found a way to make a higher plant efficiency.  The vast majority of these nuclear plants are actually able to operate at efficiency levels greater than 92 to 95 per cent.  That means they can operate at 92 to 95 per cent plus of the year, 7/24 and a 100 per cent of rated thermal power, thereby providing a full load of electric power on to the grid.  We also have 60-year plant life.  We have gone through this where we've already approved each of these facilities for 60-year life instead of the 40-year life so many previous plants were agreed to and then extended 20 to 60.  We are also currently working on all these plants that have the 60-year life to extend them to 80 years and beyond.  The improved construction is another – fourth aspect.  And that is that we can do modular designing construction and in much more efficient and effective and cost beneficial way that actually enhances and improves the schedule, enhances and improves the cost and obviously enhances and improves the predictability and stability of a mechanism to facilitate both the confidence of the stakeholders, those that would otherwise get the electricity from this facility and also the investors that otherwise would invest in to it.

We are doing prefab of a number of systems off site.  We are also doing open top construction.  In addition to that, we have improved operations which enables us to have less operational radioactive waste.  We have been able to reduce significantly the low and the medium level radioactive waste from a facility such as this.  This has also improved the doses to the plant staff, to recognise and minimise the kinds of doses that you might see.  They were already significantly low.  We have actually been able to lower them even more.  And we have been able to do less maintenance by having more enhanced and improved designs, materials and mechanisms, we don't have to take the systems down as often to do maintenance, corrective or preventative maintenance on them.

MR JACOBI: Okay. Well, can - - -

MR HOFFMAN: And we have been able to significantly reduce the outages down to 15 days. As far as the - - -

MR JACOBI: Can I just - - -

MR HOFFMAN: - - - international - you asked something.

MR JACOBI: Yes. Can I take you back and we'll just pick up on some concepts that we have just addressed and perhaps we can come back to the idea of a generic design review. I am just interested to understand the extent to which there is now a common platform agreed between safety regulators, that is, perhaps between the United States and France and the United Kingdom with respect to the approval of particular designs and a common approach to the overall designs.

MR HOFFMAN: The mechanisms we have employed, sir, is a recognition that if we have a design certification or a licence in the country of origin, that that can be the basis for going forward with any regulatory review by any international or global regulatory authority. I have personally worked with this with the World Nuclear Association and the International Atomic Energy Agency to establish mechanisms to acknowledge and recognise those levels of reviews already conducted by the regulatory authority in the country of origin of the design to facilitate a detailed review sufficient to ensure all the safety aspects are addressed but not to repeat all of the in-depth detail review to the same extent that was done in the initial design certification or licensing.

MR JACOBI: Which countries have agreed to such a program - perhaps if I can call it mutual recognition where they recognise other countries' regulatory bodies reviews. How far has that process reached?

MR HOFFMAN: That process has been reached through several mechanisms, but let me first tell you the ones that acknowledge it. The acknowledgment that has been provided where a recognition that they could utilise the licensing or design certification in the country of origin is the United States, the UK, Korea, United Arab Emirates, France, Germany, and if I can go on, you perhaps tell me, South Africa, India, China and Russia. Those main countries have all acknowledged that there are aspects of this activity that can be utilised in a process going forward.

The manner in which this was conducted and discussed - I'm sorry, I left out Finland too - was a discussion and dialogue with what we call the MDEP, the multi-design evaluation process through the collaboration of seven different countries' regulatory authorities to evaluate certain generic aspects of design for nuclear facilities to figure out matters on which they could approach it generically and have one common recognition or one common regulatory approach instead of having various ones between the countries, and we spoke to them about the benefits of this and the robustness of this process and we're currently continuing the dialogue.

So to give you an example, in the United Arab Emirates, when FANR, the Federal Authority for Nuclear Regulation, did the review of the APR 1400, the Korean type design that is currently licensed for construction and soon to be in operation in the United Arab Emirates, it was utilising this process of a recognition of licensing in Korea.

MR JACOBI: To come to one of the other topics that you mentioned, you referred to improvements in plant capacity factors and you mentioned figures that were above 90 per cent, and I am just interested the extent to which those sort of capacity factors have been demonstrated in operating plants in either the United States or elsewhere.

MR HOFFMAN: They have been demonstrated already in some of the current designs that are Generation II plus and III and what we have done is we've enhanced and improved that capability, and where that's also done is in the areas I talked about, by improved maintenance and shorter outages to facilitate a continuous operation to give as much of the year as possible to the operation of the nuclear facility.

MR JACOBI: I've seen statistics that suggest that and the US fleet has been brought to capacity factors in the high 80s and I am just interested to understand the extent to which it's thought that that figure might be able to be further increased, or whether or not that's a realistic prospect in view of the age of some of the existing plants in the United States.

MR HOFFMAN: The United States fleet has expanded from 55 to 60 per cent in the mid 1970s to as much as the low 80 per cents in the early 1990s. In the 2000s and beyond, with all of these activities that are ongoing that can be applied to any technology design, they have enhanced and improved to the high 80 per cents and overall we're actually a little over 91, and if you don't count the fact that we had a number of plants shut down for reasons such as San Onofre and Crystal River 3 that were contributing to the overall activity, the actual operating fleet had a 93.6 per cent capacity factor in 2014.

MR JACOBI: We'll come back to a number of the other issues you raised including the prefabrication issue in a moment, but I think perhaps if we could move on into our discussion, we want to pick up a discussion of a number of designs and I wonder whether we might commence with a discussion of the advanced boiling water reactor.

MR HOFFMAN: There are a number of designs that are offered now and I would like to at least go through some of them and you will find that kind of information on the slide presentation that I gave you and actually you will see that there are a number of boiling water reactor and pressurised water reactor which are light water reactor designs and for that matter some heavy water reactor designs that are currently available to the world today, and I think I would start with the advanced boiling water reactor which is a General Electric design which has three, and in many cases four-train safety systems, as you can see by the slide, the internal plant to eliminate external loops - - -

MR JACOBI: Can I just stop you there. Would you explain what a three or four-train safety system is.

MR HOFFMAN: A four-train safety system?

MR JACOBI: Yes. Would you explain what a four-train safety system is.

MR HOFFMAN: I certainly can. A four-train safety system means we have both redundancy and diversity. Redundancy is where you have multiple capabilities of the same thing, whether it's high pressure core cooling, high pressure coolant injection, low pressure coolant injection or actual containment spray, or for that matter what we call cavity flooding. So if we have redundancy, that means we have two or three or four 100 per cent capacities to provide the exact same function or safety function to the core.

The other ways we do it is in diversity. Diversity is an example of what I just mentioned and the five different ways in which you can accomplish the same thing which is to get the core cooled and filled with water to ensure that the fuel is actually cooled, and the way we do this when we say three or four trains, we mean these are three or four 100 per cent trains powered off their own emergency AC DC generators with their own DC backup systems to ensure a complete separate application.

MR JACOBI: Right. So these are all active systems.

MR HOFFMAN: Yes, sir. These are all active when I'm talking about these safety trains. Passive trains rarely - they don't have diversity, they don't have redundancy, they're typically just one mechanism through either natural circulation or gravity cooling.

MR JACOBI: I think we then picked up the fact that external loops had been eliminated in the reactor. What's the significance of that?

MR HOFFMAN: The benefits was you didn't want to have anything external that could obviously result in what we call a large or a small break LOCA which would cause a loss of cooling to the facility. So we've tried to internalise everything to put all of the active piping, all the active cooling mechanisms, all of those things which are exposed to the reactor fuel itself into the higher pressures and higher temperatures all contained within one vessel.

MR JACOBI: Perhaps if we can continue on with some of the features of the ABWR.

