SA NUCLEAR FUEL CYCLE ROYAL COMMISSION

MR KEVIN SCARCE, Presiding Commissioner
MR CHAD JACOBI, Counsel Assisting

SPEAKERS:

DR MARK NUTT and MS NATALIA SARAEVA, Argonne National Laboratory

PROFESSOR HENRY SOKOLSKI, The Nonproliferation Policy Education Centre

DR ROBERT FLOYD, Australian Safeguards and Non-proliferation Office (ASNO)

TRANSCRIPT OF PROCEEDINGS

ADELAIDE

9.00 AM, WEDNESDAY, 25 NOVEMBER 2015

DAY 27

PROCEEDINGS RECORDED BY SPARK AND CANNON

COMMISSIONER: Good morning. We reconvene this morning on topic 16, high level waste, and I welcome from the US Dr Nutt and Natalia Saraeva. Counsel.

MR JACOBI: The Argonne National Laboratory is located in Illinois in the United States and was formally established in 1946. It is a multidisciplinary science and research centre integrating researchers and experts of industry, academia and other government laboratories. The research undertaken there seeks to understand and address issues of global significance such as clean generation, environmental sustainability, technological innovation and national security. Dr Mark Nutt is the principal nuclear engineer in the nuclear engineering division at Argonne. He also holds the position of national technical director of the Department of Energy, Office of Nuclear Energy, Nuclear Fuels Storage and Transportation Planning Project, NFST. His team is performing activities to support implementation of the 2013 administration strategy for the management and disposal of used nuclear fuel and high-level radioactive waste.

Ms Natalia Saraeva is a nuclear engineer at Argonne and is also involved in the NFST, leading the execution strategy analysis effort. Ms Saraeva has previously been a staff member at the Blue Ribbon Commission on America's nuclear future, and the Commission calls Dr Mark Nutt and Ms Natalia Saraeva.

COMMISSIONER: Good morning. We do want to explore Yucca Mountain and the plans and how it progressed, or perhaps didn't, but firstly, can you tell us where the current US plans are for a high-level waste facility?

DR NUTT: As of right now, I would say they're a little bit uncertain. I assume you followed the developments of the current administration's position that Yucca Mountain is not a workable option, and convening the Blue Ribbon Commission on America’s nuclear future which Ms Saraeva participated on. Following that, the Department did a strategy in 2013 that called for - essentially it adopted or endorsed several of the recommendations the Blue Ribbon Commission made and laid out what could be accomplished over the next ten years for an interim storage facility and began siting and work towards another repository. There was also had been some development since then regarding Yucca Mountain where the Nuclear Reactor Regulatory Commission staff issued their safety evaluation reports regarding the repository and from there, it's essentially a direction from our congress on which way to go first, yeah, and that's been up for debate for the last few years. So right now it's really doing groundwork activity, open storage and disposal, to essentially be ready for when a decision is made to proceed with national policy towards disposal and storage.

MR JACOBI: Dr Nutt, I was wondering if we could perhaps start right at the beginning and think about the issue of and the technical qualities of high-level waste and their implications in the context of storage and disposal. I think we've got a graph that might pick up the issue. This is the graph on slide 1. I'm wondering whether you could give us some context and explain from that graph, with respect to the reference to high-level waste, the implications of its characteristics to the way that it must be stored and disposed of.

DR NUTT: So this graph is from the International Atomic Energy Agency standard called Classification of Radioactive Waste, and it covers all radioactive waste generated, being from low-level waste or intermediate-level waste or high-level waste, but the real, what I call, discriminators on which level they had are on the axes. The half-life and the materials or such longevity of the radioactive materials that would be in it and then on the Y-axis is the activity content, how much is there, and spent fuel and high-level waste tend to have very long-lived elements in the waste. They tend to have pretty significant quantities of it. These aren't - they're hazardous for public exposure and need to be isolated, shielded, protected, the public needs to be protected from it, and the general consensus for ultimate disposition is geologic disposal.

MR JACOBI: I'm wondering if we can come to a second slide and deal with the discrimination that exists between the fission and activation products and the actinides, and perhaps you can explain the implications of that in terms of long-term storage and disposal.

DR NUTT: Okay. So this is from a another International Atomic Energy Agency document and it's showing essentially the relative activity compared to natural uranium ore of what comes out of spent fuel and the different components that contributed to that activity. The red curve is the total radioactivity. The greenish curve is from fission products and activation products, from fissioning uranium and materials inside the fuel becoming activated from neutron absorptions. The lighter coloured line is the actinides and their daughters that build up around uranium absorption of neutrons where you got plutonium, americium, neptunium, some of the higher actinides.

Early on after discharge from the reactor, the activities - it's very hot. Namely due to the shorter-lived fission products that are in spent fuel. As time progresses, those decay away and some of the longer-lived actinides become dominant. While this is pointed at activity in terms of - you know, it can be radioactivity, it can be heat. Heat tends to follow the same type ofdistribution. So when you discharge spent fuel from the reactor it's in the hottest condition, so there's a need for some storage on site. Typically with light-water reactors that are being deployed that’s done in spent fuel pools at the reactor site and with more circulation in the pools allows the fuel to cool off for a period of time, and then once it's cooled a bit, you can then have some flexibility in

terms of perhaps moving it to dry storage, transporting it, and ultimately disposing of it.

MR JACOBI: Is the distinction between actinides and the fission activation products significant in terms of long-term disposal? The fact that it's the actinides that one is essentially having to shield from and manage, is that significant in terms of the way that the geological disposal facility is designed?

DR NUTT: Possibly. It depends on the design and the environment that the repository would be in which of the radionuclides would contribute most to the long-term risk. There are some long-lived fission products that have to be managed and disposed of: technetium-99; caesium-135, I believe. It's either 135 or 137. I always mix them up. So there's a few other long-lived fission products that don't show up on this curve because in terms of radioactivity, they're very low, but when you get out in the long time frames when you're looking at dose rates and being protective to public health and safety, and certain environments and certain repository concepts, those can tend to be dominant radionuclides.

If you look at some of the work that the Swedish have done, the Finns have done, it tends to be those longer-lived fission products that you have to remain protective of. The actinides in a lot of those environments tend to be very insoluble, so they don't migrate. Even if the waste package would happen to degrade and the waste form would happen to release the material, they don't tend to move in several geologic environments, in what are called oxidising environments. It was like the Yucca Mountain site. They tend to be a little more normal, so you can get contributions from all the actinides and the long-lived – some of the long lived fission products.

MR JACOBI: I just want to pick up in terms of the major waste sources or major waste streams, particularly in the United States. I am just interested to know in broad terms where the main sources of radioactive and nuclear waste, where they are generated?

DR NUTT: In terms of all classifications?

MR JACOBI: Well, I am just interested in the extent of the contribution to that nuclear power generation makes to waste volumes as opposed to other activities?

DR NUTT: In terms of low-level waste generation it is probably – it is the biggest contributor. We have 100 – roughly 100 operating reactors that – the maintenance of the reactors, the clean up of the cooling systems all generate low-level waste that has to be disposed of. There are smaller contributions from medical, industrial applications of radioactive materials that then become

low-level waste. So by far in terms of volume it's the nuclear industry that dominates the low-level waste disposal. Another contributor in the US would be the defence clean ups that we have underway but those typically there are – there are defence sites that are operated by the Department of Energy, they do shift some materials to commercial low-level waste facilities but by and large it's the commercial industry. In terms of spent fuel it is the nuclear industry. We generate about 2,000 metric tonnes of spent fuel a year in the fleet we operate. On a high level waste site it is again primarily the – the clean up of the high-level waste we have from the defence activities back in the Cold War that are generating the majority of high level waste that would have to be disposed of.

There is some very – fairly small amounts of high level waste from commercial generation that happened back in the seventies when we were considering reprocessing for commercial but the volume of that is pretty small. There is also spent fuels from the Department of Energy complex that – for research reactors, from former production reactors et cetera but in terms of radioactive materials across the board, it is the nuclear industry that is the primary generator.

MR JACOBI: Are there any broad rules of thumb that you can apply in terms of the amount of waste that is generated from the nuclear power plant by reference to the amount of energy, for example that's output?

DR NUTT: Well, from some calculations and an analysis we did a while ago, well back in 2010 and I believe is still relevant today, it is about making cubic metres per kilowatt hour of power and typically a - - -

MR JACOBI: So that is - - -

DR NUTT: - - - large - - -

MR JACOBI: Sorry, what class waste was the 19?

DR NUTT: Low-level waste. It 19 cubic metres of low-level waste; it's typically mostly what we would call class A low-level waste which is lower activity. There are some higher activities but we have a slightly different regulatory classification framework than what I was shown on the previous graph, on that first graph. Most of the waste is low activity waste. We do have about seven one hundredths of a cubic metre per terrawatt-hour of higher activity low-level waste. It has a little more stringent disposal requirements but it's a very little amount. The most active of the low-level waste is generated when we decommission power plants and you have to take the materials from inside the reactor core around the reactor vessel that tend to be a little more radioactive. That is about 11 cubic metres per plant and so when they

decommission the plant; it's roughly about 11 cubic metres. In terms of spent fuel it's about three metric tonnes per kilowatt-hour of electricity generation. For the US fleet it's 2,000 metric tonnes per 100 reactors, so roughly about 20 tonnes a year.

MR JACOBI: I just want to come – sorry. I just want to come – stepping away from that to deal with the overarching framework that applies to the management of waste itself and the Commission has already heard a little bit about the joint convention of which Australia is a party but I am just interested for you to explain what you consider the key elements, or the two most important provisions within that convention which guide the way that disposal of waste must be managed around the world?

DR NUTT: Well, the two that I grabbed that are looked at and there's a number of provisions in the joint convention but the two are that we have is that – that I looked at are one is the - responsibility rests with the state in which it was generated. It does allow for management to be fostered along agreements between states, so as one state – one country, another country could work to an agreement where one might store or dispose of the waste but in general it's up to the country in which it's generated. And the other one for me is the protection of the public not only today but in the future. So it's this inter-generational equity that people of today are gathering the benefits from nuclear electricity or nuclear energy and should deal with the problems of today and not pass the problems down, while allowing the future generation some flexibility to do what they feel is best for them.

MR JACOBI: Can I come from that, the Commission has heard quite a lot about the role that dry cask storage is now playing within the ability to manage waste and I am just interested to – perhaps for you to explain the background as to why it is that dry cask storage has come to assume such a particular role in the management of waste around the world?

DR NUTT: I think it is one way to temporarily manage the waste, dry storage is – there is a general consensus that it's indeed temporary, that the ultimate solution should be disposition of it in a geologic repository. There may be – there is countries that are considering fuel cycles where you might reprocess and recycle materials back to the reactor but either way you are going to generate high-level waste that would need to be disposed of. Storage is an option, it allows the material to cool, it allows – it could increase flexibility in the system. In the US, in other countries we've gone more towards off site or dry storage as kind of a longer-term solution. Other countries are looking at interim wet storage and I think it's essentially up to the countries what they feel is best for them. We've gone towards interim dry storage at the reactor sites because all of the spent fuel pools for the US fleet are essentially full. In the nineties we did some work to re-rack the spent fuel pools to increase loading

densities, managed to fill those pools up because there's no disposition pathway and moved off to dry storage for essentially all of our power plants in the fleet.

COMMISSIONER: Can I just pick up on the dry storage Dr Nutt? What sort of studies have been conducted in the US to look at the longevity of these dry storage casks and is there a view about – conservative view about how long they will last?

DR NUTT: I don't – no one has done a study to put a – what I'll call a line in the sand for how long they can last. Our regulatory framework allows storage up to 60 years, dry storage. We have studies underway within the Department of Energy's programme, the Electric Power Research Institute which is our utilities research arm. It's also investigating various aspects associated with extended storage. The Electric Power Research Institute runs a group called the Extend Storage Collaboration Project which is involved in - a number of countries are involved with it that are dealing with the same issues that we are. So there is a lot of work going on looking at extended storage and what it entails. There has been several gap analyses done to identify what the key issues are and the R&D's under way to try to resolve those, so that there is confidence in extended storage.

COMMISSIONER: I would assume some of your dry cask storage would be approaching 60 years now?

DR NUTT: No, not that long. Some of them have gone through licence renewals. The regulations allow you initially a 20-year licence on the facility then you have to go back to our regulator for renewal. Several have gone through the renewal process; several of them are coming up on it. One of the key issues with the renewals is the utilities and the power plants in the US have gone to higher and higher burn up on the fuel, essentially means they've ran it longer in the reactor cores. So there is some questions that are slowly being resolved about the long-term performance of the fuel during dry storage. There's questions that are being investigated regarding the performance of the canister or cask that it's stored in over time.

MR JACOBI: I am just interested – can I pick up from that and ask about the level of satisfaction that there is with the technique of dry storage? That is, to the extent to which it's now thought to be developed, or that there are still developmental changes that need to be made with that technique?

DR NUTT: I'm sorry could you repeat that?

MR JACOBI: I am just interested to pick up from the Commissioner's question and that is just to understand the extent to which, given the practical

experience that has now occurred with dry storage, the extent to which there is satisfaction with the technique, or it's thought that there might need to be changes with respect to the way that dry storage is conducted?

DR NUTT: I think there's general satisfaction with dry storage - - -

MS SARAEVA: (indistinct)

DR NUTT: Yes, it's passive. We moved in the US from loading what I call casks with bolted lid and cask – to welded canisters and that's reduced some of the inspection time for the maintenance, the surveillances that have to be done. We have got a very robust dry cask industry in the US that is actually doing work internationally now. A lot of the other countries that also move to dry – I know the Germans are using exclusively dry systems for storage. So there's – I think worldwide there is satisfaction in it being a fairly proven storage method.

MR JACOBI: Could I come just to the – some design features that need to be born in mind with respect to storage and disposal? I think you picked up just in an answer, the need for passivity with respect to the removal of heat, and I am just wondering perhaps whether you can pick up what you consider the important design features to be in storing and disposal of spent fuel?

