RESUMED **[3.30 pm]**

COMMISSIONER: At 15.30 we'll resume on the topic of high level waste storage disposal. Counsel.

MR JACOBI: Posiva is a Finnish organisation responsible for the final disposal of spent nuclear fuel from nuclear reactors operating in Finland. Mr Timo Aikas, since being employed by Posiva from its establishment in 1995, retired in 2014, having held the positions of executive vice president and corporate advisor. He holds tertiary qualifications in engineering geology and has worked in various aspects of geological disposal of spent nuclear fuel for over three decades, including site selection and the design and development of the Underground Rock Characterisation Facility, disposal facility and counter-system capsulate the spent fuel. Mr Aikas continues to provide consulting services to a range of clients.

Dr Sami Hautakangas is a product manager in the nuclear expert services at Fortum. Having commenced work at Fortum in 2007, he has held several roles, including manager, Nuclear Waste Research and Development, and department head, Nuclear Waste Technology. Dr Hautakangas obtained his doctorate in engineering physics from the Helsinki University of Technology in 2005, and the Commission calls Mr Timo Aikas and Dr Sami Hautakangas.

COMMISSIONER: Gentlemen, thank you very much for joining us. I might start with talking about the management of spent fuel in Finland. I'm not sure how we're going to tag team this, but I'm sure we'll work it out. Who is responsible for the management and the storage of waste?

MR AIKAS: Well, that's a question which we decided in Finland very early on, at the same time reactors were started in 1978. The government had discussed this issue with power companies and the government made a decision in 78 that those who actually produced the waste shall be responsible for all actions for safe management of their wastes, and that was the decision, the consequences of which were embedded first in the operation licences of the first reactors, and later on it became a requirement in the Nuclear Management Act which became effective in 1988. So basically the law says in Finland that those who actually produce the waste shall bear responsibility for safe nuclear waste management.

COMMISSIONER: Okay. Obviously the following question there is: how was the decision taken for the spent fuel to be disposed of? What was the process there?

MR AIKAS: Well, disposal of spent fuel was not really the issue 40 years ago, if you like, because the world was going to towards the reprocessing of spent fuel, and the government actually said that the first option should be to ship the spent fuel abroad so that there would be no return waste back to Finland, and the important (indistinct) operates the Loviisa power managed to have this kind of agreement with the Soviet Union, and later with Russia, so that the spent fuel was returned to this country so that nothing came back, which fulfilled the origin obligation.

PBO, another power company, didn't manage to get this kind of agreement, because the world had noticed that reprocessing was much more complicated as presumed in the beginning, and the price of reprocessing was growing and during the late 70s the price of uranium was going down. So actually the few reprocessing companies wanted to ship the high level waste and the low intermediate level waste back to Finland and this didn't fulfil the obligation. So the government had said that there were would be a second option, which was to consider the directly spent fuel if these arrangements would not be possible, and this policy decision was made in 1983, and later on the Ministry then made several decisions on the way when things proceeded.

And then, during those years up to 91, the Soviet Union collapsed and disappeared and Finland started to become a member of the European Union. So the government, together with parliament, they changed the Nuclear Energy Act, which actually today prohibits the export and import of wastes and says that all nuclear waste, including spent fuel, shall be safely disposed by a permanent manner in Finland.

MR JACOBI: I'm interested to pick up the somewhat unique characteristic of the Finnish example is that the power companies themselves are involved in the process of finding a site and developing the program for the disposal of fuel. I'm interested in the nature of the decision that was made that led to that particular result as opposed to having a centralised facility.

MR AIKAS: Well, during the late 70s there was a discussion about a state would actually establish an organisation to take care of nuclear waste management, but that was pretty soon abandoned, because the work with nuclear waste management is closely related to the operation of the power, because when you take care of waste you have to know (indistinct) type of waste and the characteristics of waste, and so forth. So people at the time who were the decision makers, they thought - and this is, to my understanding, a very wise decision - that this relation with waste, technically, scientifically, is kept with the nuclear power companies who actually produce. So then it's the most convenient way to confirm and assure that all aspects will be taken into consideration.