MR HOFFMAN: Certainly, sir. It's an integrated containment of reactor building, and what that means is that they have actually integrated the containment and reactor building together in aspects to facilitate a smaller footprint and an integrated mechanism for both maintenance and activities related to fuel transfer and fuel movement. What this basically does is allows the ABWR to be much more efficient and effective and to significantly reduce any kind of dose or have any external activity related to any of the refuelling. They also have a proven capital and all in cost structure which obviously is operation and maintenance.

ABWRs are actually in operation in Japan where there are four, and so these are designs which actually have a physical application that's ongoing where you can see the physical capability of the design, your performance on intended function. Now, there are no steam generators which obviously reduce the lifetime cost, and there's no external loops and no core uncovering activity.

If you turn to the next slide, you will see that there's a list of what I'll call pros and cons related to the advanced boiling water reactor, and this is really a pros and cons as compared to the most robust, most sophisticated highest level of capability that exists in any design throughout the globe, and it doesn't mean that it's not robust and not sufficient to provide the intended safety function, it just means that if you look at it in the context of all the capabilities that you could install into this facility, it may or may not have all of them.

It would almost be like you buying a car that had all of the options on it, and a car that had most of them, which still had a steering wheel and wheels, and it was safe - it had airbags but it may not necessarily have every single option that you can otherwise purchase.

MR JACOBI: Yes. Now, in terms of - could you identify what you considered to be the main advantages of this particular design?

MR HOFFMAN: The advantages of the ABWR?

MR JACOBI: Yes.

MR HOFFMAN: Well, the advantages that come to mind immediately is that there are several in operation and several under construction, so there's a predictability in the stability of actual what you're going to see. This isn't a design that's never been constructed or operated anywhere. Some of the designs we'll be talking about this morning are excellent designs, but currently they're design only. They have not yet been finalised in their construction, and so there are a number of things that, while proven through analysis and study, not necessarily proven through actual activities. If you see the pros and you like at the kind of benefits of an advanced boiling water reactor, there's a number of activities that have already taken place.

There are a number of them originally in operation in Sweden and Finland, there's four of them in operation in Japan currently, there's four under construction in Asia, there's a number of EPC contracts and activities going on. So there are proven costs, proven schedules, good overall economics and activities that really show that this design would be a good one to consider.

MR JACOBI: I think that's probably an appropriate point to pick up; you mentioned in your general list earlier the ability to engage in some pre-fabrication. I know from your list here one of the identified advantages is some pre-fabricated models and I just wondered whether you might expand on that and the extent to which there is already pre-fabrication in these large generation 3 designs?

MR HOFFMAN: The advanced boiling water reactor has the capability to do modular construction and pre-fabrication. It is not as far along in that particular aspect of, let's say, the Westinghouse AP1000 because the current APWRs that are in operation were not pre-fabricated, they were stick built, if you will - if you understand what that means, they were built right at the sight - and the ones currently under construction have a level of modular and pre-fabrication, but not the extent of which you would see if you were to buy one today.

MR JACOBI: Now, in terms of what you might identify as the key disadvantages of this particular design? Or, that is disadvantages as against the range of what might be possible?

MR HOFFMAN: Well, if there are any deficits, as I said, they are typically deficits from the actual most (indistinct) and most capable of competent of all systems. They don't have a large aircraft protection design. They do have mechanisms of double containment and other activities, but they don't have the most robust aircraft protection design, although I'm told by GE that's something they could and would be willing to do. They have no separate core catcher or core protector catcher currently, underneath the core and that's something they've talked about. It's not a European design right now and so as a result, there may be some higher lifetime O and M cost. Now, you know, this has been reviewed to prove it has design certification in the United States, has a licensing in Japan, has licensing in other Asian countries but currently isn't licensed, if you will, in Europe and so as a result, it doesn't make it the most latest design. Again, it is a 30 year old design but, nonetheless, very robust.

MR JACOBI: Perhaps if we can deal with the EPR now, and perhaps we can identify the key features of that.

MR HOFFMAN: Certainly. I hope I'm answering all your questions. Please advise me if you--

MR JACOBI: You are.

MR HOFFMAN: -- want more or less information, I'm happy to give it to you. The EPR was a design that was come up with by AREVA, obviously, to describe a very, very robust system. This particular plant is probably the largest of all of them, simply because it has more miles of cable and more tonnes of concrete than any other design. It does have four 100 per cent trains, it does have double containment to protect against commercial aircraft crash, it also has a core catcher for severe accident mitigation. Now, interestingly enough, it can run on 100 per cent MOX fuel and that's interesting to utilise mixed oxide fuel, that's a mechanism that some countries find very favourable.

It has a high plant efficiency, meaning that typically a steam 2 reactor where you're actually taking water, flashing it - heating it to steam and bringing that steam down to a turbine, and turning a big turbine, and having blading turning, going through a condenser - it's typically around 33 per cent. 31 to 33. This is more like 37 per cent. It has 10 to 15 per cent less uranium consumption. It does have small outages and again, it has a greater than 90 per cent life capacity. Now, there are three of these under construction in three countries, just not doing necessarily very well. The one in Finland and Olkliluoto 3, the one in France at Flamanville and the two in China that appear to be going better, and if you turn to the next slide on the pros and cons - and I'll be happy to go over that when you're ready, sir.

MR JACOBI: I think perhaps if we can proceed to do that, again in terms of what you consider to be the key advantages and perhaps by way of comparison, the key disadvantages against an idealised design.

MR HOFFMAN: Well, it does have a great economy of - if I look at the advantages, it has a great economy of skill. You're talking about something that's huge. It can do 1650 megawatts electric and actually with up-rates -

we've already been able to determine if there's a significant amount of margin in the safety analysis, you could probably get to 1800 megawatts electric, which would be the single largest nuclear facility operating in the globe today. It does have double wall containment. Arguably, the lessons learned from Okliluoto 3 Flamanville, and the China construction have been able to be integrated into the overall construction knowledge, and so that should give it some benefit. Again, it doesn’t have any passive features but it has the strongest, if you will, active features.

But what are the downsides? There's none currently in operation. You know, it's got an unproven steam generator lifetime, it needs the largest rates of sustained concrete pouring during a month per each construction, as been seen by Olkiluoto 3 and also Flamanville, and quite honestly the cost schedule overrun is significant right now at the two plants, and from a technology neutral standpoint, this is one where there would need to be significant re-evaluation of the performance and stability, and the predicability of being able to meet schedule and budget for this to be seriously considered.

MR JACOBI: Has there been any significant information about - we've heard quite a lot about the plants at Olkiluoto and Flamanville - has there been much that's been able to be derived from the Chinese constructions of this particular design?

MR HOFFMAN: Yes, Sir, there has. We're actually collecting that now. We've been able to collect the evidence and the information from the experiences and lessons learned from Flamanville and also from Olkiluoto. So what we've done is we've talked to the Chinese to get their experiences. Now, bear in mind the Chinese experiences cannot be equated, they're not necessarily comparing apples and apples because the different regulatory oversight structure and the mechanisms by which they can and do do construction are not a one to one to either France or Finland, so as a result when we're looking at the lessons learned, those lessons learned have to be integrated and considered in their own right before they're applied back.

MR JACOBI: I think we've already mentioned the Westinghouse design. Could we move on to deal with the AP1000?

MR HOFFMAN: We can. The AP1000 is a Westinghouse design which evolved out of the AP600, which was an initial design when Westinghouse acknowledged and recognised that it would appear that the world and especially United States was going to something less than the thousand - 1200 megawatt electric machines to maybe the mid-machines, and then that was extended to go beyond that to go to something called the AP1000, which actually has more than a thousand megawatts electric, but that's the name of it. Now, the AP1000 is a unique design. In addition to the fact that not only does it have active design features, but it also has passive safety features.  It uses the forces of nature, as I said - gravity, convection, natural circulation.  It actually improves safety and it simplifies the system.