DR NUTT: In regard to storage, it's mainly contained the radioactive materials to ensure protection. That can be done, again, either wet or dry. The pool itself can provide the containment of the fuel within the fuel rods themselves. It can provide the shielding to the workers, to the public et cetera. So the dry storage, it's loaded in to the canisters when it's sufficiently cooled to be able to handle the heat that would be produced. They're dried, they're evacuated, they are filled with an inert gas. They're entirely passive in that the cooling is all passive and the waste – the fuel itself is solid, it's not overheated. There's multiple barriers for – to the containment. There's the fuel itself, the cladding, the canister, cask it's put in to. There's fairly minimum human intervention that has to be involved.

MR JACOBI: Can I just pick up with respect to the issue of security as well? To what extent is security built in to – you mentioned the fact that dry cask storage might occur at a site away from a nuclear power plant and I am just interested to the extent to which security needs to be considered in siting and design?

DR NUTT: It has to be considered. It is our regulatory framework requires security considerations and it (indistinct) when a site is operating, get the entire security of the nuclear installation itself. When the site is decommissioned there's a security force that has to be involved along with it. The security

requirements, I believe to decrease when you go from wet to dry. Entirely passive systems, big sealed canisters, protected by big concrete shields, so there's – there's I guess, a little reduced security requirement for dry versus wet. If you go to an off site interim storage facility, the security requirements on that would – via a regulator would have to be met.

MR JACOBI: Can I come to the issue of disposal? We have heard in the course of receiving evidence from those involved in the Finnish projects, about the development of a safety case and I am just interested to understand the background to the origin of the idea, or the need for a safety case to be developed?

DR NUTT: I believe safety cases first kind of applied to anything nuclear. You have to demonstrate safety. It's kind of a fundamental tenet of nuclear so we were taught from day one of when our education started in nuclear. So it's typically for operating nuclear handling type facilities, it's pretty well defined on the type of safety assessments that have to be done. They're all engineered, all man made systems, they've all got the controls in a centre. When you get in to disposals, where I believe things get a little bit different because you are dealing with long timeframes, you're dealing with geologic systems, you are a large – sometimes large areas or footprints for the disposal facility and it leads to a little different type of safety case that one needs to consider to help build confidence in the safety of - the long term safety of the facility. Safety assessment is a key part of it. Sometimes you probably have to call for performance assessment or safety analysis. That is a key part of it. There is other arguments one would bring to bear in helping demonstrate to build confidence in the long terms safety of the facility. Natural analogues that people have investigated, all sorts of different things that people do to really build a case. But the safety case, the philosophy of the safety case is you begin it early in the development process and use it to inform your decision making as you proceed forward, identify the uncertainties, the critical uncertainties you have that one has, the key barriers that one has and focus the site characterisation and the research and development that the other way is to help resolve those issues to increase that confidence that one has in long term safety.

MR JACOBI: I am interested in the process of the development of a safety case. Is it something that's done in a single hit or is it something that one needs to constantly revise as one conducts the analysis?

DR NUTT: I believe one would want to revise it. As I said, when you're moving through a decision point to – for instance, if I had two or three sites that I was looking at, I would look at the safety cases and feed that in to the decision process by which I might select one, or how would I do my – evolve my site investigation programme and use the safety case. It is really iterative I believe, to be applied iterative for every decision point through the process.

MR JACOBI: You spoke of using natural analogues as part of the safety case. I am just interested with respect to geological disposal, the extent to which it is necessary to use that concept; I think we have had explained to us is multiple lines of reasoning?

DR NUTT: Yes. I mean there is – for Yucca Mountain we did a very extensive natural analogue study that looked at gathering analogues worldwide that were similar to processes, we were looking at relevant to the repository performance. One example that I had the pleasure to go visit was a uranium ore body in Mexico, outside of Chihuahua that had very similar characteristics as the repository environment at Yucca Mountain. So we were able to look at it, study it, track the migration of the uranium and its daughter products and use that to give us some – give us confidence that our predicted – long-term predicted models were giving representative results. There's others. People looked at long-term glass, we looked at – since Yucca Mountain had large emplacement drifts, we had investigations in to some old caves in Europe where the art is still on the walls that we looked at to look at how caves can distribute water around them rather than drifting through the art and destroying it. So there's a variety of different ways you can use them to help build the confidence in the analytic tools you are using to assess performance and safety.

MR JACOBI: I am just interested in the extent to which I can pick up, and whether natural analogues are the whole or their not, the extent to which it's possible to validate the computer models that you're otherwise using to make these sorts of predictions?

DR NUTT: I'll say it's not possible to validate the long-term disposal models in the traditional sense. In that you can't do an experiment and then run the model and validate the experiment for the repository itself. You can do a variety of techniques to again demonstrate your confidence in the models and their ability to reasonably predict or estimate exposures out in the future. We have spent a lot of time in Yucca Mountain licensing effort on that topic of demonstrating the validity of the models and the approaches we were doing. One of the keys in my opinion of the repository assessments is really explicitly quantifying the level of uncertainty that you have in the models, in the approach. I'm a proponent of the probabilistic performance assessment where you – in the assessment itself you capture the uncertainty and you propagate it through the end to the result.

MR JACOBI: Can I come to the Yucca Mountain process and I am just interested to understand the nature of the waste that it was proposed to be addressing this part of the Yucca Mountain repository and also to pick up any issues of the variability in the spent fuel that you needed to deal with?

DR NUTT: So when the Nuclear Waste Policy Act was promulgated in 1982, it limited the capacity of the first repository to 70,000 metric tonnes. When the Act was amended in 1987, it stopped our second repository programme but it maintained the 70,000 metric tonne limit on the Yucca Mountain site. In 1985, a decision was made by President Reagan to combine high-level waste from our nuclear defence work, with the civilian waste, so it was roughly about 60,000 metric tonnes of spent fuel and 7,000 or 10,000 metric tonnes of federal government managed, Department of Energy managed waste. That was a combination of spent fuel from production reactors and research reactors and high-level waste from the clean up of the reprocessing plants on the defence side. Commercial spent fuel is standard boiling water reactor, or pressurised water reactor fuel. It varies somewhat and just depending on the vendor that built the reactor and the model of the reactor, there is different numbers of pins, different pin dimensions but all in all it's pretty – for the purpose of disposal it's fairly homogenous.

On the defence side, the spent fuels that would be disposed of for coming out of the department side, there was quite a lot of variability in terms of the materials and in the safety assessment it would have been very difficult to quantify the performance of all that spent fuel. Some of it was aluminium clad; some of it was old reactor fuel. So there was a choice made to be very conservative and they simply assumed that when the waste package contains fuels degraded, that that material was immediately ready for – available for transport via groundwater pathway. The high-level waste glass is – there's some variability but not significantly. The model that was put together to model the degradation of glass waste form include that variability and uncertainty in it.

MR JACOBI: Do the differences in the origin of the fuel have implications in terms of canister design or other issues?

DR NUTT: There was a fairly standard design for high-level spent fuel from the commercial side and it's a 25 per cent pressured water reactor waste package for a 44 per cent boiling water reactor waste package. On the defence side, it was the waste package itself was a single canister, sealed canister with defence spent fuels in a larger canister with five canisters (indistinct) of the waste surround it.

MR JACOBI: I think we might have an image on slide 11. I think this is from the environmental impact statement.

DR NUTT: Yes. Yes, that would be – so in that one, the commercial spent fuel that's 90 per cent of the inventory or 60,000 metric tonnes, with the other 10 per cent being the Department of Energy managed materials spent fuel or high-level waste but the (indistinct) of that is some of the variability in the

spent fuel, some from test reactors, the end reactors, one of the old production reactors, different types of research reactors have been out.

MR JACOBI: In the process of the development of the facility, were there changes made with respect to either the canister systems or the facility design? I'm interested to understand how they evolved.

DR NUTT: Yes. The designs did evolve both for the surface handling facilities and the subsurface repository itself. So (indistinct) in this large spent fuel handling pool. They're all wet pools where the fuel would've been received and what I call a reusable bolted transportation cask. The fuel would've been unloaded into the pools and then loaded into waste packages. They would've been evacuated, sealed and disposed of. The change in - I don't have it written down - a change in roughly about the 2000, 2002 time frame, where the project started looking at dry transfer systems and bringing in the fuel in a dry system, opening the cask up dry and transferring the fuel dry

And then there was a subsequent change in about 2005 where the idea moved to what we call transportation, aging and disposal canisters, a canister concept that would meet the transportation regulations, the storage regulations, the disposal regulation. They could be loaded at the reactor site, sealed, to never be opened again, brought to the repository, put inside a waste package and disposed of. A lot of those design changes from wet to dry and a dry standard to receiving canisters was somewhat due to the higher seismic loadings at the repository site, and that is somewhat seismically active, so there were some pretty large seismic ground forces that had to be managed, and it was to build more modular facilities, smaller facilities that could be deployed in phases, could adjust to funding levels, could adjust to changes in the schedule of arrivals.

So on the subsurface, there was probably more evolution. When Yucca Mountain was first being looked at, the investigators were looking in what they call the saturated zone, which is below the watertable. They started in roughly 1983 looking at potential benefits there could be by moving above the watertable in the unsaturated zone, and made a decision to do that by - you know, roughly about 1983 they were looking at something similar to like what you probably saw with Finland and Sweden where there were small canisters being put into a form and realised that by moving into the unsaturated zone allows one not to have to backfill the drifts for the tunnels immediately. You could put the cans, larger canisters in a tunnel. You'd ventilate it so they can handle higher heat loads, and a design move to a large canister being placed on its side in the emplacement tunnels.

Waste package design evolved originally kind of a corrosion, stainless-steel type material evolved into having to put some corrosion-resistant materials on

it. In 1999, prior to doing the environmental impact statement for Yucca Mountain, in the site suitability evaluation that was done for the site recommendation there was a significant design alternative study that led to some changes in the waste package design, the inclusion of a titanium drip shield to further isolate the waste from any water that may be dripping through the emplacement tunnels.

Some of this was driven by the urban performance assessment work that was being done where the results of the performance assessment would link into the ongoing design and would necessitate some changes to reduce risks and improve repository performance in regard to safety, and essentially settled on the design that went through the Nuclear Regulatory Commission's licencing review, which (indistinct) safety evaluation reports were just released last year. So the design does evolve. In my view, it should evolve, it will evolve. Its understanding of the repository environment proceeds.

MR JACOBI: We had an extensive discussion about the technical evolution. I'm interested to understand the extent to which the community around the facility was engaged during the process of this technical development.

DR NUTT: The community involved in that period was really driven by the requirements in the Nuclear Waste Policy Act interacting with the affected state, affected units of local government, adjacent states. The Department had a number of hearings. The documents were all released. I'll use an example. From some documents issued with our site recommendation, from 1995 to 2001 there were 126 official hearings. There were 600 hours of meetings in 2001 alone. And they also offered tours of the site and there was a visitors' centre which people could visit in Las Vegas regarding the site. But most of the engagement and how the public was involved was prescribed per the Nuclear Waste Policy Act.

MR JACOBI: Can I take a step back? Prior to the particular site being selected and identified, I'm interested to understand how the siting process and how this particular site came to be identified.

DR NUTT: Well, prior to 1982 there were investigations looking at different sites for disposal of waste. There was a recommendation by our National Academy of Science in 1957 to proceed with geologic disposal. We started looking into it and investigating it. It was somewhat of a low level. They identified a site in Kansas (indistinct) ultimately proved that it wasn't going to work. Then after that, they promulgated the Waste Policy Act in 1982 that really laid out the process by which it would go for, and I believe one of the figures - what were the steps?

MR JACOBI: It's the rear slide, slide 12.

DR NUTT: Yes, from the state in the (indistinct)

MS SARAEVA: Slide 4.

MR JACOBI: Sorry.

DR NUTT: So it began in 1983 with the identification of nine potential repository sites that were investigated, and then to 1985, of that, five sites were nominated for further consideration and it moved through, essentially, into 1986 and 87 where three of those sites were identified as candidates for site characterisation. In 1987, from 1987 there was some political opposition and some of the states where the – one or two – all sites were located, began to see there was going to be an increased cost associated with site characterisation and congress amended the Waste Policy Act in 1987 that selected Yucca Mountain as the only site to characterise. So it did not select Yucca Mountain as the site that was going to be developed but it set up – of the three sites, characterised that one. That one in their view looked most suitable at that time, so between 1987 and 2002, the Department of Energy did site characterisation work and studies in design work for Yucca Mountain that ended with a site recommendation decision that was made by the Secretary of Energy essentially agreed to by the president. The Nuclear Waste Policy Act allowed the Governor of Nevada to disagree or veto, which he did and then it went to both our senate and our house and they overruled that veto. President Bush signed the site recommendation and the law.

From there the department progressed to submit the licence application to the Nuclear Regulatory Commission which was done in 2008 and then from there we had the (indistinct) no longer pursue it. So it was a fair step wise iterative process to try to get the site selection, the congress decision 1987 had some ramifications in Nevada. They were adamantly opposed and remain such throughout the entire development of the repository project and they are today.

COMMISSIONER: Would it be fair to characterise this process as top down?

DR NUTT: From 1987, yes. I believe personally, prior to 1987 it was a fairly comprehensive siting process to try to look at a variety of sites and a variety of locations to come up with a few. There was some top down focus on it but that really I think changed in 1987 when it was somewhat more of a political decision to pick Yucca, than a technical one.

MR JACOBI: I am just interested to pick up, you said before that a decision was made with respect to the Yucca site in 1987 and I am just interested to understand the extent to which there was any social consensus or any study of when a decision was made, that it was the suitable site about whether or not

social considerations were taken in to account, as opposed to technical considerations.

DR NUTT: So the question was whether any studies done on the social consideration as opposed to technical considerations, I'm not aware of any that looked in to that. We could – we can look and see what was done but I personally am not aware of - - -

MS SARAEVA: (indistinct)

DR NUTT: Yes, I am not aware of anything where they actually looked at the social implications of what may have been done in 1987.

COMMISSIONER: Was there any – Dr Nutt was there any concept of recompensing the local community for having this facility on their – in their backyard for instance?

DR NUTT: I'm sorry; you broke up a little bit.

COMMISSIONER: I was just wondering whether there was any thought of recompensing the local community for having a facility on their site, on their land?