MR JACOBI: In terms of the development of such a facility, I'm interested to understand what the legal requirements are that are imposed in Finland in order to be able to construct and operate a spent fuel disposal facility.

MR AIKAS: Well, would you like to answer some - - -

MR HAUTAKANGAS: Yes. Well, I can take this one. In principle, the Nuclear Energy Act includes this kind of decision in principal, DIP, process where this includes that government approves DIP to the applicant in the very early stage of the process, in the beginning of the process, and in order for government to do this decision, there are a couple of important statements to get: one is from the municipality of the facility so that the municipality has veto rights to this DIP; the other important factor is that you need to have a positive resolution from the safety authority, STUK, in order to go forward in order to have this DIP from the government, and once the government has made the decision, it's the parliament who approves this decision.

MR JACOBI: Could you explain how much information needs to be able to be provided with respect to the concept in order for a DIP to be granted? It's not a construction licence or an operation licence application, as I understand it. How much information needs to be provided at that stage?

MR HAUTAKANGAS: Well, I think one of the important aspects is that the environmental impact assessment is one crucial part of this DIP process. So this alone is quite big work in order to understand the environmental impacts from the facility. This also includes social impacts, this environmental impact assessment.

MR JACOBI: How much must the concept of the particular design of the facility be laid out at that time?

MR HAUTAKANGAS: That of course depends on what kind of concept the applicant is planning to go forward. Quite often you might have quite good understanding in the really early stage, what kind of a power plant will be established, but the planning is more or less in concept show level. You cannot have at that stage really (indistinct)

MR AIKAS: May I add something?

COMMISSIONER: Yes.

MR AIKAS: Well, including the local municipality, the Finnish authority for radiation and nuclear safety, abbreviated STUK, they have also a veto right. The kind of level of depth of technical design and the assessment is depending on the safety appraisal of STUK which (indistinct) will ask STUK to do in the case of the position in principle. There are no formal requirements of the level of conceptual design at this phase, but it has to be sufficient to that degree that STUK can make the safety appraisal and evaluate that the proposed facility, whether it's a reactor or a nuclear waste facility or whatsoever fulfills all the requirements of the safe facility in terms of the structure, systems and the operation. This is very important also in this phase, so that this authority has a particular position in this decision making phase.

MR JACOBI: I just want to pick up about how the program's implementation was proceeded with, with respect to the geological disposal facility in Finland, and I think we've got a slide that picks up the plan. This is slide number 8. I'm just wondering perhaps whether, first of all, we can pick out the DIP aspect to that process. Could you explain where the DIP occurred in the context of the other steps in that particular program?

DR HAUTAKANGAS: Can we see the slide?

MR AIKAS: Sorry. This is the normal schedule or program, if you like, which was planned in Finland in the early 80s when we planned this step-wise approach for site selection and construction (indistinct) operation of the spent fuel repository in Finland. As you can see, the decision in principle is made at the stage when the site was selected in the process between 99 and 2001, so that the earlier phases were more like scientific and technical going from the (indistinct) site candidates and obtaining information (indistinct) in the concept and making the safety assessments.

Then after a careful and detailed characterisation of four candidate sites, this application for decision in principle was submitted in the spring of 1999 after the assessment process was completed, and that was taken in 1997, 1999. In one of (indistinct) impact assessment report is a vital report because that has to be an addendum to the application, so it's a very lengthy process and it took two years for government to review our application and then come to a conclusion and make a decision.

MR JACOBI: I'll come to the issues of sighting in due course, but I'm interested at the moment to understand how rigidly were those phases laid out in terms of those that were involved in making the decisions? I notice that it's described in a series of phases, but was there a rigid structure that you followed, or how was it that particular structure emerged or developed?

MR AIKAS: In the history books, we said that we were lucky to stage the cases as they were, but some - - -

DR HAUTAKANGAS: Yes, I think that one description of this phase were made in the decision in 83 by the government where it was laid for the first time for the general timetable for the whole process. In that decision, it was said that the site selection should be done by the year 2000, and the operation of the facility should start in 2020. There was also a timetable for handover of the application for construction licence which was planned to do in 2010.

MR JACOBI: Was there anything else that was laid out? We've heard from many people they've had timetables where the timetables weren't realised, and I'm just interested in terms of the things that were done was there anything else specifically that was laid out from the start that you were clear that had to be done in a particular way?