So if you can see from the drawing, those passive systems for core cooling, containment isolation and residual heat removal - and for that matter containment cooling - provide a significant amount of capability for this machine to actually operate for a longer period of time than the two previous ones we talked about, without any external electricity.  The number of pumps and safety clasp valves have been reduced almost 50 per cent from the previous design and there's an in-vessel retention of core melt, so you actually have the core catcher capability and you have - as I said - the passive containment pooling.

MR HOFFMAN:  We have an issue where our regulatory authority has turned – it has changed its mind about something which is impacting several facilities operating, even as we speak.  But I can have that dialogue later.

COMMISSIONER:  Can I just interrupt?

MR HOFFMAN:  (indistinct) policy.

COMMISSIONER:  Can I interrupt?  Can you explain to us where you say – we have got 72 hours.  At the end of 72 hours, what needs to be done?

MR HOFFMAN:  Typically at the end of 72 hours, even though its analysis is very robust and also very conservative, you need to provide some kind of means of forced cooling.  Now what the AP1000 people are telling me now if there were design certifications, if there are the continuous licensing, is that they believe they can get that out to seven days.  So they are continuing extended analysis.  What that gives you is a 72 hour time period in which no operator action has to be taken and you can be confident there will be no fuel, no core melt.  At the end of which time period there needs to be some kind of electricity restored, or some kind of active system restored that will actually provide cooling either in a forced cooling such as fluid(?) being pumped in there, or even though our mechanisms where we can hook up fire hoses and just dump water in to the cooler.

COMMISSIONER:  Okay.

MR JACOBI:  Now we discussed at the outset the ability to potentially reduce generic licensing time by reason of other countries are proven.  We understand that with respect to this particular plant design, the licensing process, the design licensing in the United States took about 15 years.  I am just interested to understand about whether it is thought that that sort of experience is likely to be replicated with other designs?

MR HOFFMAN:  Well, I don't know where you are getting – I don't know where the 15 years came from.  Obviously if you go back and you look at the design certification and the timeframe for licensing, we developed intentionally what we call the single one-step combined operating licence, or COL process.  But we did that because what we discovered was we were issuing a construction licence and then we were having construction going on and we were deep in to construction and having a great deal of financial capability in to the facility, only then to have the public take issue, it can obviously extend the actual going in to operation.  That was an issue for us because in many cases, prior to this, the vast majority of our nuclear plants could not begin to take credit for or get return on investment until they actually went in to commercial operation date, or what we call COD.  So as you can well imagine, if you've got three or four billion dollars invested over a period of six or seven years and now that is being extended by the public, or anyone who is taking issue with something, that you need to resolve irrespective of how simple or complex then that is a significant problem.  So we did what we call a combined operating licence process.  We actually utilise that, if you will, we piloted it on the Vogtle and VC Summer units which are each building two units in South Carolina and Georgia.  Those took a little more time than the subsequent units will.  I truly believe that if you set up the appropriate regulatory infrastructure, you can licence one of these in about two years.

MR JACOBI:  Now in terms of the construction experience with the AP-1000 in contrast to perhaps the two types of plants that we have just discussed, in terms of – do we have experience with respect to their operation and maintenance and their actual construction costs?

MR HOFFMAN:  Well we have some sense of the construction cost.  There are no AP-1000s currently in operation in the world.  They are being constructed in China and also in the United States.  And there is a different variability of how they are being constructed but we have a sense of construction costs, we also have a sense of what we expect the maintenance cost will be and the operational cost.  Now I will tell you, much to my chagrin, we have not done very impressively in the United States.  As I will just tell the Commissioner, I am technology neutral Mr Commissioner, I work for all these organisations.  I know them all well and I personally and my company were involved in all of their design certifications and licensing.  So I know everything about every one of them.  But having said that, there are some things that we are not doing as well on, both QA issues and on prefabrication and module construction.  And I believe those lessons learned will make the subsequent plants work much much better.

MR JACOBI:  Can we come to - - -

MR HOFFMAN: In other words, the construction timeframe should be reduced significantly. I can't honestly say what it will be, although I could give you a sense after we are going through. We are already evaluating that, we are looking at saying okay we had this problem with this particular module, what was the delay? What was the cause of the delay? What was the impact of that delay and how could it be precluded? And what would that mean? In other words, if we had a construction schedule that looked like this and it had shifted out to the right because of these things, how far back to the left can we bring it. Can we put it back on the initial construction schedule? And what I believe is that we're working very closely with Westinghouse and with Vogtle and with VC Summer to understand that so that we can make that happen. So as you see, we are going forward with Vogtle 3 and 4 but three first. And a lot of the lessons learned are to be applied on Vogtle 4.

MR JACOBI: Can we just come to – very quickly, perhaps deal with what you consider to be the advantages and particular advantage of the AP-1000?

MR HOFFMAN: The what of the AP-1000 sir, sorry?

MR JACOBI: The advantages.

MR HOFFMAN: The advantages. Certainly. Well, you know if you look at slide 68, you can see that there are pros. There is a reduced number of components and systems for that matter. So what we have done is we have simplified the design a great deal by having less active features, if you will, and being able to rely more on some of the passive we haven't had to have that much. We actually have a core outlet temperature which enables us to eliminate some fuel both crud and corrosion problems. We have what I will call a 17 by 17-fuel assembly which is incredibly strong competition, very robust and very capable of supporting long term runs of operation. The footprint of this plant is significantly less than the footprint of several other plants, although it tends to come in what I'll call two packs. Westinghouse doesn't like to sell one of these units by itself and that's because there is an integrated aspect of the first and second units that actually make it less costly if you build two than if you build one. Doesn't mean you can't build one, it just means that if one is X, two is not two X, it's like 1.4 X.

Now what are some of the downsides? There is none, as I said, currently in operation. It takes about three of them to produce the same terawatts, if you will, of an APR-1600, of two of those. So you are looking at that, and what does that mean? Staffing numbers, number of outages over lifetime, spare parts. So there's going to be things that actually impact the long duration of the O&M cost over the life of the facility. There are some lower thermal efficiencies as I said, their EPR is 37 per cent, this one is only 34 per cent.

You can do 15-day outages but there are some things related to steam generators because the lifetime is not proven but they have tried to learn all the lessons from the previous steam generators to do this. The aircraft protection is not EUR sufficient. It meets the US requirements, it meets China requirements but the actual EUR has not yet blessed on the aircraft protection of the AP-1000. I don't think it is going to be a huge leap to get there but it is something you need to be aware of.

MR JACOBI: Could we move on to one of the Korean designs, the APR-1400?

MR HOFFMAN: Certainly, sir. The APR-1400 is really a GE system 80 plus with some significant enhancements. As you would have known, I am sorry, I didn't get a chance to go through some of the evolution but at one time, combustion engineering had a system 80 and then they built a system 80 with some plus variations to enhance and improve it in our Palo Verde station in Arizona which has three units currently operating, one of the larger units really in the United States. So what they did was they designed – it is based on what I will call an advanced light water reactor requirement, or URD requirements. It is based on having a 60-year design life, proven technology, plus some extensive testing. Again, fully digitised control room. They do have four trains of safety systems, some passive design features but not the kind like you would see on the AP-1000. They are less impressive and they are not nearly as able to do what we call core cooling. But there are some elements that would actually support it. They do have severe accident mitigation with external RPV cooling and cavity flooding and they have one of the world's largest two loop plants with two hot lakes, four cold lakes and two steam generators. There is four under construction in United Arab Emirates and there is four under construction in South Korea.

COMMISSIONER: Right. Can I just butt in there Mr Hoffman? What is your assessment of the progress that has been made in the UAE in particular with these plants?

MR HOFFMAN: I think the progress in the UAE has been phenomenal. The UAE was wise enough to take the time to make sure they understood what they were going to have to invest, both in time, money, resources and capability, and they brought in a number of different international experts to assist them in their determination first and what technology they should choose.