DR NUTT: There wasn't anything – so our Nuclear Waste Policy Act had guided what had to be done for the local community in terms of what we call a payment equal to taxes that was done. There was some tax that had to be given to the state to do their own studies but I don't believe there was anything that was required in terms of what I'll call benefits for hosting the repository. I know people had brought up the subject and some of the opposition in Nevada was – they did not want to take any benefits; they didn't want to be seen as being bought. They were opposed and always opposed. That is part of the – I think the ongoing discussion that is happening in the United States with the recommendation by our Blue Ribbon Commission to follow consent the siting process. What does that entail? And we don't know right now.

MR JACOBI: You spoke of there being a number of public hearings that were conducted in the post 2000 period. I am just interested to understand what those public hearings related to? Were they hearings associated with the EIS, or were they related to other issues?

DR NUTT: They were mainly related to the environmental impact statement. Our laws – our National Environmental Protection Act requires the development of an environmental impact statement and it involves public comments on the environmental impact statement, public (indistinct) on the draft, consideration of those for the final public hearings and consideration of

comments made to hearings. There were also hearings that were held around the site recommendation decision that was going to be made by the department. So in a sense, I think that the department held more than they were required to by the law, so they did try to have – get to as many people that could be affected. They weren't just in the repository location; they were around the country and some of the cities that might be affected by transportation.

MR JACOBI: I just want to move to some of the work that has been done since the Blue Ribbon Commission and that is I am interested to pick up on the concept of execution strategy analysis that has been done. And I am just interested to understand perhaps first the backdrop to why it is thought to be important to study timeframes and how timeframes are fixed and whether there have been any particular difficulties associated with fixing timeframes for these large projects?

MS SARAEVA: So when the Blue Ribbon Commission worked out previous experiences of siting different waste management facilities in the United States and abroad it came to the conclusion that the practice of having some rigid outlines was not proven to be very effective because like implementing siting and implementing such a facility is very complex issue. Now I don't mean technologically but there are also other components to it like social funding and that so if they're very rigid deadline is set and not – and then not met so stakeholders and publics tend to lose trust. So that is why the Blue Ribbon Commission recommended that rather than having rigid and non-moveable they should be phased and adaptive approach (indistinct) like several (indistinct) they're re-examined and (indistinct) pending on how the project is going.

MR JACOBI: I am just interested, and if one isn't to fix a clock associated with particular decisions being made, whether you have any views as to what tool you might use for the purposes of managing an overall process?

MS SARAEVA: Well, definitely some tools available that can help reach the (indistinct) estimate some timeframes and some phases duration. Under nuclear – and it is cheaper for (indistinct) nuclear fuels storage and transportation planning project we are developing tools for education strategy analysis (indistinct) ESA, so ESA allows us to see different ways of implementing future projects, assess a big picture. So what would it take from the start to the success and it also depends how you define success. So what would it take you to implement a project and try different ways how you can gear it and we use – in our approach we use a variety of subject matter experts on the topic which balance different big level objectives, duration and cost and (indistinct) we use a tool which is - allows use a dynamic and probabilistic solution and that takes into account models of (indistinct) but uncertainties and risks because sometimes we tend to be optimistic about how soon we can

accomplish one or another activity and the duration sometimes do not include potential - the risks. So there is a tool, that uses GoldSim software that allows us to assess the performance of project (indistinct) impact of uncertainties and risks.

COMMISSIONER: Thank you very much for spending some time with us – our morning, your afternoon. We very much appreciate the work that you put in to this. It has been very helpful for us to understand the development of Yucca Mountain and what is happening subsequent to that and we very much appreciate your participation.

DR NUTT: You're welcome. If you have any follow up questions, or any additional information you are looking for, please let us know.

COMMISSIONER: I think we would like to follow up the model and we will do that out of the hearing but thank you again. We will now adjourn until 11.00. We will move across to the subject of nuclear non-proliferation.

ADJOURNED **[10.03 am]**

RESUMED **[11.00 am]**

COMMISSIONER: We'll reconvene at 1100. The topic is security and non-proliferation risks, and we welcome Professor Henry Sokolski. Thank you very much, professor, for joining us. Counsel.

MR JACOBI: Undertaking nuclear fuel cycle activities for peaceful purposes carries with it the unique potential for some technologies and materials to be adapted or diverted for non-peaceful means. History has shown that governments and non-state actors have made attempts to adapt technology or divert materials. The Commission's terms of reference require it to consider the extent of the risks associated with the establishment of a range of nuclear facilities. This includes the potential expansion of the mining and milling of uranium or the establishment and operation of facilities to process uranium into nuclear fuel to generate power or to store and dispose of nuclear waste, including spent nuclear fuel. Each of these activities carries some proliferation and security risk.

The concept of proliferation relates to a national government's acquisition of nuclear technologies and materials for the purposes of establishing a new nuclear weapons program. Security is concerned with the protection of materials and technologies. Both of the issues are related. The Commission is concerned to understand which activities present particular proliferation and security sensitivities and how they might be exploited. The Commission will then need to consider the regulatory and other means which are in place to

minimise those risks, including international safeguards and physical protection measures and their effectiveness in achieving those objectives.

The Commission will analyse those risks in a South Australian context, that is, by conducting the additional risks created by the potential establishment of South Australian nuclear facilities or by the export of products from such facilities. In that sense, the Commission's task is narrower than would be the case if it had to review issues of proliferation and security more generally in the context of nuclear facilities located in anywhere in the world.

As has been explained in the issues paper, the issues of non-proliferation and security fall within the realm of the commonwealth government, and in the case of non-proliferation exclusively. The task for the Commission is not to review the organisations responsible for those matters or their effectiveness, but rather to identify the reasonable range of risks associated with the potential expansion in activities and report on that range. The Commission has already touched on these issues in the evidence of Dr Tom Cochran, and to develop its appreciation of these issues, the Commission will today speak with Professor Henry Sokolski about the extent of those risks, and Dr Robert Floyd, Director General of the Australian Non-Proliferation and Safeguards Office, ASNO, about the international and local regulation and management, and indeed, it will return to this issue in the coming weeks.

Professor Henry Sokolski is the executive director of NPEC, a not-for-profit organisation established in 1994 and based in Washington DC in the United States. NPEC seeks to promote and enhance the understanding of strategic weapons proliferation issues, and Professor Sokolski also serves an adjunct professor at the Institute of Politics in Washington DC. Previously, Professor Sokolski has held positions including deputy for non-proliferation policy in the Pentagon and is a member of the Central Intelligence Agency Senior Advisory Group. Between 2008 and 2010, Professor Sokolski served as a member of the Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism, which was established by the United States congress, and the Commission calls Professor Henry Sokolski.

COMMISSIONER: Professor, if I might go directly to the risks, you will appreciate the Royal Commission is looking at the opportunity, cost and risk of extending its activities beyond just mining into areas of power generation, of waste and storage, and front-end nuclear activity. For a nation such as Australia, what do you think the non-proliferation risks might be as we expand in those areas of the nuclear fuel cycle?

PROFESSOR SOKOLSKI: I think the key risk in every case, even including mining, turned very heavily on whether or not the activity can be sustained by domestic consumption and finance privately. If those two conditions are met,

the risk with regard to exporting to marginal customers with marginal non-proliferation credentials is all but eliminated. The second concern, however, may be independent of that. It is conceivable, although I think the invisible hand of Adam Smith will guide you away from these dangerous, uneconomic activities of reprocessing spent fuel and enriching uranium.

But if, per chance, you were able to make money through domestic consumption there still would be a second risk, and that second risk would be the example that you would set for your neighbours and the world. That would be a problem as well, because these activities, whether meant to be peaceful or not, bring nations to the brink of bomb making, and really cannot be safeguarded in a fashion that meets the IEA's own criteria for timely detection.

COMMISSIONER: I might pick up that issue of safeguarding in a minute, but based upon what you've just said, do you see a non-proliferation issue with light-water reactor power generation, for instance, if activities were to be constrained to that?

PROFESSOR SOKOLSKI: Yes, I do. The problem with light-water reactors is that despite their peaceful intent by their designers, they can be used to make weapons-grade and weapons-explosive plutonium in large amounts. The United States government in 1987 actually considered seriously buying an incomplete civilian reactor in Washington State to produce weapons plutonium and tritium to put pressure on the Soviet Union. For a number of reasons, including glasnost and détente, we did not follow through on that, but technically it was very attractive. So power reactors are safeguarded by the IEA in recognition of this possibility.

So light-water reactors are not immune. I think if you are looking for an immune activity to proliferation implications it would have to be very small, zero power research reactors that could not produce enough material to make a single bomb in anything less than five to ten years. Those I think you can let spread almost about anywhere, and you can get timely detection of diversion in plenty of time. Once you depart from that, you back into some very tricky propositions.

COMMISSIONER: We are talking about an Australian context here. So what do you see are the difficulties in providing safeguarding for a country such as Australia?

PROFESSOR SOKOLSKI: Well, in the case of Australia, assuming there was no desire to get nuclear weapons, and the memories of past programs were well behind you, you could argue that safeguarding wouldn't be an issue except to the extent that it presented a precedent for other countries. This is why I get back to the first criteria. If you launch into a program that is state supported -

that means subsidised, directly or indirectly - and the project depends on that support, you will then enable other countries, including your neighbours, to argue that, well, they too would like to engage in these activities.

Once you engage in a power reactor program in a country that may not have the intent of keeping the program peaceful into the future, you run into problems. So you have to think ahead of whether or not you have the high economic, if not high moral, ground to be able to say, "We engage in this activity because we don't need to have state support. It actually is financed and supported by domestic financing and consumption." That standard would probably allow you to go ahead and not only have to worry about safeguards, but the example you've set.

COMMISSIONER: We had it put to us that nuclear power generation might be the saviour in terms of climate change. Would you add that to your economic analysis of light-water reactors in terms of accepting their development?

PROFESSOR SOKOLSKI: I think I would not, and I'll tell you why. This is a topic which has been debated very extensively here in the States and as a result, the folks promoting nuclear power and the folks who are against nuclear power have gotten focused on very, very detailed analytical models. The best, or I should say the one used the most, is put out by an auditing firm called McKenzie. This model has been used by Greenpeace analysts and the largest merchant utility utilising nuclear power, Epsilon, and they both use this model and they both agree that it's a good model, and this model tells you that you should do about ten other things first if you're serious about reducing carbon before you buy a new power reactor. That strikes me as very, very interesting and as positive.

More recently, I think you can read an article that was put out by Chris Buckley in the New York Times, and he makes the case that others do, that China must go with nuclear to reduce its carbon footprint. But he repeats the claim by the government of China that at most by 2030 if every one of the reactors they built was built on time, which will be a remarkable achievement, they will only have 10 per cent of their electricity generation supplied by nuclear. The rest will likely be fossil fuels.

I think this tells you how far you can go with nuclear. First, not very and second, there are quicker ways to reduce carbon that are cheaper. Mostly it has to do with management of consumption which is a fancy word or phrase for turning the lights off more regularly and the second thing is doing natural gas substitutions for coal. Those are your quickest, cheapest ways to most dramatically reduce carbon and that is the project probably of the next three decades. That is where you will make your advances. Also grid

rationalisation; most people don't realise it but if you look at an outlet, power outlet, and you ask yourself the question of what am I paying for when I pay the bill for what comes out of that outlet? Most people think that they're paying mostly for electrical generation. I think in the United States, usually my students say 70 to 90 per cent of their bill must be related to the generation of power. Actually two thirds of the cost have nothing to do with generation, has to do with balancing the grid.

If you rationalise your grid by making it more efficient, you don't need anywhere near as much power generation. It's very non-intuitive and that also will be a major avenue for reducing the amount of electrical generation and therefore the amount of carbon. The investments of the Chinese demonstrate this. They are spending more on their grid rationalisation and are interested I think even more in capitalising on liquefied natural gas imports and natural gas substitution for coal than they are in nuclear, which is not generally well known.

MR JACOBI: Professor, I was just hoping to pick up, the Commissioner's question, I think specifically asked as to whether or not you should factor in to the – your economic argument, other benefits? That is, other than the fact that it might be profitable and benefits such as CO2 abatement, in to your calculus with respect to that matter? That was – I think his question, irrespective of whether you might - - -

PROFESSOR SOKOLSKI: Well - - -

MR JACOBI: Irrespective of whether or not you might have an argument about whether those benefits exist or they don't?

PROFESSOR SOKOLSKI: Well, I thought I was trying to answer that by saying the model that merchant – the largest merchant nuclear utility in the world uses, tells them that the economics do not recommend it until very, very late in the game. They argued that having used this model that the price of carbon as a tax, which currently is zero most places in the world would have to rise to somewhere in the neighbourhood of $160 per tonne, or conversely you could have a combination. If the price of natural gas for 1,000 BTU they argue rose to the level above – in the United States of above $8 per 1,000 BTU and you had a carbon tax of over $25, it would then perhaps make sense to build new power reactors. Those figures, economic figures make it very clear that that is very distant. Our price now is for 1,000 BTU for gas is now around $2 and we don't have any carbon tax at all. Zero. And I think in Europe it's not even anything close to seven. So the short answer is, I wouldn't factor that in, or if I did, it would be very slight because the economics currently don't seem to sustain that argument. What the economics argue is that you should do many other things before, if you are interested in reducing carbon, and so I

wouldn't give that much weight. In fact there are a numbers through this model assigned to it and the economics don't look very strong for using nuclear for carbon abatement.

Let me give you one example, just to drive this home. If someone comes to you and said, I can eliminate all the carbon emissions in the world but here is the catch, I need 200 years and a quadrillion dollars now. And someone comes to you and says in 20 years, I can reduce your carbon emissions by 50 per cent and I don't need you to do anything but follow the economic signals you are current getting by doing gas substitutions, it's pretty clear what you would do. That is the reason why I would not give much weight to that fusion option, economically, for obvious reasons. There is a time value to money investments in carbon reductions and that is what that model, the McKenzie model does. I recommend focussing on that and thinking about the economics of any carbon abatement scheme, whether it's wind, solar, nuclear or anything else.

MR JACOBI: Can I come back to – closer to home and to non-proliferation, and - - -

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: - - - I am just interested in picking up on where you see the relative risks associated with proliferation existing, thinking about the entire nuclear fuel cycle? Is it right to say that the greatest risks exist in the area of enrichment and reprocessing?