We happened to be a part of that and so they were able to decide based on their unique application which were the three best technologies for the United Arab Emirates, the unique aspects being a desert, how far away the actual cooling source was, what the actual cooling requirements were for a containment in order to have this, what kind of temperatures would you need to have, and a number of other things which go into, as you're well aware, the kinds of considerations that go, the seismicity, the geographical aspects, the socioeconomic, there's a number of different things that went into this consideration, and when we got to the end of this and selected the final three, negotiated with the three final designers to determine which was the best from a financial standpoint.

So the APR 1400 has been a very excellent consideration to go forward, and the reason for that is that Korea, the country itself, the Republic of Korea, totally backs this. This is a state-owned industry with KHNP and KEPCO and they have the full backing if you will of the South Korean government which has stood behind everything related to the pricing and whatnot, and also the commitments to meet certain schedules. Now, have there been some variabilities? Yes. But they have been minor, they have been identified early on and they have been able to find ways to address them.

So I believe that APR 14 is a very impressive design, just as is the AP 1000, and so I think the important thing to note is that all these designs aren't created equal, and when it comes time for the great country of Australia to decide what, if any, nuclear designs would be best for them, a serious consideration of all the same kinds of criteria that all the other countries have gone through will be paramount in ensuring that for your application this is the best design for your utilisation there in Australia.

MR JACOBI: Can we just come very briefly to deal with again what we might characterise as the advantages and disadvantages.

MR HOFFMAN: Some of the pros and cons are on your slide 70. If you take a look at the design basis, as I said, you know, Shin Kori 3 and 4 is under construction, so we have a lot of construction lessons learned that have been fed back all along in the activity related to the United Arab Emirates as far as the Barakah units, they have a robust plant design, they have a small technology leap. If you look at the system 80 plus that was built, the OPR 1000 that was done in Korea was really based on the kind of design and characteristics that came out of - excuse me one second.

COMMISSIONER: Mr Hoffman, can I just - - -

MR HOFFMAN: I thought I told everybody not to call me, but clearly I didn't.

COMMISSIONER: Would it be helpful if we break for five minutes so you can sort whatever you need to sort out.

MR HOFFMAN: I have already sorted them all out. I told them, "Don't call here again."

COMMISSIONER: Righto. Well, let's get on with it then.

MR HOFFMAN: You have a short period of time. You should have my undivided attention. I am actually privileged and pleased to have an opportunity to help provide information on this very important decision-making process and fact finding mission that you, the Commission, are conducting. If this phone rings again, I will just throw it out the window and we won't have this problem.

COMMISSIONER: Right. Let's move on. Shin Kori has had some problems. What's that been about?

MR HOFFMAN: Most of the Shin Kori problems - and I don't want to throw my South Korean colleagues under the bus - have been unique to South Korean approaches. Some of the culture and the activities that have been conducted have led to a less than impressive approach to some things. You may have noticed they had some components that were not certified, not designed, they were actually falsified design criterion application, and while these weren't the most important components, that leads to the entire consideration and entire aspect of, "Okay, if this is wrong, what else is wrong?"

I can honestly say having worked for (indistinct) United States submarine navy, then been a director with the Nuclear Regulatory Commission, my assumption always is, if there's one thing wrong, there's something else wrong, and we always look for those. So we did the same thing. We went over to Korea to try to investigate where this was happening, why was it happening, what was the root cause, what was the actual basis for it and what, if anything, did we need to do to stop it. I believe it has been stopped. I think these were unique to Korea. Based on what we have done in the United Arab Emirates I don't believe any of this has carried over externally or outside of the country.

COMMISSIONER: Right, thank you very much.

MR HOFFMAN: My pleasure, sir. Now, if you look at the rest of the benefits, you know - did you want to ask another question, sir?

COMMISSIONER: Yes, I did. Let's move onto ABWRs if we can.

MR HOFFMAN: Absolutely. The ABWR is a Japanese design by Mitsubishi. You may be familiar with it. It's quite a unique design. It's got four trains of safety systems also but it's not four times 100 per cent, it's four times 50 per cent, and so as you can well imagine, what you're looking at is a capability where you're going to have 50 per cent of a performance off something like A and C or B and D, where you are, if you prefer a one in three and two and four, where we actually separate the things predicated on whether or not it's a diesel generator, number 1, number 2, or alpha or bravo.

But they do have a thermal efficiency which is very high in the USA version and they were able to do a great deal of activity, they only have 14 feet fuel length but they also can handle a full marks fuel pour. They do have reduced staff exposure, again full digital INC, reduced operational waste, and they have a very impressive, very impressive three fan and modular design. There are two under construction in Japan that were there when we started this. They're now on hold, but those two ABWRs had gotten far enough along to give us a sense of both the design, capability and the constructability of this particular design.

MR JACOBI: Were issues of prefabrication able to be demonstrated in those particular two plants that were being constructed that are now on hold?

MR HOFFMAN: Yes, sir, that is correct, and they still have some actual prefabrication that's already taken place and some of those prefabricated modules are still residing where they were fabricated.

MR JACOBI: Perhaps we can move on to the ESBWR.

MR HOFFMAN: Certainly. This is an interesting design. You know, if you look at GE Hitachi and Hitachi GE, you really have to look at it from a perspective - and this may sound confusing to you because it certainly confuses us from time to time - there are two basic companies doing this. GE Hitachi has the ABWR and Hitachi GE has the ESBWR. Now go figure that out. You know, the ESBWR has evolved through a number of different applications until simply being the economic simplified boiling water reactor.

What they have basically done is they have taken out the jet pumps and by doing that they have a simpler, safer, using passive concepts to the max, and when I say that, this is a unique application like the AP 1000 where they have as much passive as they do active fuel cooling. There is no operator action for up to 72 hours and just like AP 1000 they claim they are going to be able to get that to seven days. They have eliminated a number of ABWR systems from the ESBWR, thereby significantly improving its simplicity and reducing a number of different components that could otherwise fail, require maintenance and so on and so forth.

They have eliminated 25 per cent of the pumps, valves, motors. Again they have passive residual heat, as I said. They utilise the best features of all the BWRs and ABWRs in truly trying to make a design that was Generation III++ to try to demonstrate the capability. It has the lowest what I'll call core damage frequency. They have significantly reduced the construction and schedule and O&M cost. Now, the downside is you don't see any under order or any under construction, and while all these things are on paper, they look valid, they look valid from the perspectives of you do some kind of comparison back to the experiences we've had on the other design, that arguably Hitachi GE is telling the truth about the capability to actually construct and place into operation this facility in a reduced timeframe at a reduced cost.

MR JACOBI: Perhaps if I can pick up the safety features of this particular design. Could you just give us a brief outline of those.

MR HOFFMAN: You know, I think the greatest safety feature is that you have no steam generators and no plant refurbishment cost. By having these prefabricated modules and having this passive cooling, you're able to continue to cool this facility for at least 72 hours and probably as much as seven days with no operator action. The only other facility that can say that in a large build is the AP 1000. So basically the ESBWR is sort of like the AP 1000 of boiling water reactors. But, you know, the natural circulation, the only downside of that is that it causes new uncertainties. There is an issue of core stability in a core this size. They can do load follow, which many of the other facilities cannot do, but there are none currently in operation.

Now, because they only have 10 feet length of fuel, they have to use 30 per cent more bondo manufacturing, which has more transportation, more dry storage, higher disposal waste, but when you look at it from an overall perspective, it balances out well against its competitors.

MR JACOBI: Okay. And then, I think finally if we can come to the Candu modern design, the ACR-1000.

MR HOFFMAN: Yes, the ACR-1000, as you may also know, evolved out of an ACR-600. At one time, the Canadians were thinking to build a plant in the state of Virginia in the United States, and that was going to be an ACR-600, then later expanded to an ACR-1000.

It is essentially 1165 megawatts electric of an advanced Candu. They've taken their current Candu's, many of which are in the operation of both Canada and Romania and other countries, and done an evolutionary development. Now, this is a light water cooled but heavy water moderated facility, which means that you can get a lot of burn up with a very small amount of enriched uranium. But the beauty of it is, is that you can burn MOX and thorium fuels; that's something that the others cannot do. It does have a four loop design, it does have a single wall strength and containment building, and a reactor bowl that's water filled, for a core catcher function.

Now, there are none under order, and none under construction, but the ACR-1000 is a unique development, beyond the Candu's. If you look at how many, as I said, that are operating in many countries, they have all good characteristics, they can be also utilised significantly with their online refuelling.

So what are the kinds of pro's, you see? Pressure tube replacement's a lifetime limit, but you can actually do online refuelling, as I said. And, you have fuel flexibility for the kind of core and kind of fuel you have to acquire, which gives you some flexibility if you're a country that's only going to have so many plants. Otherwise, you might be somewhat held hostage to one type of fuel or another, if you're purchasing all LWR fuel, Westinghouse, GE, whatever it may be.

Well, what are some of the down sides? There are some additional people that have to be utilised, they do have more staffing numbers, they have some extra overhead, there are some maintenance and de-commissioning costs. And again, they are moving towards some other ways.

You know, there are some really important Candu features. You can actually burn light water reactor spent fuel through what we call du-pick in a Candu. If you're interested in finding a way to do this, and you want to be one of the first of a kind, then you can actually take everybody else's spent fuel and burn it as your fuel application, thereby removing (1) their spent fuel need to store it, (2) the concern about proliferation. So there's a tremendous number of advantages that a Candu-1000 or an ACR-1000 has.

COMMISSIONER: Mr Hoffman, having been into Canada when they were about to start their pressure tube replacement program, I note on your cons it's 30 years. I'm assuming that this sort of reactor would probably have a 60 to 80 year life, or is that optimistic?

MR HOFFMAN: That's the design intent. The only concern is, they have not been able to demonstrate the ability to get to 30 years with these kinds of, basically, tubes. I think that's the concern, is that they really don't know; they're doing it through analysis, and based on the analysis, they believe they can get to at least 40 and probably 60, but I don't know that that's been approved by a regulatory authority yet. I know that it's in the works, and there are discussions going on about it.

COMMISSIONER: And the pressure tube replacement's at least a couple of years, and reasonably financially cost effective?

MR HOFFMAN: You can do pressure tube replacements in just a short period of time, and the cost is not that great. So you know, even though you may only have a 30 year life, and I'm not saying it will not have been that way, it is our hope that they can get out to 60 years, and that's their intent.

Currently, they claim that they can do 60 year life. Now, when I've asked them specifically about that, when I've worked with them on these kinds of enquiries, the response I get is that, "We're working towards getting a 60 year pressure tube capability. In the meantime however, the overall facility will be able to do a 60 year life, or as far as a licence, but we may have to make some changes along the way."

COMMISSIONER: Thank you.

MR HOFFMAN: You're welcome, sir.

MR JACOBI: Perhaps if we can move away from the particular designs that we've been discussing. There is some interest in Australia in the progress of the US new reactor building program, and I'm just wondering about whether you could give us a brief overview of the current state of new US nuclear reactor developments?

MR HOFFMAN: I would be happy to do that. I would just call your attention to when you get a chance, those other slides that actually give you, if you will, a key features, all in one page, on your 79. So you could see some of those things, really, in their own case.

You know, we've gone through quickly in a number of large build designs, and I hope I've at least given you a sense that there is some variability. We haven't touched on all of them, there were a couple that you did not necessarily want to consider, that's understandable. That's been true of every single country who's had their own desires to make sure that they have a sense of what design would be appropriate.

So what are some of the latest developments? You know, the globe is undergoing some transition. As you can well imagine, in a post-Fukushima environment, we're all seeing some change, if you will. To give you an example post-Fukushima Daiichi in March of 2011, there's been a number of activities that have been slowed down significantly across the globe, that otherwise would be quite robust.

In many cases, renaissances were considered in what was going on, new build, new activities, expanding the current fleet. And that has changed significantly. In Japan, there are 43 reactors that are considered operable, that means they could be operated, started up and actually provide power to the grid. But 24 of them are on a re-start approval process, and one of them has been re-started, and the second one may be any moment.

What we're discovering is that, and that's good, and the Japanese regulatory authority has undergone a significant amount of reconstruction and realignment, to facilitate a full recognition of the kind of culture and safety environment necessary to operate a nuclear fleet in any country.

I'm going to stop, give you a chance, if you want to ask questions now, I'm going to move on to the next country and then I'll kind of integrate those.

In the UK, you may have noticed recently that there's a design, generic design approval process at Brandwell, and that's really based on a Chinese design. This is where you're actually seeing a merger, because CNNC and CGN design. And this might sound surprising to you, that a country such as the UK is going to rely so significantly, potentially, on the Chinese export of a design to be built in their country. But a lot of that is obviously happening, because the Chinese are spending a great deal of time and effort to be a part of the financing model of this particular design.

You may also be aware that the French, through EDF, have actually purchased British energy, are continuing their activities to build two EPRs in the UK. And if you're familiar with that, you'll also be familiar that they're saying the cost of those two EPRs could be as much as $20 billion, which, in my opinion is outrageous, and in the opinion, I'm sure, of the UK public will be outraged once they see their new electric bills.

In the United States, we have five plants under construction; one of them is an old plant with Generation 2 Westinghouse design – you want me to stop?

MR JACOBI: No, no.

MR HOFFMAN: Okay, good. It was (indistinct) tube, it was a construction licence that was issued, construction was begun, then ceased, due to the lack of electricity at that time. And then they have completed it, and they should be going operational this calendar year. The other four are Votgle 3 and 4 in Georgia, and VC Summer 2 and 3 in South Carolina.

Economic issues are, to some extent, holding back the others. Now, why might that be? I do want to at least give you a sense Mr Commissioner. The reason that this is going on in these particular states; in the United States all 50 of our states are not treated equal in the manner in which they actually utilise, monitor or oversight construction of any kind of energy producing facility, much less a nuclear one.

In the states of Georgia and South Carolina, the particular entities that own and will operate these nuclear facilities are able to begin to recoup construction costs during construction, through the actual application of increasing the actual cost to the consumer.  Unlike so many other states, where you can't get any return on investment until you get to commercial operation.

So as you can well imagine, Georgia and South Carolina are very pro-nuclear, simply because (1) they have a significant growing need for electricity, (2) they are very, very pro-business, (3) they have the capability to acknowledge and recognise the return on investment during construction, and (4) their political system is really oriented towards having a political will which supports the construction of nuclear.

We don't enjoy that in all the other states.

MR JACOBI:  We have heard, as part of the Commission's process that in particular gas prices in the United States have had a profound effect upon the building of new generation capacity particularly in nuclear.  I am just interested in your view on that.

MR HOFFMAN:  Well, my view is the fact that it is unfortunate.  Clearly we have the low price of natural gas, which I think is skewing, if you will, the actual energy mix.  I am a – if lack of anything else, maybe all of the above. You know we nuclear engineers, United States are not anti-solar or anti-wind we just understand and recognise that wind and solar have limited capabilities and applicabilities in our country.  We have invested billions and billions of dollars not only to research but also in to subsidies and currently wind and solar only provide 3.8 per cent of the electric generation capacity in the United States.  Nuclear currently provides 19.6 and that 19.6 per cent of the overall generation capacity in the US; it also provides 63.3 per cent of the non-carbon emitting generation of electricity in the US.  And so as a result, we believe nuclear has to be a part of the mix.  But nuclear is not enjoying a very favourable situation.  Quite candidly, what we have is we have laws and infrastructure which support renewables but don't support nuclear.  An example is sir, if we're operating a nuclear plant which is typically best operated at 100 per cent rated thermal power, the electricity to the grid and a low dispatcher distributing accordingly, in what we call base load.  Are you familiar with the term base load?