PROFESSOR SOKOLSKI: Yes. But with one qualification; you can't reprocess without a reactor. If you only – if you didn't have reactors in the world, reprocessing wouldn't be a threat. So you need to have two to tango and I think people get this wrong repeatedly. They think, well all we have to do is prevent the reprocessing. Certainly when I was learning first about this topic back in 1973 and four, there was an optimism that we could somehow prevent the enrichment and the reprocessing clearly. The problem is that increasingly, enrichment is being seen as something that is not to be viewed as dangerous and as normal and reprocessing may get that status fairly soon on the one hand and the on the other hand, we have learned over the last 20 years, that the ability to find covert facilities is very, very wane, we keep getting surprised late in the game about where things might be. When you put all of that together, it really recommends thinking about more of the fuel cycle rather than less and I think what we have learned over the last 40 years is that it's too optimistic to think you only need to worry about what you can see in the way of enrichment and processing.

MR JACOBI: I am just interested in just thinking about the fuel cycle conceptually and that is that if I was to have a nuclear power plant in isolation

of enrichment or reprocessing - - -

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: - - - and I am just interested to understand your view with respect to what you consider the proliferation risk is, associated with that?

PROFESSOR SOKOLSKI: Well, clearly if you only had a power reactor and you did not have reprocessing enrichment and you were confident with that, then I think you would be quite safe. It's the lack of confidence in the other propositions that brings the trouble and I must say, we are moving towards a world that is accepting of enrichment and of reprocessing which complicates the problem doubly. Not only now have to worry about covert lines but overt lines. Because once those activities begin, even if they're monitored, they cannot be safeguarded. The reason why is you can inspect but you cannot get timely detection of abrupt or even gradual or incremental diversions from those very large processing facilities.

MR JACOBI: I actually want to come back and just deal with that particular issue in a minute.

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: But I am just interested, if one comes to a country like Australia which is a signatory to the MPT - - -

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: - - - and is involved internationally in non-proliferation efforts, I am just interested to understand what you see is the real proliferation issues, if a country like Australia was to engage in more fuel cycle activities and perhaps if we can start off with nuclear power plants?

PROFESSOR SOKOLSKI: Well again, I think you make a pretty good case that if you could restrict the activity only to a light water reactor, and you could convince the world that you are not engaged in any of the other activities of enrichment or reprocessing, you would have a technical leg up. You would still be setting a precedent if however, you were subsidising that activity because others would then use that as an excuse to go ahead. So you would be in a smarter position if you did not have those things but you wouldn't be totally clear.

MR JACOBI: Do you think that risks change if one then adds enrichment or reprocessing in to that mix?

PROFESSOR SOKOLSKI: Substantially, dramatically. So you go from sort of okay to really bad and the reason it becomes really bad can be seen, I think most easily by looking at the current situation in East Asia, which is not that distant from you. I have been spending the last year travelling back and forth talking to Chinese, Japanese and Koreans, South Koreans. And the problem there is once you get in to this activity, in this case reprocessing by the Japanese, they were going to open their facility up really massively large facility for recycling weapons explosive plutonium in March of next year, if you get engaged in that activity, well the Chinese were very interested in following suit. And then the concern was well if the Chinese or the Japanese went ahead, the Koreans would demand that the United States allow South Korea to do the same thing. In all of these countries, when you start engaging in uneconomic dangerous separation of plutonium, the prospects are very, very great that you will be stockpiling literally tens of thousands of bombs worth of plutonium for many years.

Now the idea that countries like Australia would engage in this, would only give further credence to the idea that, well everyone's doing it, why not us? You might even see your neighbours follow suit. I mean it's pick a sensitive possibility. I understand the Indonesians are now interested in possibly buying Russian floating reactors. What else might they be interested in? What might the dynamic be between your country and Indonesia if you engaged in certain other additional activities? One wonders.

MR JACOBI: You have identified, I think so far, some deficiencies that you consider exist in the safeguard system with respect to - - -

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: - - - the ability to detect, and I am just interested to understand what you consider the key deficiencies are in the system that might relate to Australia?

PROFESSOR SOKOLSKI: I think you are never going to be able to keep track of the gases, powders and liquids involved in enrichment in reprocessing and most fuel fabrication and probably uranium feed activity such as hexafluoride plants. So whatever your intent, you will inherit the great tradition that we have learned about in the United States, it's called material unaccounted for and in our case it's several thousand kilograms of material. We don't know where it is. We still don't. So you, if you're lucky, if you get engaged in this activity, will be able to join us in this great tradition of not knowing where literally hundreds of bombs worth of material will be. So there's that; I think you have to be concerned about other people's experience making fuel and their inability to keep track of all of it. Under the best of circumstances, large facilities technically, according to the IEA, you can keep

track of everything statistically but one per cent, that sounds pretty good until you look at the size of many of the facilities that would be recommended for commercial size activity and you consider that if you put humans in the loop, the number goes up. It goes up several fold and then the numbers get very large per year.

So even again, under the best of intentions, you create an environment where you are having to argue about where things went and justify why you shouldn't worry. That's not anything that encourages a great example for the rest of the world. And it's just – it's no one's fault, it has nothing to do with motive.

MR JACOBI: Sorry, am I to understand from that, that there are simply inherent deficiencies in the system of accounting in your view?

PROFESSOR SOKOLSKI: I have to admit that my background is that of someone who studied constitutional law in graduate school for many, many years. I do read, however, luckily. There's hope for people like me. You can get in to other topics, so I am not going to propose that I am a physicist, I know my limits but there are certain laws of physics that I'm aware of, or I've heard about and diplomats don't like dealing with these laws. They'd like to have a world that doesn't accord with the laws of physics and so they talk about things as if technical realities can be ignored. You can keep track pretty well of large solid objects, this is commonsense but when you're talking about particles of gas, particulates of powder and liquids, the measurement capabilities of all of the things that we can imagine, are not what they need to be. You are going to lose track statistically of some of the material.

More important, far more important than that gradual diversion problem that I've raised, it's a technical reality, is that when you start dealing with materials that are themselves nuclear explosives, plutonium that's separated and is plutonium. Highly enriched uranium. These items can be directly made in to insertable weapons cores and the amount of time that you can have after detecting a diversion, before it becomes a bomb is too short to allow any political intervention to prevent the bomb from being made. So those two realities are to paraphrase Senator Gore, Vice President Gore, "stubborn and inconvenient truths" that yes, I don't think diplomats fully, fully grasp.

MR JACOBI: Are you of the view that there are unilateral actions that a state might take over and above whatever the safeguards requirements are that are promulgated by the IAEA that could communicate clearly its intention either not to engage in particular activities, or to further demonstrate the fact that it is not seeking to divert material?

PROFESSOR SOKOLSKI: Well, you would have to allow wide area surveillance of the kind that was experienced during the Iraq – after the Iraq

war, which is extremely unorthodox for a sovereign state in peacetime to do. But it is an area where the IEA could, this is very woolly headed but this is conceivable, it could be given the authority to do a wide area surveillance search of a country in a much more robust way than it currently does. Now they currently argue that they can get a sense of whether a country has a covert or undeclared facility by interviewing and discussing and examining open source materials. This is what is the lead up to an additional protocol. But I think in some cases, the agency would be hesitant to use that kind of technique with certain countries for fear that they might make a mistake. The work around would have to be some rather energetic inspections, I suppose and this is well beyond my arena. This is very woolly headed what I am suggesting.

MR JACOBI: What I had in mind was the ability to demonstrate, for example, the material wasn't being diverted by taking steps to demonstrate compliance that were over and above those that had otherwise been contemplated? Do you think - - -

PROFESSOR SOKOLSKI: I think that's what I – I think that's what I was trying to forecast what it might look like. It's a tall order but I think it would have to be something along the lines I mentioned. Unless you have something specific in mind?

MR JACOBI: I was interested to pick up, you spoke about, I think a link between the economics of nuclear fuel cycle activities and proliferation - - -

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: - - - risks, and I am just interested to pick up on the two themes. As I understood the first was that if one engaged in non-economic nuclear activities, one would have an incentive, as I understand it, to seek to recoup on one's investment by selling to parties with perhaps questionable proliferation standards. I'm interested to understand the extent to which there's any example that might demonstrate that proposition.

PROFESSOR SOKOLSKI: I always like to start at home. People tend to listen to you if you point to yourself, so let's start with the United States. Iran, we trained most of the people who are senior in that program at MIT. We subsidised that and we changed the admission requirements to make it easier for them to come in. Why? Well, we are going to sell something in the order of 20 or more power reactors. It's going to be an enormous market. There were ads celebrating how the shah was going to buy all these reactors and they were all going to be American. We were going to help them actually set up a big reprocessing plant.

Now, we put our foot down and said, "Well, maybe we can't do the latter," but

it's not well known that towards the end of the shah's rule he met with the president of the United States, Jimmy Carter, and even that was considered perhaps something we would reopen, and I think part of the reason we did that was our desire to support the shah, but part of it was it looked commercially very attractive. He had money, a lot of it. So that's one.

Then there's India. Similar. We were going to do both good for ourselves and good by them and good by the world. Enormous market. All these people needing electricity. So first we went with the Canadians and tried to bootstrap them technically with what was called the Canadian-Indian-US Reactor, CIRUS reactor, and we gave them all the technology and training they needed to operate that plant and to do recycling. All this was under a pledge that it would only be for peaceful purposes. They used that to make their first bomb. They call it a peaceful nuclear explosive.

We also sold them two light-water reactors at TerraCorp. We thought that they would promise not to reprocess that. They said, "No. You misread what we promised. We would like to reprocess it." We have never resolved that. We continue to give them technology, and even reopened the whole question of whether it was okay for a state that had bombs and never signed the pledge under the Nuclear Non-Proliferation Treaty not to, whether or not it would be okay to give them civil assistance. We cut a new deal in 2008 and the materials that we are now selling, which include some uranium, now is making it easier for them to make more bombs, and we did all this because there was a market and because we thought we could capture it. We have failed to capture it yet.

MR JACOBI: Professor, could I interject there? The examples you've identified involve the export of technology, and I'm interested in whether there's a distinction between that and the export of, for example, fuel by a country such as Australia were we to fabricate fuel in Australia to be sent overseas and to be used in power reactors elsewhere, or, for example, for it to offer enrichment services.

PROFESSOR SOKOLSKI: All these activities are scenario dependent, but to use the Indian example, which comes close to home for the Americans, and, I think, for Australians, for obvious reasons; you've just cut a deal to do the exporting as much as we have. The Pakistanis make a very good case that by sending civil material that is under safeguards in India, you are freeing up domestic production of uranium that is not under safeguards to go to make more bombs. This strikes me as a pretty strong argument, not just because the Pakistanis are making it, but because people who are senior officials in the US government, now retired have made this argument, people who focused on nuclear proliferation issues. So, yes, you run the risk in certain cases of actually encouraging certain bomb-making activities even if you sell the

material under safeguards.

Now, that isn't true for countries that have all of their facilities under safeguards, but you'll see what happens when you're desperate to capture market share: you go where you can. The United States, I believe Russia, France, Japan, Korea, have all tried to see if they could make sales to India. Similarly, sales are now being contemplated for Saudi Arabia, a country whose leadership has openly discussed its desire to make nuclear weapons at some point, and have talked about their civil activities as a way to bootstrap themselves into that capacity or option. I could go on, but, yes, there's a connection even there.

MR JACOBI: Can I pick up on the second strand of the argument you made, and that was the relationship between non-economic activities and offering an example to other countries and the extent to which that might be used as providing for a foundation for other countries to engage in such activities. I'm interested to understand the extent to which you consider there have been real world examples of that.

PROFESSOR SOKOLSKI: I think it's pretty clear that India, which is enamoured of breeder reactors - which make regular reactors look like money machines; these things are very, very uneconomical, well beyond anything you could accuse any light-water reactor of being - and their desire to close the fuel cycle got a lot of impetus from the similar activities that could be found earlier on in France, Great Britain, Germany and the US. Now, each one of these countries has turned those projects off, but not before the Indians pointed to them as examples for why they should proceed.

Their breeder reactor, I might add, is unsafeguarded and is almost certain to be used to produce weapons material for their weapons program. They point also to perhaps what Japan originally intended to do. Their program is still on paper, but in practice, it's not operating at all. So, yes, that's one example. I could point to others, if you'd like.

MR JACOBI: Can I pick up on a different topic, which is the relevance of what I might describe as multinationalism or internationalism with respect to fuel facilities. I'm interested in your view as to the likelihood of success of such an approach to be able to provide a relevant arrangement for non-proliferation, particularly for enrichment activities.

PROFESSOR SOKOLSKI: Yes. Well, there are two ways to look at this: one is the hope established, as far back as 1946 under the root plan and the staff work of the Acheson Lilienthal report, which first discussed the idea of having international ownership of all dangerous nuclear activities, as they described them - if the world had actually been arranged under such tight

controls as were suggested there, I would venture to say that it would make some sense. The premises of such tight control that all dangerous, large reactors, all mining of uranium, all enrichment, all reprocessing, would be owned and operated by an international authority makes one's head spin. I mean, the likelihood of that happening now is very, very remote. Everything is nationally owned in those categories. There is nothing internationally owned.

But one can imagine that scenario, and that is the scenario that has been offered up on a voluntary basis. What if we had a voluntary international enrichment effort? Well, perhaps. I am very sceptical though. There is a real world example of a multinational enrichment effort. It was Urenco. What happened there? Well, first, I understand the Israelis went in and managed to take an awful lot of information. They have an enrichment program for their weapons program that's based on the technology they were able to get. And then of course Mr AQ Khan visited and he, in turn, took the technology, gave Pakistan its first batch of uranium for its first bombs and of course he shared the technology in turn with Libya, it looks like Iran and we're still tracking down all the other places it may have gone. What is interesting is to even make these transfers look more attractive, the Pakistani agent in this case, and I think the government had some knowledge of this, I'm trying to be very diplomatic here, sweetened the deal with all sorts of other things, including preliminary bomb designs. So that experiment in multinational control of enrichment did not go very well. The idea that somehow new circumstances would permit you to succeed after that failure just shows the pride of optimism of the human spirit. I am not sure there is something that's happened that would suggest success in the future in a way that would be convincing.

There are people that say oh well, you could black box the technology. This again strikes me as diplomatic physics. It's what – if you don't know very much about the technology, you can imagine it not being accessible to anyone by some series of devices. If you know a lot about the technology, much like I guess cyber competitions, you know how to break the link. That which is devised by humans technically can be seized, broken in to by humans and we've learned this the hard way in the case of Iraq. I don't think that's going to change.