MR JACOBI:  Yes.

COMMISSIONER:  Yes.

MR HOFFMAN:  Then we use others for peakers.  What we have done is we have revised the laws to require these nuclear plants, during the highest peak times of their generation, where they would otherwise do base load at 100 per cent, to de-rate to require these wind and solar sources at three to four times what they would otherwise pay to produce it to begin with, to offset, to order to benefit and show that we're having a greater utilisation of renewables. And while this sounds politically wonderful, it's basically killing the nuclear industry. So what we have is we have nuclear plants which are perfectly capable of being operated both safely and economically but cannot economically compete in the region in which they are operating, such as Kewaunee or Vermont Yankee which if we could have lifted up and transported to the southeast of the United States they would still be operating. So I personally am spending a lot of time with our governors and our congress to make them understand the benefits of the nuclear energy and especially that not all megawatts are created equal, that nuclear power megawatts are actually more valuable.

One time I would be happy to send you this but essentially we have done studies that a single nuclear power plant which we have currently 99 operating, produces over 500 million dollars of goods and services in the state of which it operates. It provides greater than 20 million dollars in infrastructure for hospitals, police, roads, infrastructure. It also generates $1.04 for every dollar that is spent. It generates 700 to 2,000 jobs at 42 per cent average higher salary than the rest of the state. It also produces 69 million dollars in federal income tax and it also produces a significant amount of other activities such as drycleaners, restaurants and other stores that provide support to everybody that works at them. So our nuclear power plants are not only significantly beneficial from the perspective of providing base load, safe economic available and certainly environmentally friendly energy but also from the economy too, sir.

COMMISSIONER: Thank you.

MR JACOBI: If we could step back? We were discussing some trends around the world in terms of new construction projects and I think we dealt with – we have dealt now with the United States, we have dealt with the position as it prevailed in the United Kingdom and I am just wondering about whether we might – you might deal with the position as you see it in Asia?

MR HOFFMAN: Well, it's interesting. First of all, you know my next slide really talks about you guys. But there is a number of different activities, obviously Asia has the most construction going on of any region in the globe and the vast majority of that construction is occurring either in China and/or India. A smaller extent Russia because Russia has other activities but if you look at those slides, what that is really intended to give you, at a glance, is a sense of the kinds of under construction and what the China mega nuclear market looks like. I would say, just in a summary aspect, that this will continue. The Chinese acknowledge and recognise the lowest cost capability for them to provide massive amounts of electricity and distribute it across large and long periods of distance, is to do it through nuclear. Obviously as you know, they have a significant footprint when it comes to carbon production, so much so if you see the cities of Beijing and others; it makes you wonder how people actually breathe in those particular areas.

So China has embarked on a very, very robust nuclear build programme and they not only embarked on one that's very robust in the country, by purchasing certain designs and making changes, but now they have taken the AP-1000 and they have enhanced and improved it to a 1400 that they are going to be exporting. So China is now moving in to the export nuclear construction and operation market along with the Russians. As far as the country of India, unless you want me to stop, sir.

COMMISSIONER: No. It was India, I was going to come to next.

MR HOFFMAN: As far as the construction in India, India also recognises they need to add more facilities to what is going on in their country. Now India, unlike many other countries, with the exception of Canada, has a lot of heavy water cooled plants. They don't have many light water reactor cool plants. And so they are selecting different designs, both from the United States, China and for that matter Russia, that they are going to be building and you can see some of those throughout the explanations. I have broken it down by the vendor, where the plant is, the type it is, the commercial operation date are expected to be and then what their status is, whether they are under construction or whether or not they are near start up, or just in a kind of contract. Same thing with the China new build market, where you see so many different plants ongoing and then if you go to page – slide 45, you can see the number of builds that are going on all the way out. Now the Chinese, like the rest of us, stopped for a short period of time post Fukushima to re-evaluate their processes and going forward and did indeed slow down the mechanisms to re-evaluate their safety related programmes.

COMMISSIONER: Mr Hoffman, can you give me a very brief summary of where you think Saudi Arabia might be going to in the next few years?

MR HOFFMAN: We have had a number of conversations with Saudi Arabia and they – you may be aware that in our country we have what we call a 1, 2, 3 agreement, which is an agreement that basically comes out of our Atomic Energy Act, which is an agreement related to the utilisation of commercial nuclear applications that are non-proliferation and so on and so forth. Many of these agreements we have signed with countries throughout the globe and there has been some consideration as to whether or not everybody needs to have what is called "the gold standard" where the United Arab Emirates agreed to – even as a sovereign nation, did not consider enrichment and reprocessing. We really believe that any sovereign nation has the right to enrich and reprocess.  We also believe that we provide sufficient amounts of affordable and available uranium or thorium that you won't need to do enrichment and reprocessing.

Having said that, we are working with the country of Saudi Arabia now on a 1, 2, 3 agreement and other technology transfers under our VOE8/10 programme and I met with the Saudis week before last at the IAE general conference in Vienna, where I was there speaking with our Secretary of Energy, where we talked about what is their programme?  What are they looking at?  If I look at what they're saying, that they're going to be seriously considering doing technology selection and evaluations in 2016, I say that because two things have happened.  One, they have hired STUK, which is the regulatory authority in Finland which has been oversighting so many of the plants there as an advisor.  And STUK can – we work with STUK so they recommended us.  So we are well aware of where they're going and we'll be helping them to set up their regulatory infrastructure.  Second, they have acknowledged and recognised that planning process to have a platform and have a foundation of nuclear to overtake some of the other (indistinct) shutdowns of the other conventional type power plants in the country.  So I believe that they are going to be moving forward and much quicker pace in 2016 but I don't think we're going to see any construction until the end of this decade in Saudi Arabia.

COMMISSIONER:  Right, thank you very much.  We might now move to small module reactors.

MR HOFFMAN:  Say again, sir?

COMMISSIONER:  We might now move on to SMRs.

MR HOFFMAN:  Okay.  I did want to call your attention to the regions, if you see it and I don't want – you know, we've talked about Asia, we've talked a little bit about Europe, not much and we talked about the importance of this on Australia, what's happened in the US and the UK.  But I would just add for that matter to the Middle East, North Africa.  I would just call your attention to the fact that there is some building going on, if you will, in South America too.  So they are a number of the countries are continuing to move forward.  Now if I look at this SMR technology overview, it's important to note that small module reactors as they're called, got to where they were called, did not start out that way.  Modular can be applied to any kind of reactor as we all know, whether it's large, medium or small.  They used to be just called small or medium sized reactors.  Somewhere along the line because small wanted to be more attractive, they through the word "modular" instead of "medium".  So if you see on slide 90, we actually give you an SMR definition.  Typically according to the IAEA deal, anything less than 300 megawatts electric is a small reactor, 3 to 700 is a medium and larges are typically 700 to 1700. Now, modular just means multi-modular NPP as you might see it. So what's happening in the rule related to this? This is a unique and attractive thing. People are seeing applications for small modular reactors that otherwise didn't necessarily exist in other application.

I do not believe that small modular reactors will replace large built. I think what they'll do is they'll augment them in unique applications for places where; (1) The grid cannot handle it, or (2) You don't have that need for power, or (3) You don't have the cooling mechanism, the siting characteristics or any of that kind of need, or you don't have the financing necessary to finance a large build, and or you were actually building up to a progressive standpoint to get to a certain point. So there are a number of small modular reactor technologies that are currently under some consideration or development across the globe. Slide 91 gives you a sense of what the next 20 years looks like. Do you want to ask me a question, Sir?

MR JACOBI: No, keep going.

MR HOFFMAN: Okay. If you look at these, some of these are more robust than others and some of them will go further. Now, it's important to note that regulatory authorities like being simple and they like to have something that's predicated on a known basis design. So a light water technology small modular reactor is going to enjoy a much more favourable review process, scheme and time frame that may be necessary in an exotic one that's got some unique features that have to be proven through analysis or study, or a combination of both. So if you look at all the ones that I've put in yellow in here, these are the ones that probably have some of the more capabilities to move forward. Now - and I don't mean to leave PRISM out, because PRISM is a unique application that can actually be used and probably will be built in the UK related to a burning, if you will, of all of their weapons-grade plutonium to facilitate an elimination of that.

That's PRISM's unique capability as a GE and Hitachi design, but if you're looking at a standpoint of how many megawatts do I really want - and, of course, a PRISM's 311 so it's really not small or small-medium - if I'm really looking at something that's in the something less than 250 megawatts, then I'm looking at - from the US I'm looking at the Westinghouse small modular reactor, I'm looking at the Generation mPower which is resurrecting itself. I'm looking at the SMR 160 from Holtec or I'm looking at the NuScale which comes in 45 megawatt electric type of modules, of which you can get as many as a 12 pack on one particular site, but across the rest of the world I've got some other activities going on with CAREM and ACP1000 out of China, and some others.

So I'm going to take you to the next slide which is 92, which also shows small modular reactors have unique capabilities to be more than just energy producing. They can provide direct process heat for chemical processes, they can provide industrial heat for heating capabilities, they can provide power and co-generation for unique applications and they can also provide desalinisation and other applications too. So there's a number of different ways which a particular application of an SMR can be utilised to actually achieve three or four different goals.

So where are SMRs currently under construction across the globe? If you look at Russia there are several ones that are currently under construction. Some of them are in commercial operation here, the next year - there's a delay due to some insolvency related to these activities, but they were going to be an ice breaker reactor design, and they were going to have a floating nuclear power plant that basically can be pushed over to a very, very remote location, as you see from the top of the map, where otherwise getting into building a plant was almost impossible. Now, there's still a desire on the part of Russia to do that, they're still doing studies, and they're still considering it.

MR JACOBI: Mr Hoffman - - -

MR HOFFMAN: If you look at the next slide you can see the kind of application. Yes, please.

MR JACOBI: Mr Hoffman, if I can get you to deal with the two particular plants, the CAREM plant that's under construction in Argentina, as I understand it, and the plants that are under construction in China.

MR HOFFMAN: The CAREM under construction in Argentina is currently a prototype. It is - construction started in 2010, the commercial operation should really be next year. They're saying 2016, 2017 - there's been some issues that are precluded getting there, but it's going to actually be scaled, it's going to be 200 megawatts electric, it's going to be an annual refuelling and we're looking at taking 24 months, and they're going to be able to do desalinisation. Now, it does have simplified modular natural circulation and integral steam generators, so it is a unique application which, when constructed, will actually help us understand better the characteristics and the performance of many of the SMR designs that will follow.

MR JACOBI: Is there any commitment to take it out? To take it beyond the prototype at the present time?

MR HOFFMAN: Yes, Sir. It is right now - I call it a prototype but it's actually, again, it's 200 megawatts electric. It can be scaled there. So what they're doing is they're building the prototype and their plans are if it works well - like they think it will - then in the next few years their plans are to expand it to 200 megawatts electric. You know that the Argentines have large builds, just as Brazilians do, but they acknowledge and recognise there are areas in the country where there are long distances between the actual grid capability to provide power across these long areas, and from what we call grid stability and maintaining the KBAR power factor, they're going to utilise them in that way.

COMMISSIONER: Mr Hoffman, if we could go to China, if you wouldn't mind.

MR HOFFMAN: I'd be pleased to. There are a couple that are going on in China. One is an HTRPM which is really a two times 105 megawatt electric (indistinct) units, really driving one turbine. This is really the pebble-bed concept. I had the distinct pleasure of working on the pebble-bed modular reactor concept in South Africa. Unfortunately I was called in too late to make that project go, but at the end when we finally decided what the design should be and finally decided what the regulatory infrastructure should be, we had the capability to go forward - by August of 2009 we had mapped out a mechanism to make the pebble-bed modular reactor a reality in South Africa. Unfortunately the government pulled the funding in December of 2009. But this HTRPM is much like that. It's a concept utilising the German pebble-bed concept with some enhancements and variabilities on improving the pebble-bed design to capabilities in cooling and heat transfer across the pebble-bed and the actual (indistinct) so right now that construction started in 2011. It hasn't been a high priority but it's moving along and they're saying that they're start up is planned for early 2017. We are watching and trying to get feedback on that because now we're talking about more like a Gen 4. Even though it's a small modular reactor, it's also a high temperature reactor, if you will. It's a high temperature - that's what the HTR stands for - and then there are ACP1000 - did you want to stop there?

MR JACOBI: No.

COMMISSIONER: No.

MR HOFFMAN: Their ACP100 is a small modular integral PWR. It's planned on being underground, shift this one unit, they can get eight modules per nuclear power plant. Again, as you can see they can also do desalinisation. They're currently building two demo units (indistinct) and the cost of these first two units they're saying is only going to be $800 million. Now, we're watching that very closely. Obviously the Chinese had the capacity to do construction for significantly less, probably than any place else in the world, so we're trying to translate that into reality, related to what that construction might cost some place else.

So we're watching it from a standpoint of duration, they're saying 36 to 40 months with a 60 year design life and 24 month refuelling. I've been involved with some of that, working with the Chinese. There are some very unique capabilities in that design. I truly believe that ACP100 can be a design based on where they're going. They can be utilised and exported to other countries for application and so it is one that clearly is worth consideration.

MR JACOBI: In terms of where that stands in terms of it being a tested prototype, where is that in terms of its development?

MR HOFFMAN: Well, they're actually constructing these first two units and they're calling demo units, but in reality they are just like what the real unit would look like with some testing capable - in other words, what I would not see on an operational unit is all of the feedback moves and testing to demonstrate the results of the safety analysis. What they're intentionally doing is instrumenting all of these two initial demo units to ensure that they can demonstrate beyond a shadow of a doubt, to demonstrate through actual application that which they're demonstrating currently through analysis.

MR JACOBI: I'm just very conscious of the time, Mr Hoffman, and we're going to run out of time in about 10 or 15 minutes. I was just hoping we might, very quickly, first deal with perhaps a brief overview of the US SMR concepts and then we can move to - very, very briefly - the Generation IV.

MR HOFFMAN: I'm happy to do it (indistinct) I'll go quickly. You know, you saw that we jumped over the South Korea Smart Reactor - - -

COMMISSIONER: Yes.

MR HOFFMAN: - - - but it is one that continue to move forward. We have four major designs that are going on in the US. Generation mPower which is a 180 megawatts electric which actually could be scaled up (indistinct) Westinghouse SMR which is really a smaller application of a light water reactor concept to 225 megawatts electric, the SMR 160 by Holtech and the NuScale, which can be built. NuScale is very far along working very closely with the Department of Energy with funding and activities. I believe the NuScale was an interesting design, it’s a very, very robust design, very capable, natural circulation, light water cooling, very easily well-known but they’re having to do a number of different things in order to prove some of their design characteristics. The B&W mPower design really slowed down significantly when there was a divestiture of the actual company holdings. They are restarting this year and Generation mPower reactor will become more of a light water reactor application that you will see later.

The Westinghouse small module reactor, I would say to you, the design certification is ongoing, they've done a plan submittal but you don't hear as much about the Westinghouse one because they didn't get DOE funding like NuScale and Generation mPower did. So as a result, you don't know just how far along they are but they are continuing to investigate what they can do, while they've got it slowed down, it certainly a unique design that can be utilised and it's just one unit, 225 megawatts electric. The Holtech 160 – you want me to stop?