MR JACOBI: I am interested to the extent to which what you have described with respect to URENCO represents a failure of multinationalism in the sense that other countries couldn't be assured of what other countries were doing because no one country had control of it. I am just interested that the examples you have given involve, in essence, the theft of the technology and I am just interested to understand the extent to which multinationalism might though have a role in offering other countries assurances that the host country isn't seeking to use the technology for another purpose?

PROFESSOR SOKOLSKI: I think that raises an interesting theoretical. In the case of Germany and the Dutch and now I guess the Americans and the French, the concern that it might be seized to make bombs is very low. But you know if you had a multinational fuel centre in East Asia or in the Middle East, yes we can see at least this much evidence that there be a worry. My friends who are South Korean were asked pointedly well why don't you just let the Japanese do your recycling, or why don't you let them do your enrichment? You could do it together, and the rejoinder was why would we want them to do it, we would prefer to do it ourselves. That is a backhanded way of suggesting that they don't feel comfortable doing it in places where there are competitions. They feel like that would only allow the Japanese to have all the benefits of having the facility there, without South Korea having the benefits of being able to compete. And this is not economics we are talking about but it's national security (indistinct) I think you would encounter that kind of fear and loathing in other places where you might want these facilities to work. For the sake of peace, they would work the worst in those locations. You might want to find another Holland, if you want to do this.

MR JACOBI: Yes.

PROFESSOR SOKOLSKI: Right, and – but even there, it didn't work very well did it.

MR JACOBI: I am just interested to pick up about whether you see that there is any place for multinationalism at all with respect to fuel facilities? Reading the speech that you gave back in – I think 2014, at the IAEA, you did talk about in the end that – and I think it was expressed in this way, that some honesty about the difficulties with safeguards could lead to an agreement that an enrichment facility be organised on such a basis. I am just interested as to whether you think that modern nationalism has any role at all in the process?

PROFESSOR SOKOLSKI: It would if you recognised why you need it. We are in denial about how safeguardable these activities are. We just say, well who can inspect or monitor, you can get timely detection and even the IEA in its more honest moments, will tell you that's not true. It will not meet the timeliest detection goals which have absolute numbers in a time and amounts and they cannot make those goals. So think if you have that first and if you could find a host location, I suppose it would make more sense. You would then have to prevent any additional national facilities and probably wean those facilities that are nationally owned off their national management. That is a pretty tall order. Most people are talking about – when they talk about multinational enrichment is well it's voluntary. We added on top of the existing structure and this somehow adds dramatically to our non-proliferation goals. I think that's not the case.

In other words, the suggestion in the paper that Victor Gilinsky and I gave, was you would have to go back to something more like an understanding of things in the Ashes of Lilienthal report in the Beirut plan. That's a pretty tall order. I don't mean to deny its role at all but I just caution that this is not something you can do a la carte.

MR JACOBI: Can I just pick up on why you think that – perhaps what you described as an overlay would not be effective?

PROFESSOR SOKOLSKI: The reason why is there is so many other sources for these materials. It isn't as though one would go to Kazakhstan for example to get surplus uranium. This is something that they've thrown out. Who would go to whoever supplies it currently at a market price and there is so many other suppliers. Also, it would not be binding that anyone go buy through this particular location. It might not be economically viable as a result. There is a reason why they haven't been created to date; those that have the technology who can make some money enriching fuel are doing so and have captured so much of the market that it's very hard to break in to the market. Right now, moreover there's a 50 per cent surplus of capacity to enrich, over demand and that is likely to continue to grow. To open up an additional facility and just – and to say it's multinational, it's voluntary to come to it, I don't think would necessarily help tamp down the problems associated with enrichment as a proliferation problem, or as a solution I should say.

MR JACOBI: I am just interested, perhaps this final question, in terms of – in your experience, has there ever been a case where a country has been able to effectively communicate an assurance that it was not minded to – that is was minded to engage in nuclear activities, perhaps nuclear power plants but to communicate effectively an assurance that it had no interest in developing a weapons programme, or proliferating?

PROFESSOR SOKOLSKI: I think de facto, certain countries have pulled that off, when they're part of an alliance system or an economic system NATO or the European Union but I have not – I would have to really reflect on that to think about has anyone explicitly pulled that off. I can't think of one.

MR JACOBI: Just that there are models where, for example, a country has indicated, and I am thinking about for example the United Arab Emirates, where the explicit policy of the model was, well we want to develop nuclear power but we explicitly disclaim - - -

PROFESSOR SOKOLSKI: Yes.

MR JACOBI: - - - engagement in other activities within the cycle.

PROFESSOR SOKOLSKI: You pick a case I know something about. That agreement was oral then it became very weak on paper and then it became firmer as a result of complaints made by organisations like my own. Actually, almost exclusively by my organisation, if I can brag a little. However, what we finally got is a very interesting obligation. It says, and this is instructive for this Commission, and I'd like to think it strengthens my argument a bit - in that agreement, if you read it carefully it says that the United Arab Emirates will be free to demand conditions more liberal than these restrictions if the United States offers any such more liberal nuclear cooperation with a Middle Eastern nation.

Now, there's been a bit of a kerfuffle recently when the chairman of the House Foreign Affairs Committee publicly stated that he had gotten a phone call and had a conversation with the ambassador from the United Arab Emirates that conveyed the thought that the UAE now felt like it could demand exception to the requirement that it not reprocess or have a heavy-water reactor, because we had a struck deal, after all (indistinct) that allowed them to enrich and therefore, under the terms of the agreement, they should be freed from the obligation. Now, I believe if you contact the embassy, they deny that call ever occurred, but eyebrows go up because it's in the agreement and it may well be that at some point they might feel that they're no longer obliged.

So all of these things that are set as precedents, as good as they are, have an undercurrent, and the more you learn about those undercurrents, the more worrisome even these efforts, which are really the best of what American non-proliferation restrictions have to offer, offer.

COMMISSIONER: Professor, thank you very much for your evidence today. It's been very useful.

PROFESSOR SOKOLSKI: Okay. Well, thank you very much for letting me speak and answer your questions.

COMMISSIONER: We'll adjourn to 1300 when we'll have Dr Robert Floyd from the Australian Safeguards and Non-Proliferation Office.

ADJOURNED **[11.52 am]**

RESUMED **[1.10 pm]**

COMMISSIONER: 1300. We will reconvene on the subject of security and non-proliferation risks, and we certainly welcome Dr Rob Floyd, the director general of the Australian Safeguards and Non-Proliferation Office. Thank you for joining us, Dr Floyd.

DR FLOYD: Thank you, Commissioner.

COMMISSIONER: Counsel.

MR JACOBI: ASNO is the commonwealth authority responsible for maintaining Australia's commitments under the Nuclear Non-Proliferation Treaty, the NPT, its safeguards agreement with the International Atomic Energy Agency and the Convention on the Physical Protection of Nuclear Material and Australia's other bilateral safeguards agreements. The director general of ASNO undertakes the statutory functions of the Director of Safeguards, the director of the Chemical Weapons Convention Office, and the director of the Australian Comprehensive Test Ban Office. Dr Floyd was appointed to this position in 2010.

Previously, Dr Floyd has held a number of senior positions with the Department of the Prime Minister and Cabinet where he provided advice to the prime minister on policy issues, including counter-terrorism, national security and counter-proliferation. Dr Floyd was also appointed to the IAEA's Standing Advisory Group on Safeguards Implementation, and the Commission calls Dr Robert Floyd.

COMMISSIONER: Dr Floyd, can I start? If we were to contemplate the sorts of fuel cycle activities that are part of our terms of reference, what would be the implication for Australia's international non-proliferation policies upon us?

DR FLOYD: Yes. Australia clearly is involved in the nuclear fuel cycle already with uranium mining, but we don't really take it much further than that. We have a research reactor, and we've set up the regulatory infrastructure within Australia to manage the risks that reside around proliferation, security, safety, environment. In my office, and my statutory responsibilities, it's about managing the risk of proliferation and security. If we, in Australia, took decisions to extend our nuclear fuel cycle footprint, then my office would have to look at how we manage the safeguards, that is, the measures to stop proliferation, and the security issues.

One of the biggest implications, I don't think our broad policy on non-proliferation would change. Our policy is that we take a very high standard when it comes to non-proliferation. We are very active internationally in putting in place the international architecture, working on conventions that counter weapons of mass destruction, et cetera. None of that would change.

What would happen is a lot would be expected of us. It is because we have a high and a strong reputation on non-proliferation issues that if we were to develop other elements of the fuel cycle, we would need to be consistent with our policy to demonstrate best practice, best international practice, within

Australia as an example to other countries, and consistent with our general policy approach to maintain our openness and transparency as far as we can, that no other country would have a doubt about whether Australia has changed its idea and is thinking of proliferating. Of course we would not.

COMMISSIONER: Evidence that we got this morning tended to suggest that nations with good track records such as Australia's are treated no differently than anyone else and that because of that, we can't trust that as a premise for moving forward. How is Australia seen in terms of its NPT credentials?

DR FLOYD: Australia is viewed upon very positively with regard to its NPT credentials, with regard to how we implement safeguards, and one of the reason why we're viewed positively - and this is not just blowing our own trumpet - is that we go beyond what we are legally required to do to build confidence - in my space, and I won't speak for others, but in my space - in the way that we put safeguards into place and in the way that were put security into place, is that we go beyond what we're required to do and we also step beyond so that we can be open and transparent and be able to demonstrate to others so they can have confidence that we are complying with our commitments.

COMMISSIONER: Would you expect us to be treated differently because of that track record and perhaps trusted in a different manner than other state actors?

DR FLOYD: Ultimately, it all boils down to trust, and in my space we often talk about "trust but verify", but it boils down to trust. There are things that states - and when I say "states", I'm generally referring to a country rather than the great state of South Australia. There are things that states can do build trust and there are things that states can do that cause trust to be eroded or not to be built. In Australia's case, I think we have a high level of trust from other countries about our non-proliferation stand and credentials. It is no secret that there was a time many decades ago that Australia looked at should they develop nuclear weapons, but I think it would be very difficult to find people who would then say, "I still have doubts as to whether Australia did give up that idea," and are pursuing this, because the international community trust us because we go the extra mile when it comes to these issues.

COMMISSIONER: Are there any nations, in your view, that would be seen as examples of this particular activity that the Commission might learn from?

DR FLOYD: Yes. There's a very good example, and I was visiting there just recently and I was talking to my Japanese colleagues and I said to them, "Those with much," as in, nuclear material and technologies and capability, "much is expected," and they have nuclear technology, which is entirely civilian in its use. They have 40, 50 reactors, not all of them operating. They

have enrichment capability; they have reprocessing capacity; they have a large stockpile of spent fuel. So they have much, and much is expected of them in terms of building the confidence of other countries that they are entirely focusing on civilian activities.

So Japan has put a huge effort into that, and the IAEA has put a huge effort into that. The IAEA has established a regional office in Japan. The IAEA has been working very closely with the Japanese regulators and entities to look at how would they safeguard Rokkasho this large reprocessing plant that they're developing, and Japan has taken a similar position to the one that we take, is that they will not be limited just by what is legally required, but they're looking to see that they can actually convince the rest of the world of their credentials, which are entirely civilian in orientation. So it's a good example.

COMMISSIONER: So they're a good international role model.

DR FLOYD: It's a very good example of a large nuclear footprint and they get it. They take it very seriously that they need to build confidence in the rest of the world to have the permission, in a social sense, to be able to do the things that they do. Yes.

COMMISSIONER: All right. Can I move now into the specific rather than the general, and we're now contemplating the activities that are part of our terms of reference.

DR FLOYD: Yes.

COMMISSIONER: So which particular activities within the fuel cycle, enrichment, fuel fabrication, nuclear power generation, storage - where do the major NPT concerns arise?

DR FLOYD: The major proliferation concerns arise around areas where it can directly support the possible development of nuclear weapons. So the key issue there is about the material that would be required for a nuclear weapon. There are two sorts of materials that could be used for a nuclear weapon. You could either have separated plutonium or you can have highly enriched uranium. So anywhere where those materials reside in the fuel cycle is of high proliferation sensitivity. So attached to that is where there is specific technology and no how required to develop those materials, then those technologies are of high proliferation sensitivity. So to unpack that, if you want to have highly enriched uranium and weapons grade that could be used in a weapon, you will need to have enrichment capability. So if a country develops enrichment capability for civilian purposes, that is actually a proliferation sensitive technology and a part in the fuel chain and therefore there will be high focus by the International Atomic Energy Agency, by other

countries on safeguarding that.

The second stage in the fuel cycle where the technology matters is that when you have spent fuel from a nuclear reactor there is plutonium contained within that spent fuel. If you are to separate that plutonium, that separated plutonium can be used for a weapon and you do that through the process of reprocessing. So the technology and the facilities that can reprocess spent fuel to separate plutonium is a highly sensitive part of the fuel chain from a proliferation point of view. The third area, I would mention, is any repository and storage where you have a lot of material that could be directly used and so if you had a large repository of spent fuel that contained plutonium then that amount of material becomes of interest; but only can it be used if there is a reprocessing capability. Now the International Atomic Energy Agency would look very closely to see if there is any indication of clandestine undeclared reprocessing capabilities, if you had this large amount of material. So the two stages of most significance is enrichment and reprocessing but it's the material that matters. If you have highly enriched uranium anywhere or plutonium anywhere then it's of key interest.

COMMISSIONER: So the activity of generating power from nuclear power plants is in itself not a proliferation – a major proliferation concern?

DR FLOYD: I'm glad you raise that. I listened to the evidence of Professor Sokolski this morning and I agree with him, that in some cases people underestimate the importance of power generation from a proliferation point of view. Some say it's of no significance. He said it was of some significance because if you don't have spent fuel, then what is your reprocessing actually going to reprocess? I think he's absolutely right. So it is important that we look at this as a whole system but that doesn't make a light water reactor operated in normal methods for power generation, efficient methods, of as much proliferation sensitivity as a reprocessing plant or enrichment plant. It just means that yes, you do have spent fuel; that if you had a reprocessing capability you could use that fuel. So it's not of zero proliferation concern to have light water reactors but it is certainly not the highest concern.

COMMISSIONER: Okay. If we now look at uranium exports, at the other end of the scale, I am interested to understand what Australia does to ensure that those exports are used for peaceful purposes?

DR FLOYD: The main thing we do and it takes a large amount of the effort of my office, is to establish firstly treaty level commitments and arrangements with any country that is to receive Australian uranium and any material that is derived from that, we call it Australian obligated nuclear material. We negotiate those treaties and we seek and we get a treaty level commitment by a

country that it will only be used for peaceful purposes. We establish arrangements to ensure that any facilities that our material would go in to, are under the International Atomic Energy Agency safeguards measures. That means they will be subject to IAEA inspection and the IAEA concludes their conclusions about peaceful use of those facilities and non-diversion of that material. But we also get other assurances in these agreements. We get assurances on security that our material will be secured to the standards recommendations that come out of the International Atomic Energy Agency based on some international conventions on the security side of things.

We put in place arrangements around the provision of consent for enrichment. If any of the Australian material is to be enriched above 20 per cent, then there is a consent required from us, as to whether that is to happen, or if reprocessing is to occur, or if that material is to be transferred to a third party, another country. Our material can only be transferred to another country if we have a bilateral treaty level agreement, a nuclear cooperation agreement with that other country. So there is this network of legally binding arrangements. There then is reporting on tracking and the disposition where and how much our material is spread across their nuclear fuel cycle which comes back to my office and we examine that carefully. We have in many cases, annual meetings with those countries where we discuss any issues that arise out of the information that is provided to us. And then my office is required by legislation to produce an annual report, where I need to conclude as to whether our material is fully accounted for and we are in compliance with our commitments.

COMMISSIONER: So you are working on data provided by the IAEA?

DR FLOYD: Not directly. The data that is provided to the IAEA by a state is confidential, the data that I work on is the data provided by the country to my office.

COMMISSIONER: So we are relying upon the country to report?

DR FLOYD: We are relying on the country to report and there are the legal obligations in the treaty and the administrative arrangement which goes in to more of the technical details of how this reporting is to be done. And we are relying on the conclusions that the IAEA draws from their inspections and the reporting requirements from the state to the IAEA. So it's the marrying up of these two and any other information that would be drawn. Now the IAEA's efforts and activities are not limited to the accounting of nuclear material but that is an important part of their safeguards activity.

COMMISSIONER: And that is the recently concluded – same arrangements for the sale of uranium to India from Australia?

DR FLOYD: All of our policy is consistent. The way that our policy is implemented may vary from state to state and the way that it's described and implemented in the case of India – and India is a – it's a different circumstance where it is a state that is not an MPT party, so it doesn't have the normal kind of safeguard's agreement with the agency but it has a specific one. Some would say their specific safeguards arrangement with the agency is tougher in some ways than those that other states have on. There is elements that go either way. So within the uniqueness of the Indian context that we now have in place the legal arrangements which ensure that our policy can be met.

COMMISSIONER: I know counsel is champing at the bit here, so before I let him loose - - -

DR FLOYD: I'm not sure I'm happy about this but - - -

COMMISSIONER: It was also put to us this morning that in relation to the sale of uranium, when you embark upon that, because of the commercial nature of the activity, that you sometimes sell your uranium to states that don't have a strong MPT pedigree and it was put to us that that's a very good reason not to be in the business. I guess my question to you is in those relationships that are established with Australia and the people that we supply uranium with, how much work is conducted to ensure the credentials of the country that we sell uranium to?

DR FLOYD: I'll give you a little insight as to what my office has to do. We will get, from time to time, different countries approaching my office and saying, "We would like to buy Australian uranium," and they don't have a bilateral treaty arrangement with us. The first step that I have to take if I'm going to pursue that is that I've actually got to get a negotiating mandate from the Cabinet. So we have to write a submission to the Cabinet laying out the case, and then the Cabinet makes a decision as to whether we will actually commence negotiations with a country. It's the Cabinet that then looks at all of the balancing factors of the considerations as to whether we should or should not enter such an arrangement with a country.

So it's taken very, very seriously at the point of even starting a negotiation. It's certainly not a business development thought from my office as to where we should go. It is a very considered decision of the Cabinet, and they will weigh many different aspects, security aspects and economic opportunity, bilateral relationship, many different aspects in the consideration of giving me a mandate to negotiate or not.

MR JACOBI: I want to come back to the Australian-obligated nuclear material. In the submissions that the Commission has received, there have

been some criticisms made with respect to the extent of inspections made at facilities at which Australian material is either handled or processed. I'm interested in your view as to the extent of the inspection obligation at those facilities.

DR FLOYD: Thank you, counsel. Earlier I mentioned that Australian-obligated nuclear material can only go to facilities that are permitted by our arrangements and that those are subject to IAEA safeguards. In the case of IAEA safeguards in non-nuclear weapon states, then all of those facilities are going to be inspected at some point or other by the IAEA. It's important to point out that in the case of nuclear weapon states, the intensity of safeguards inspections is way lower. It doesn't bear sense that they should be putting a huge amount of effort into that where they have a weapons program, they're allowed to have a weapons program where they have a civilian program, but every facility where Australian-obligated nuclear material can go can be subject to IEA inspections and certainly these are under IEA safeguards.

MR JACOBI: I want to deal with - it was raised in the discussion morning - the ability for a country to communicate to other countries its desire to not proliferate. I'm interested to understand, first of all, perhaps by some examples, how you can take unilateral steps that are beyond the IEA standards to communicate that matter.

DR FLOYD: Yes. I certainly see that if Australia was to take a decision to extend elements of the nuclear fuel cycle that we would want to take a strong position of convincing other countries that we are doing this for entirely peaceful reasons, and the strongest way, as I mentioned before, is to go beyond your legal requirements. Part of that could be to internationalise key elements which could be sensitive, such as enrichment or reprocessing, and things were decided, and so that means that you not only have the IAEA's eyes on a facility, you have the statutory officer responsible for these matters in the country watching the facility, but you then would have a board or some kind of management structure with multiple countries represented on it, and those countries are very keen to make sure that proliferation is not occurring, and so they would be on it.

Now, nowhere does it say that you must internationalise sensitive elements of the fuel - well, actually in the Nuclear Suppliers Group guidelines it does make that link, but not in the NPT. So internationalising it, I think, it would be certainly seen as something going beyond. We go beyond already with the information we provide on our uranium exports. We provide more information than what is absolutely required. We go beyond already in our level of transparency on some of the reports and findings from the IAEA. You can find them on our website or in my annual report. We put a lot of information in that annual report than what many other countries do.

We are committed to transparency where we can. Now there are some limits, but - yes, so these are all the areas where we go beyond what is the legal requirement. We don't say, "Well, I don't have to do that. I will not." We look at, "Well, I could do that. Why not?"

COMMISSIONER: Can I just pick up - because it reminded me of some more evidence this morning on the internationalisation of enrichment. It was put to us that that's a bit of a guise; it's not been very successful in preventing the disclosure of technology, and there were some notable examples given. What's your view on the ability of the internationalisation of some of that front-end activity to convince states about the bona fides of the people wanting to engage in that activity?

DR FLOYD: Right. Let me take the guise issue first. I know this is a point that various people who argue against nuclear energy use, and let me be clear. I am neither a proponent for nuclear energy or against it. I am responsible to manage some risks. That's my role, so I'm seeking to give this in a perfectly even-handed way. But some would say that a state that develops a civil nuclear energy industry would do it as a guise, as a cover, for developing a weapons capability, and they state this as though the evidence would bear that out. Well, let's have a look at that just for one moment.

There are 30 something states that have nuclear power plants, or 35 or so that have got nuclear energy elements in their jurisdiction. But then, if the concern is that if you have civil nuclear then you are on your way to having a nuclear weapon, then how many of those 30 somethings, let's say the 35, have got nuclear weapons? Well, of them there are the five nuclear weapon states. Now, they're the ones under the NPT that are allowed to have nuclear weapons, although moving towards disarmament. There are another two or three that have not joined the NPT and have developed nuclear weapons. So they not broken their commitments; they never actually made the commitments, but they're within that group. So we can take eight out of that.

So how many others? We're down to 27 or so states. So how many others, out of the 27 that have got a civil nuclear fuel cycle, have developed nuclear weapons, apart from those that were allowed to have nuclear weapons? And at that point, the number becomes rather small as we end up with the DPRK, with North Korea. In the case of North Korea, it is interesting it was the safeguards activities that picked up issues that were going wrong there, and we know where that's ended up. We have Iran where there are significant non-compliance findings that have been found. We have a couple of other states where there was some minor non-compliance, but that has been corrected and fixed. And then we have four states that had nuclear weapons, but have now given them up, and three of those are previous Soviet Union states, and

South Africa.

So when we look at the number of countries that have a civil nuclear programme and people say that's only a precursor for having a weapons programme, I suggest to you Commissioner that the evidence doesn't actually support that conclusion. It is a very small number of states that would go that direction.

COMMISSIONER: I think the evidence was presented in relation to convincing the international community that a multinational organisation running enrichment for instance - - -

DR FLOYD: Yes.

COMMISSIONER: - - - wouldn't be a convincing argument to justify a view about the safety of that particular activity because of what has happened in the past, in that these international organisations have let information – have let technology slip and nations have developed nuclear weapons because of that.

DR FLOYD: Yes, the example that was given, there was as an example about URENCO - - -

COMMISSIONER: Yes.

DR FLOYD: - - - that was from a long way back where that actually occurred. I am not saying that as an excuse - - -

COMMISSIONER: Right.

DR FLOYD: - - - but that particular instance did occur a long way back and we learn from those experiences. I think that it is very clear that to have an internationalised enrichment or reprocessing capability is going to give more protection than not having it, absolutely for sure. It is – I think the convincing argument is to be welcoming this other participation in and therefore the exposure which comes with that. Now we would have to have other participation anyway - - -

COMMISSIONER: Yes.

DR FLOYD: - - - because we need to source the technology from somewhere. If we are to do that, there is also the need to put in place various bilateral agreements beyond what we have at the moment to enable that and there would be all kinds of constraints that would come with that as well. And any internationalised body would then sit over that arrangement in some ways as well. There would be elements of that that you dovetail in to it. Although

nothing is perfect and nothing can eliminate risk entirely, I think that is a utopian view, if we can reduce risk to zero, then I think internationalising the most sensitive portions of the fuel cycle is certainly a very positive step towards reducing that risk substantially.

COMMISSIONER: And that develops international credibility?

DR FLOYD: Absolutely it does. If Australia was to choose to embark, let's say upon enrichment and we chose not to have any internationalised type arrangement but we would have some special arrangements to get the technology but not let them be part of it, and we didn't really have a compelling case of domestic need or maybe even international demand for the products of enrichment, then if I saw another state around the world with those characteristics, I would have significant questions. And so countries would have to have that about us. If that was the way, if Australia chose to go enrichment we were to set it up, then my job will be a lot harder in convincing the rest of the world of our bona fides are entirely civil.

MR JACOBI: I just want to pick up on something else that was discussed this morning and that is that to the extent to which countries that have sought to pursue a nuclear power programme, have disclaimed participation in other parts of the fuel cycle. And I think the particular - - -

DR FLOYD: UAE.

MR JACOBI: - - - discussion was United Arab Emirates and I am just interested to understand your view with respect to the significance of such a model to offering assurance to other countries that your power programme was indeed directed for entirely peaceful purposes.

DR FLOYD: Yes. The UAE, I think is a very good example of a country choosing to go beyond what they have to do. And the UAE saw a need, their own assessment that they needed to have nuclear power. They then took – and this was their sovereign decision, they then took a decision and reflecting on the part of the world that they actually reside in, that if they wanted to be successful at this, they need to choose the best practice path and they need to reduce risks and perceptions of risks as much as possible. They sovereignly chose to then forswear enrichment and reprocessing in their territory. That was the decision of the government of the United Arab Emirates and that was their policy and the way they chose to go forward. I think that was a very wise decision, a very good decision. That decision is reflected in various bilateral nuclear cooperation agreements with the UAE, including our own. It reflects that. Yes, as Professor Sokolski this morning mentioned, there is a clause in there about relativity with other countries but the intent of the UAE is clearly to build confidence and they have done that by forswearing those elements of

their fuel cycle.

They could see that they did not need those elements on their land and by having it; it would create many stumbling blocks for them to be able to actually get the nuclear electricity generation capacity which was their prime objective. The international community look on that decision and how they have gone about it and many of us actually admire the decision policy framework that sits behind that in the case of the UAE.

MR JACOBI: Could I come to deal with – and perhaps to come back to the tracking of nuclear material as it travels around the world and the accounting systems associated with it. I think we heard this morning but we have also received in submissions that there are criticisms of both statistical certainty that we have about measuring amounts of material but also that there are, I think it's expressed in these terms, accounting discrepancies which are said to be commonplace which inevitably cause difficulty. And I am just interested to understand your view with respect to whether those issues can be overcome and the extent to which I think it was described that there was material which could not be accounted for.

DR FLOYD: Yes.

MR JACOBI: Represents a particular problem within the system?

DR FLOYD: Yes. I'm absolutely delighted that you have raised this question. There is a technical term in the nuclear material accounting world limited to three letters, MUF, which stands for material unaccounted for. And that is the issue of the discrepancy that was being spoken about. Let me just illustrate what – where MUF comes in to play. It's not things that have been lost or forgotten about, or hiding in some nook or cranny that couldn't be accounted for. That is not what material unaccounted for refers to. What it refers to is often a statistical issue, is that let's say for reprocessing you have spent fuel that comes out from a power plant and that spent fuel contains some plutonium but it's actually not feasible to measure exactly how much plutonium is in the spent fuel. So you could do it at some highly developed research laboratory et cetera but in an industrial context it's not feasible to do that sort of thing. So you actually model and you estimate how much plutonium is in that by the burn up rate, the characteristics of how the reactor is being used, the material that went in et cetera. So you have a number X of how much plutonium is there.