COMMISSIONER: No.

MR HOFFMAN: Okay. the Holtech 160 actually has 145 megawatts electric and it's got a unique core design. All of these have the capability to be cooled if you will in a post-accident environment without any operator action. That is the unique applicability of them. They have smaller cost (indistinct) arguably they have smaller economies of scale, they have smaller footprints, they have smaller initial investments and what they basically have become is they have become somewhere more accepted as a result, by public opinion, because they keep arguing that they're "safer". Now of course safer is subjective but what you are seeing is, is that because they can operate for long, long periods of time, in some cases unlimited without any operator action in a post-accident environment, that has been very attractive to the public, especially in a post-Fukushima environment. But SMRs they are interest in the United States is really growing rapidly because they can be utilised, unique applications either in military facilities or very, very significant guarded facilities and things of that nature. But replication can be very important and I think repowering our fossil sites in the US is a major issue because we have a number of three to 500 megawatt electric coal fired stations whose cost of actually upgrading to the new EPA requirements would be more than just building a new plant. So if you look on slide - -

COMMISSIONER: Mr Hoffman, can I - - -

MR HOFFMAN: - - - (indistinct) construction period finance drivers, you see the growing interest and the time periods they can be done. A lot of this is just getting the first design certification. So that's something we're pushing for but design certification does not have to take place in the US only, we're pushing for design certification of some unique designs that aren't even listed here in Canada because they have a more refined process to do so. If I take you to slide - - -

COMMISSIONER: Can I just stop you there?

MR HOFFMAN: (indistinct)

COMMISSIONER: Can we stop you there? And just ask one question before we move on to Generation IV. Which of the designs in the US do you think is closest to commercial application?

MR HOFFMAN: Well, currently I think NuScale and Westinghouse are the two closest. Holtech and mPower, because mPower slowed down and Holtech are a little bit further behind.

COMMISSIONER: Right. Thank you.

MR HOFFMAN: But I would say the benefit is that those are more familiar designs because they are light water reactor.

COMMISSIONER: Can we move to Generation IV.

MR HOFFMAN: Because they're based on designs we used in our submarines which has some benefit because they have an applicability that's already shown. Let me quick move to what we'll call, for lack of anything else, Generation IV Technologies overview. If you look at the slide 113 the pebble-bed modular reactor module, this is one that was started, that's going on with a slight variation in China. It's a modular gas cooled pebble-bed reactor with online refuelling that generates electricity being gas and steam turbine. It can also do process heat and desalinisation and electric activity. So China is continuing to move forward. The next will be Generation IV, formerly, if you will, Hyperion. It's a led business – primary, secondary loop it's very exotic and it's not that well known. It is one that can be built but it's a much longer lead-time, simply because it is such a significantly more exotic design. Toshiba's 4S very small, could have been built, wasn't built in Alaska, at one time in Galena. They are really trying to work towards doing this. It's a very small, as far as electric outputs, only 10 megawatts electric but again, it could also be utilised for different things such as desalinisation and also process heat. But it's sodium cooled, so it's a little unique in the sense that it's a little exotic. Sodium cooler has a number of issues that have to be addressed. Can be, but still need to be. The GE Hitachi PRISM, most unique in the sense that while it's a liquid metal, it can basically be utilised to burn, if you will, or utilise weapons grade plutonium, so it actually burns the plutonium as a fuel generation. So it burns up a lot of people's latent fuel concerns related to proliferation.

Now if you look at the Next Generation nuclear plant, Department of Energy is working on, that is the AREVA design and there's a number of different things that's going on related to that but they really haven't decided where they'll go. But if you come back, you can see on page 118 what prismatic fuels and PBMR fuels look like. On slide - - -

MR JACOBI:  Can I just - - -

MR HOFFMAN:  - - - (indistinct) I just draw your attention to - - -

MR JACOBI:  Can I just - - -

MR HOFFMAN:  Sorry.

MR JACOBI:  Can I just pause you up there?  Can we come back to the GE Hitachi PRISM and - - -

MR HOFFMAN:  Sure.

MR JACOBI:  - - - the Commission has received many submissions that refer to the PRISM concept and I am just interested in your view as to the likely commercial timeframes for the potential deployment of that particular reactor technology and also the sorts of investments that might need to be required in order for it to be able to brought to that stage of development?

MR HOFFMAN:  Well, the letter of intent was updated over five years ago. The COL prototype is ongoing as a manufacturing licence.  It's already been issued but it's not a combined operating licence related to actually building one.  I've worked very closely – there's a gentleman named Dr Erik Loewen at General Electric who is the chief engineer for PRISM.  Dr Loewen was also president of the American Nuclear Society like myself and I've worked very closely with him.  I have spent a great deal of time looking at this design.  It can be licensed.  It has unique capabilities but it is one that has the wherewithal to be licensed in a short period of time if a government has the wherewithal and the political will to move forward.

MR JACOBI:  I'm just interested to understand the extent to which there has either been demonstration or prototype versions of that particular reactor constructed?

MR HOFFMAN:  I'm sorry?  Ask me that again, sir?

MR JACOBI:  I'm just interested to understand the extent to which there has been either demonstration or prototype versions of the PRISM reactor constructed?

MR HOFFMAN:  I don't know where there are other ones that are built?  Do you know of some?

MR JACOBI:  No.  Sorry, I think we're at cross-purposes.  I'm just interested to understand has there been a demonstration or prototype built of the PRISM?

MR HOFFMAN: No. No, there has not. Well, look I want to say that there has, there's parts and pieces that are built but is one integrated reactor core capable of doing what PRISM does, no. But what they've done is they built it in parts and pieces to demonstrate the unique capabilities of those portions of the overall system to demonstrate their capability to function as expected.

MR JACOBI: I think perhaps just one final question Mr Hoffman, and that relates to your view about where you think the markets might be, either for SMRs or Generation IV reactors? Whether you think there's a view for – sorry, whether you have a view that they would be either developed in the United States, or elsewhere?

MR HOFFMAN: Well, there is a market for small module reactors in the United States and in Canada because we have unique applications where we've demonstrated certain military units and vital facilities do not have independent power supplies that are capable of keeping them safe from, if you will, terrorist attacks and other acts of nature. So as a result, the SMR continues to be considered for military applications in the US. In addition to which, it has been considered, as I said, to replace coal fired plants but the timeframe of licensing one and get it to the design certification is what has got to drive that. I believe what is going to drive the Westinghouses and the NuScales is if you have an actual buyer. Now currently we have an organisation in the state of Utah, what we call (indistinct) that claims that it wants to actually buy and operate – own and operate a NuScale reactor. And if that's the case then they will probably utilise that as an opportunity to move forward. Now as far as the Generation IV applications, those are somewhat more exotic. Where am I going to see those? I'm going to see those more in places where countries have a unique desire to do science and technology and aren't just so structured and wired in the actual generic application of them. So there are needs, people are looking at advanced reactor concepts, if you will, and seeing where can those be utilised as we go forward. How can we learn more and more things to benefit, you know human kind from the investigations and experiments we can do? But in reality advanced reactor concepts like the Generation IV are typically electricity producing, along with other things SMRs can do too. So I think they're not going to enjoy the same attention, either in the US or globally.

COMMISSIONER: Okay. Mr Hoffman, we will call it a close there. I want to thank you very much for this very quick, deep dive in to nuclear technologies. We have certainly enjoyed your slides and I thank you very much for your time this morning.

MR HOFFMAN: Mr Commissioner, it's a pleasure to have had a chance to work with you all, it's a privilege and if there's anything else I can do, or any other information you would like at any future time, yours is (indistinct) to contact me. I certainly wish you well sir, on your endeavours and I certainly hope for the very best for the great country of Australia, sir.

COMMISSIONER: Thanks Mr Hoffman. We will adjourn now until 10.00.

**ADJOURNED** **[9.01 am]**