When you then move in to the reprocessing system, there is this wonderful thing called an accountability tank and I think everybody should have one of those. And that is where the material is dissolved and when it's dissolved, then they take samples in the tank and because the concentration could vary at

different places in the tank et cetera then there is a lot of work gone in to what is an adequate statistical sampling. So they sample the tank and from that, then they have an estimate of how much plutonium was actually in that material. So originally had the modelled number and that is with a whole bunch of stochastic, Monte Carlo elements in it, so there's a certain level of uncertainty around that. Now you have a sampled number but it's not a 100 per cent, you don't sample everything and of course there will be differences between the two. That difference is called MUF. Material unaccounted for. And so it goes on as you move down through the chain because ultimately then you would have some fuel elements that might come out of – with plutonium in them, and you then have an absolute knowledge of how much is there, and that will be different to what was in the tank and some of that may be because it's stuck around the edge of the vessel and it doesn't get fully washed off, or could've got aerosolised, or even a little bit of the plutonium could've been, say, in an acid waste stream or something like that (indistinct) can be positive or negative, particularly when there's statistical comparison to then measure, because the statistical comparison might've said that there'll be more, it might've been less. So it's not a sign of bad practice.

So how do we then approach this from a safeguards' point of view, because plutonium really matters. We don't deal with accounting alone when it comes to safeguarding the plutonium. What we look at is the system as a whole, and you want to make sure that the system is contained, that you've got surveillance on the system, so that you can say, "I know that nothing got out of there." You know what went in in terms of the spent fuel and you'll see what goes out in terms of the fuel that was fabricated and generated, and if you know this shell is entire because you've got surveillance on it, you've got containment measures in place, you've got process flow monitoring in place which will show if there's anything odd that's happening and if there's a discrepancy where there's some take-off that doesn't make scene - so it's the whole system of safeguards.

So the accounting piece, which includes material unaccounted for, which is generally a very small percentage, then sits within this broader framework. It's not that when you consider how much material is unaccounted for in the US system when there are so many facilities all over the country, et cetera - it is not that they've lost this material. It's a statistical versus a measuring difference, a modelling difference, et cetera, in most cases. I hope that's helpful to understand the concept.

COMMISSIONER: Before we go back, if there were to be material lost, how is that reported through the system? A plutonium discrepancy, for instance.

DR FLOYD: If there was a plutonium discrepancy, it would be picked up by the IAEA in their analysis of the various information that they would receive

and any other information they would get, not just that, which they're measuring. That's if it's something which is untoward, the system would then pick up that up. If there was something which seemed odd, as I was mentioning before, because of the process monitoring that goes on - because what they're looking for is diversion, has diversion taken place. So if the IEA had the slightest concern that diversion had taken place, they would be going back in and following up. There's a whole bunch of formal processes of inquiry that then follow through to seek to get that accounted for.

And plutonium that you're mentioning, if there was a known discrepancy that came to the attention of my office, we would declare that to the Agency. We don't hide those things. My office is looking for those things. The Agency's role and my office's role are actually similar. Both of us are wanting to make sure that no proliferation is taking place. It's not as though it's only the Agency wants to work that out; it's that my office is dead keen to be able to work that out, yes.

MR JACOBI: You mentioned being able to measure materials within flows, and I'm interested in picking up on the idea of the extent to which it's practiced that there is in fact design of industrial systems to provide for proliferation control, that is, not having to retrofit an old plant, but in fact if you were building a new plant, the extent to which you can actually take account of that.

DR FLOYD: Yes. This is a very important part of safeguarding facilities, is that if at all possible, you design safeguards in at the early design stage. Now, you design safety in; you design security in; you design safeguards in. If you don't in safeguards - let's go back to that as a specific focus - then you may be required to retrofit stuff later, which could be prohibitively expensive, but to be able to achieve the safeguards required, that may be required. So it's in your own interest to make sure that you do this early. It also allows a whole range of possibilities that might not be possible otherwise.

So it's economically sensible, and in terms of the confidence it's sensible, that you do that, and again, going back to the example I used earlier about the Rokkasho reprocessing plant in Japan, the amount of effort that has gone into the design of that plant with the IEA's involvement and the number of people days that are focused on that facility alone, as well as the Japanese government and the owners, is huge, but because of the difficulty and the sensitively of dealing with plutonium, you really do have to design this stuff in right from the start.

MR JACOBI: In submissions that the Commission has received, there's a suggestion that commercial confidentiality in some way affects the ability to implement safeguards. I'm interested in the extent to which the ability of, for example, a corporation to assert confidence could be a barrier to deriving

information that you would otherwise require.

DR FLOYD: Yes. There are various limitations to the information that can be provided. Commercial confidentiality is possible, but the bigger issue is often about security sensitivities, and for sensitive technologies it's actually very helpful for as few people as possible to know how those technologies work and to have visibility of them, and so for security reasons, there can be arrangements put in place such that it's not disclosing the technology whilst it is disclosing the amount of material and flows and things like that.

MR JACOBI: Perhaps I can draw a distinction. Does that represent a barrier when it comes to materials accounting?

DR FLOYD: No, not a barrier to materials accounting necessarily. I can't think of an instance where that would be the case, but it means that in some cases, if there's an inspection to take place in a sensitive facility that certain things would be covered and visibility of the actual technology might not be there. So there are some limitations, but that's where, again, it's the whole system that matters, and that's where the containment, the surveillance, the process monitoring, the accounting, all of these things together. And the IEA is not limited to the information provided by states. They also use other information to draw their conclusions, and so if any of this it doesn't hang together, they have the ability then to pursue that further and ask questions and seek to get clarification.

MR JACOBI: The contention is also made that sovereignty can be used as a barrier, and I'm interested in the extent to which - because we're only considering Australia and the potential for an Australian facility, the extent to which Australian sovereignty could be used as a basis for impacting upon safeguards, given the fact that we are, as I understand it, signatories to the NPT.

DR FLOYD: Yes. Sovereignty is kind of the argument about, "If the NPT doesn't require me to do it, then I won't," and so the policy disposition that I mentioned that I Australia has on non-proliferation doesn't match that. Australia's policy position is that we wish to be very clear and convincing in being able to demonstrate our bona fides, that we are acting according to our commitments. So, yes, we do have debates, particularly in the context of the International Atomic Energy Agency where some states are saying, "No, no, no. I am not required to do that and I won't," and that's a perfectly reasonable, legal debate, I say to you, counsel, that you can have that debate and a state can say, "I'm within my right not to do it," and they well could be.

That's not the line that we in Australia would generally take on these issues. So that's how sovereignty kind of plays out. In fact, I think it's quite

remarkable when you think that sovereign states chose to join the NPT and in joining the NPT, said, "We will provide all of this information." It's quite remarkable in itself because that was out of their sovereignty. They carved that out and said sure we're willing to share this and allow this sort of invasive inspection et cetera.

COMMISSIONER: When I look at the safeguards it's obviously built about known technology.

DR FLOYD: Yes.

COMMISSIONER: And lots of experience with that.

DR FLOYD: Yes.

COMMISSIONER: It's been put to us that we should contemplate new technologies and just by way of an example, breeder reactors. So I am kind of interested to understand what sort of safeguards are thought to be required for these new breeder reactors? Are there safeguards? Are they safeguards for the pyroprocessing plant that accompanies them? And then perhaps we could explore what you think would be required if there aren't any?

DR FLOYD: Right. The issue of first of a kind technology whether it's a reactor or another processing plant or an enrichment or reprocessing certainly comes with major challenges of safeguarding. And the challenge is firstly to design what safeguards you could put in place and would be adequate to put in place, to be able to detect if there was any misuse, diversion et cetera. And to keep running on that example that we have with Rokkasho that has been an ongoing activity for many, many years between the Japanese and the IAEA to design the safeguards arrangements that would be satisfactory for that facility. That's a first of a kind. Now if there was to be a second Rokkasho anywhere in the world which some would doubt, but if there was, well then it would be easier the second time around to look at that. Another case has been looking at the safeguards arrangements required for the deep geological repository in Finland. That has been a multi-decadal piece of research and development and negotiation and consideration by the various players that are involved to come up with that. Now once it's arisen in one case, then the second case will be much easier but it's not actually straight off the shelf to apply those arrangements.

COMMISSIONER: What – get to that.

DR FLOYD: Get to that one in a minute. That's fine.

COMMISSIONER: (indistinct) detail.

DR FLOYD: Just go to your – some of your fourth generation reactor - - -

COMMISSIONER: Yes.

DR FLOYD: - - - ideas.

COMMISSIONER: Sodium cooled for instance.

DR FLOYD: Sodium cooled. Is that there is substantial safeguards challenges about any new reactor type, as there is for security and safety but to work out how you then manage those risks for any new reactor type is far from an insignificant task. The amount of research and development that is required merely on how to apply safeguards, is many years of work. And then as that technical work is done then you can look at the – the legal and the practice framework that sits around it. So first of a kind has a substantial overhead in terms of designing and conceptualising safeguards and then implementing.

COMMISSIONER: Is that the responsibility of the nation that is building the reactor, or is that something that is done in the IAEA?

DR FLOYD: The responsibility sits in a number of places. Obviously the developer of the technology has a huge vested interest in seeing that the safeguards can be developed. Again, back to this design – you know, safeguards by design issue is that you want to work that out early so that it all fits together as a cost effective system. It is a discussion with the international atomic energy agency primarily but the statue involved and certainly thinking of a number of technologies around the world, is that their research and development community had been very involved in looking at how safeguards could be applied. Sometimes it's applying new technologies that haven't been used before to be able to sense, to monitor, et cetera. It is dealing with highly hazardous materials but then being able to actually measure and monitor those things. It's very challenging stuff. So it is an activity that if the state, like if Australia was to have some new fourth generation reactor to be put in Australia, yes we as a regulator would be involved but I would imagine our R&D community would probably also have some significant involvement. But wherever the country of origin of the technology would have a substantial involvement as well.

COMMISSIONER: You alluded to a considerable amount of time to develop that knowledge, to be able to bring forward - - -

DR FLOYD: Yes.

COMMISSIONER: - - - a safeguard regime that would be acceptable to the

international community.

DR FLOYD: The history of this shows that it takes a substantial amount of time to work through all of these different issues when it's a first of a kind reactor. I look at the GIF forum – Global International Forum for fourth generation reactors and their timelines and their thinking for reactors like the ones being considered here in Australia, it could be 2035 before there could be a first demonstration and then you've still got all of these other considerations and the various licensing. And so ultimately, when all this stuff is done and licensing is possible - - -

COMMISSIONER: Might the same considerations be applicable to, for instance, an enriching technology like Silex.

DR FLOYD: Indeed, yes. Any new first of a kind technology poses technical first of a kind issues that then have to be addressed. I guess that's where using known technology, if it's for nuclear power plants, light water reactors that are well known is a much easier regulatory task and a much quicker process in terms of getting something licensed and established because you don't have these first of a kind issues to have to work through.

COMMISSIONER: Could I now move to deep geological storage and noting that the Finnish and the Swedes that are more advanced, the proliferation and safeguard issues associated with those, could we just walk through broadly what considerations one needs to have in mind about those sites?

DR FLOYD: Yes. I haven't seen the final outcomes as to whether they're up to on the safeguards issues for the Finnish repository. I certainly have seen some of the earlier stuff. I'm involved in the IAEA arrangements, I actually chair the standing advisory group on safeguards implementation for the director general of the IAEA and so we provide him advice on safeguards implementation matters, so I get to see some things that aren't necessarily publicly available and I won't go to any of those confidentialities but the broad issues, the challenge with a long term repository of spent fuel from a proliferation point of view and therefore a safeguarding point of view is that you're dealing with a facility which has a life for centuries at least. You're dealing with a facility – you are dealing with material where it's accessibility in terms of its radioactiveness will change over time and it could become more accessible in that sense further down the track. You are dealing with a facility that could have a large amount of nuclear material that if somebody was able to get hold of that and then potentially reprocess that, then they could have many bombs worth of plutonium that they could extract out of that. So that is the kind of concerns.

So we go back to this issue of how do you then have confidence that that

material is secure and is not being diverted when it is deep down in a geological repository? And so there are a range of technologies that one needs to think about whether it's ground penetrating radar to be able to detect what's there, whether it's vitrification so that you could put material in to a matrix which would render it unrecoverable but if you had doubts at some point then generally you need to be able to find the material so that you can actually verify what is going on. And so these present all sorts of major challenges. Challenges that have to be thought about over the time horizon of centuries.

So that's the broad sense, is that there's material, if it was to be extracted and to be used, that it could be used for weapons purposes and reprocessed. So there needs to be then confidence that that either cannot happen, or if it was to happen, would be detected. So again, the whole issue of containment, surveillance, et cetera, on a site, and many different technologies would come to people's minds as to what you might want to use, and I would say over the lifetime of that facility, being hundreds of years, the technologies that would be used further down the track will be quite different to the ones that are being thought about now.

So it's a significant safeguards issue, but I understand that they've come to some arrangements as to how that can be adequately done in Finland. So if Australia was to go this route, well, then there's a lot of stuff that we'll be able to borrow and learn from the Finnish experience.

MR JACOBI: We've already had a bit of a discussion about the sorts of bilateral arrangements that would need to be entered into. I'm interested, just in broad terms - thinking about it, I think you referred to the NSG Guidelines - about what the arrangements would be that would be required for us to access sensitive nuclear technology, which, I guess, are associated in some way with the non-proliferation aspects.

DR FLOYD: Yes. Much of what we discussed has been about nuclear material and not the technologies. The technologies are controlled through various export control regimes, and the Nuclear Suppliers Group and the controls around that is the most relevant of those. So it is not specifically about does the NPT allow you to do something or not allow you to do something. It then becomes do the export control regimes allow it or not, or what are the constraints that might be put in place by the Nuclear Suppliers Group, and that's where the control is exercised.

COMMISSIONER: Can I just pick up on that? We read in reports about black-boxing technology and the effectiveness of that as a means controlling access to technology. It was also put to us today that what man can create to protect, man can also create to access.

DR FLOYD: Sure.

COMMISSIONER: In terms of black technology, is that respected as a means of protecting technology internationally?

DR FLOYD: Yes, it is. Black-boxing, covering in various ways, whether it's by information barriers that would be put in place or physical measures, et cetera, essentially just making it so that people who don't have knowledge of the technology can't gain that knowledge, yes, is a broad practice which is used for a whole range of sensitive technologies. As we discussed earlier, zero risk is unattainable and as long as humans are involved, then there's always issues that could arise, and that is where you then manage that risk and look at how you would then control that.

And I have sympathy for those who would say, "Well, if there was no such technologies, well, then it wouldn't spread." Yes, of course that's true, but I'm also heartened then by - and my concerns also go to the AQ Khan network, which is a well-known proliferation of technology that has caused globally quite some concern. So, yes, it can happen; there's an example. But I'm quite heartened by the overall performance of the Nuclear Non-Proliferation Treaty when it comes to limiting proliferation. When that treaty was being negotiated back in the 70s, they had an expectation that by the year 2000 there could be 25 or 30 states that could have nuclear weapons. That was the reasonable expectation on the basis of what they saw.

And here we are now, well the other side of the year 2000, and we still have the five weapon states that were recognised as having tested weapons before the NPT came into being. Then we've got three states that never joined the NPT, so that's eight. Then we've got North Korea on top of that. That's nine. That's not 25 or 30. So, yes, there's always people who will seek to work around a system, and this is what keeps us always having to be on the edge, never to be complacent, is that our battle is never over. You haven't solved it and then you can just relax. It's an adversary of proliferation that needs to be continued to be addressed.

So I see that there are some encouraging signs that the arrangements can make a difference. Can they deliver zero risk that anything could go wrong? No, but there's very few things in life that can deliver that. I think the message is that we must maintain our vigilance and our focus on these important issues.

MR JACOBI: I want to come back to the treaties that we were talking about before, in terms of the arrangements. I'm interested to understand the sorts of time frames that are involved in negotiating the sorts of treaties that are nuclear cooperation arrangements and those sorts of things in order to be able to share technology between countries.

DR FLOYD: The time frames to set up the treaties?

MR JACOBI: Yes.

DR FLOYD: It varies quite a deal from country to country. It can be very quick in terms of the negotiation. If a country is willing to accept our normal treaty arrangements, then one could move through that quite rapidly. But the whole process is likely to take a couple of years, and it could be longer.

MR JACOBI: And longer for new technologies if one wasn't simply - - -

DR FLOYD: Okay. Yes. I was thinking the process for normal nuclear cooperation agreement, because there's a mandate-seeking part which requires Cabinet's consideration, there's actual negotiations and then there's the administrative arrangements and then the finalising and all of those sorts of things. A couple of years for our normal sort of arrangements is what we consider. For the first-of-a-kind - dare I use that terminology about a treaty - if we were doing a first-of-a-kind treaty which was dealing with some of these sensitive technologies, it probably would take us longer, because of each step of that process would be having to think about and work on things for a first time, so there would be some time.

Now, some of our treaties, in the broad, could be used to facilitate technology cooperation, but I would imagine in most cases there would be additional legal arrangements that would be put in place, particularly if it meant Australia getting access to sensitive technologies.

COMMISSIONER: Can I just go back to peer review? We've heard about peer review of particular parts of the nuclear cycle. Could you outline your peer review, and perhaps talk about the broad process within the IAEA and what it seeks to achieve.

DR FLOYD: Yes. Most of my evidence today, Commissioner, is focused on safeguards. Maybe I'll talk about security on peer review, because security is a very important issue as well, and as Dr Carl-Magnus Larsson gave in his evidence some time ago about the peer review processes on safety, there are peer review processes on security and also on safeguards. On security it's called an IPPAS mission, which is an International Physical Protection Advisory Service mission, constructed of an international team, as well as representatives from the IAEA, where there's a negotiated scope for that particular work; a large amount of preparatory work required by a state to go through in preparation for such a mission.

And in the case of security, it's looking at how well we are implementing

essentially the Nuclear Security series recommendations on how security should be implemented. We had one of these missions in November of 2013, and I must as regulator responsible for security it was an incredibly helpful and useful thing to have, where a bunch of experts from other countries and from the IAEA cast an eye over how we do our stuff and then they give us the benefit of their collective experience as to things that they would recommend or suggest that we think more about or do differently et cetera. Tremendously useful. Various of my staff and also some others from the Nuclear Science and Technology Organisation participate in these reviews in other countries and so we then learn from other countries as to how they implement. This has now become, and largely this is because of the Nuclear Security Summit process that President Obama kicked off, is that it's now become considered like the normal standard that responsible countries would do. Is that they would have IPA submissions. It's not based, again, on treaty compulsion. This is another one of these examples of what you could do out of your own sovereign choice.

And good practice with the IPA submissions is that you would have a follow up IPA submission where you have had a chance to respond to the recommendations, put things in to place and then say well now come and have a look again. So continuous improvement by all countries involved, a great thing. I think there is some 60 odd countries now that have had IPA submissions, so that's a good thing. In the safeguard space there is ISAS activity, so it's another peer review activity. It's a little bit different to these others because our safeguards interaction with the IAEA is very legally based, while with safety and security a lot of that is the responsibility of the state and you've got recommendations and guidance and things like that coming from the IAEA. So in safeguards, we have legal requirements and there is a process where we are constantly getting feedback and various reports on whether our reports were adequate, appropriate, whether there's any problems or not. But on the broad as to how it is implemented there is these ISAS submissions. So similarly, it's a peer review that looks at your broad approach to safeguards implementation rather than your reporting and your activities with the agency. Very important activities.

COMMISSIONER: I do think we want to move to security but there might be some final safeguard questions.

MR JACOBI: There is just one. And we heard in evidence this morning some issues with respect – and criticisms of the agency with respect to difficulties associated with the timelines for detection and the ability to in fact act, I am just wondering whether that can be placed in an Australian context and whether you have particular concerns about the ability to detect something in Australia and then to act?

DR FLOYD: Yes. Yes. The time to detection is obviously a very important

characteristic of the safeguard system and this has been born out publicly with the Iran deal and the negotiations there, is that you've got to have adequate visibility far enough ahead to know that you've got a problem, so that if a nuclear weapon was the target, that you could take appropriate actions early enough.

MR JACOBI: The task of the Commission is to focus, I guess on the potential for facilities in Australia to be developed so the - - -

DR FLOYD: Yes.

MR JACOBI: - - - challenge isn't the challenge with Iran, I am just interested if one puts oneself in the context of Australia today, or perhaps 10 years in the future, what is the position with respect to the difficulty of a timeline to detection and then to act?

DR FLOYD: Yes. The reason I use the Iran example is that we've got to start thinking about Australia as a proliferator. That is the context that we've got to think about this timeline and timely (indistinct) and so the question then is, well as we are at the moment, the biggest concern would be say diversion of uranium. It's undeclared and it's been diverted somewhere and somebody's getting it and they're using it for a weapons programme. So we've got to work out well then how do we assure that that's not happening. How could we know soon enough that it's not happening? Now if that was the case, and you're dealing with uranium or concentrates, your biggest signature of your problem is not going to be the uranium or concentrate that might have been diverted but it's the facilities further down the track that somebody has got to have somewhere. So it is not so sensitive in that way. But if we were to develop some of the sensitive technologies, have facilities on those sensitive technologies here in Australia then the timeline is much shorter and the confidence that people would have. But it's got to be based on a scenario of proliferation.

And the scenario of proliferation essentially is going to be Australia as choosing to proliferate. Well, clearly Australia is not choosing to proliferate and the agency would have its interests as to how quickly it needs to be able to detect whether we have got clandestine activities, whether we are diverting, whether we are misusing our nuclear power plants so that we could develop more plutonium by running them inefficiently and these kinds of things they then need to know. Now if you're going to misuse a nuclear power plant, then the monitoring that's in place would show that up very quickly. And so the detection time is not a problem in those scenarios. So it's an area where there are people in the agency that are focussing on detection times very, very closely at different points in the fuel cycle and for different reasons, to see can it be adequately managed. We would always want better.

MR JACOBI: Can I pick up, I think the issue – the scenario of diversion takes us I think to the question of security and I am just interested and perhaps you can just briefly outline the extent to which I understand we've got a risk based approach and I am just interested to understand perhaps first what are the key risks, or what are the key risk materials that are identified in such an approach?

DR FLOYD: Yes. Well the – for security there are two broad areas of concern, is that one area of concern is theft, that somebody is going to steal material and then use it for a nuclear explosive device. So if they're going to do that then the primary interest is going to be plutonium and it's going to be highly enriched uranium. The second part of security is more about protecting against the risk of sabotage, of using the facility as source of hazard, daren't call it a bomb but a source of hazard et cetera and so compromising it and blowing it up or whatever. So the materials and the concern are slightly different. In sabotage then you're looking at well then what is the potential consequence of something being breached or being blown up to the hazards to human health that might surround those areas, while theft is take the material and then use it to make an explosive device. That said, on the theft side we have a structured arrangement of different tiers of concern of three different levels, depending on the amount of material that might be held in a facility. So they are categorised, there's category 1, 2 or 3. And it depends on the amount of plutonium or the amount of highly enriched uranium et cetera that might be in a facility.

That then feeds in to the risk based approach to security and the risk based approach to security ultimately then results in security plans for facilities and those security plans are developed by the facility owner/operator and are then – and often in consultation with my office. We don't work at arm's length, so that we are disinterested but we are very happy to go on that journey with the facility but then we ultimately then assess those plans. And a fundamental part of that plan is what we call the design basis threat. So this is essentially a scenario of threat that we, together with the intelligence community, come up with and define and then the security plan has to meet and so it would be to do with how many people, what level of capability they might have that might be seeking to compromise a facility and so the security plan has to then meet that. It also has got elements not just of say forced entry but also of cyber security elements as well. So there are different parts to the security plan. So it's all in that risk environment and it's fluid and needs to be revisited and revised as the risk environment changes. It certainly then talks about layers of defence, and defence in depth is that you don't then just rely on one layer, but you deal with multiple layers, you deal with multiple technologies, et cetera, to ensure your security.

MR JACOBI: I'm interested in perhaps stepping beyond the idea of the plan

itself and how the plan is developed, but the extent to which that plan is then tested against scenarios to the extent to which people might have practice implementing such plans.

DR FLOYD: Yes. The plan is designed against a scenario to begin with, and then the security arrangements are tested with exercises in various times, and exercises are an ongoing and not an uncommon activity at a place like ANSTO. They are very vigilant at testing their systems via exercises. Those exercises would reflect the design basis threat in various ways so that they're realistic and reasonable. That ties into some of the other responsibilities that ARPANSA has in terms of emergency response and some of those elements, so it all interacts together. So, yes, there's quite an active program of exercising that goes on at these facilities. My staff are also involved in testing the security in some facilities as well, yes.

MR JACOBI: One of the issues that's been raised is - I think it was suggested in a submission - and these are expressed in terms of risks, that there's a risk that nuclear radioactive material should not be targeted. I think it's expressed in terms of "terrorist transport". I'm interested to understand the extent to which that sort of sabotage scenario or diversion scenario might be planned for.

DR FLOYD: Yes. Transport security is an important part. My comments thus far were more on the facility rather than transport. Yes. Transport can be a vulnerability; you've got things on the move and you've got less control space. But you've also got measures that you can put in place. Transport plans are required to be submitted to my office for nuclear material and we then review and consider those plans. There are, as I say, pluses and minuses about in-transit as to some things are easier, some things are harder. Butut then we have risk-based recommendations as to what sorts of measures need to be put in place.

COMMISSIONER: I think, as the last question - unless my trustee counsel has more - is this concept of a state-level approach where there's full integration. I've heard it, but I haven't seen any of the details. Could you walk us through that process and how you think it might apply to the sorts of activities that we've got under consideration?

DR FLOYD: Yes. The state-level approach and the state-level concept is the latest evolution of how safeguards are implemented, and there's some serious work been done in the Agency, the International Atomic Energy Agency, and elsewhere, over quite a number of years. The basis of it is that it is better to be able to look at a state as a whole when considering issues like what sort of frequency and intensity of safeguards need to be put in place rather than having a formulaic criteria-based approach which says, "If I've got a facility of a particular sort, then I have to have these particular measures in place, that's it."

But if you can look at a state as a whole, then you can calibrate your level of concern, which then affects your intensity and frequency of putting safeguards in place.

Now, to bring that home is that when the IAEA looks at Australia and sees that we do not have enrichment, we do not have reprocessing, we don't have power plants, we've got lots of uranium. They look at then pathways for acquisition of material technologies for weapons development and they see actually the pathways are pretty sparse for Australia to get from what we've got to a weapon. And so their assessment then would be of lower concern and therefore, the implementation of safeguards in Australia would be at less frequency and less intensity.

If we were to then have more elements in the fuel cycle, then they would take that into account when looking at the state as a whole, and they'd be looking at the acquisition pathways, which then would be more and more direct if we had that. If we just had, say, light-water type reactors, well, then that takes you one step further forward, but you've still got reprocessing, which would have to be clandestine. So it's still difficult, but it takes you a significant step forward over just having uranium being exported. The result would be that the intensity of safeguards in Australia would be higher; the frequency of various measures would be higher.

So if Australia is to take a decision to move towards greater elements in the fuel cycle, there's an impact for the Agency; there'll be an impact for my office, et cetera, particularly if we're dealing with some more novel aspects. There'll be substantial upscaling required in my office and adding extra skills, et cetera. But these things, Commissioner, are all doable.

If you're coming towards your last question, I want to give you my last pitch, and my last pitch is that the risk of proliferation is always serious and the risk of security is always taken seriously, and my task, my statutory responsibility, is to manage those particular risks. We do that with the nuclear footprint we have at the moment with a research reactor, with uranium mines, with the transport that is associated with that, and then the following of Australian-obligated nuclear material around the world.

If Australia took the decision to have additional elements in the nuclear fuel cycle here in Australia, then my office would continue to seek to do that. In my statutory responsibilities I would continue to report to the parliament on our performance on nuclear security and on safeguards, and we would be more engaged with the IEA on a whole bunch of things than what we are at the moment if we had these other footprints. I would say that these risks are manageable, and when I look at the international system and the national system that we have in place, with that appropriately scaled up and

appropriately resourced, et cetera, we can continue to manage the risks, which are serious and must never be discounted, to deal with proliferation and security. It's not beyond the wit of man to do that.

COMMISSIONER: Dr Floyd, thank you very much for your extensive evidence. We appreciate the time that you've taken to join us and for the preparation of the work.

DR FLOYD: Thank you.

COMMISSIONER: We'll now adjourn until Monday.

MATTER ADJOURNED AT 2.28 PM UNTIL MONDAY, 30 NOVEMBER 2015