MR AIKAS: Yes, today this appears the government made the decision in 1983 on this program on these stages, but of course there was a consultation between the (indistinct) and the government and indeed the issue was in 1982 when this program was laid out and submitted as part of the renewal of (indistinct) operational licence application for working with reactors, so actually this program was very carefully planned so that it's a stage-wise process. In 2000, we thought that we might be ready and collected enough scientific and technical information to make the site selection.

The 2020, which was set for the start of the operation, came from the waste because it has to be cooled down enough before it can be stored and the calculations at the time for that spent fuel basically showed that forty years would be ample time for cooling period, so it was a kind of summary of many issues coming from the technical side, the preparedness, because you have to remember in the early 80s we didn't have too much resources either to conduct these investigations and characterisation work.

The competencies have to be developed also in parallel with the program, because Finland was very new with nuclear power in the early 80s because the power plants had been started between 77 and 80.

MR JACOBI: I noticed in the slide there's a reference to the regulator, STUK, having been engaged in work from about the mid 80s, and I'm just interested to understand what was the framework in which interactions were occurring between the power company (indistinct) and STUK at the period of time before there was in fact a licence application or a decision in principal?

MR AIKAS: If I may answer this? When this decision in 1983 was taken by the government, basically the framework for the program was set site selection 2000 into operation around 2020, so the government also required power companies to submit every year a research plan for the activities which are going to be taken, and this was an annual plan. Today it's a three year plan, so power companies are trusted today more than at the time. The government gave the task to their expert body, STUK, to review the research plan not only for the coming access but also the results and prove the conclusions where we are actually (indistinct) our conclusions (indistinct) when there was a major step in the program, STUK always conducted a larger review of the results.

COMMISSIONER: Timo, can I just butt in for a minute. Could that timeframe be safely compressed? Say, for instance, it only took 30 years to cool the spent fuel, I'm just interested to understand if you could compress the timeframe and, if so, what do you think would be achievable now that we have a lot more knowledge and technology available.

MR AIKAS: Yes, sure. Not only Finland but also many countries, they have conducted research into the final disposal and it’s obvious that today we know better what issues are the most important in terms of the geological environment for the waste, for the (indistinct) whatsoever and of course this concept (indistinct) can be made (indistinct) the important issue to understand is that each repository is a kind of first of a kind because it will be implemented in a particular (indistinct) a particular site, so that the concept has to adopt the features of the geological environment of the particular site, but this R&D phase most likely can be made today much faster than we make in Sweden and Finland, so that if this – let’s say these lessons learned can be used so (indistinct) can be different. The cooling of the spent fuel of course is what it is, it can’t be helped.

COMMISSIONER: Yes.

MR JACOBI: I’ll come to deal with what I think is on the slide as phase 4 as we go through some of the other slides. I’m just interested to next understand for what amount of waste. You indicated that you could not import waste in to Finland and I’m just interested to understand for what volumes of waste is this particular repository being planned?

MR HAUTAKANGAS: At the moment the construction licence is now granted for 6500 tonnes of uranium and in addition to that Posiva has also studied possibilities for up to 12,000 tonnes of uranium, but in the very beginning of this era there was of course much more smaller amounts in plants because it was only including the waste from the owners reactors.

MR JACOBI: The figure that you've mentioned is that capable of addressing all of the spent fuel from Finland's current nuclear plants?

MR HAUTAKANGAS: Yes.

MR JACOBI: Does the figure include the potential – we understood that there's a – I think it might be a sixth reactor proposed to be constructed in Finland. What's it's capability to address volumes of spent fuel from those reactors?

MR HAUTAKANGAS: In principle I guess the 12,000 tonnes includes also a couple of new reactors as well to the existing operating units, but on the other hand (indistinct) has now made research for owners only, so at the moment the idea is that the repository will operate only for owners waste.

MR JACOBI: Sure.

MR AIKAS: Could I add a comment? We also have to remember not only the number of reactors which is important, but the operational lifetime of the reactors has been prolonged, so in the beginning the reactors were supposed to operate only for 25 to 30 years, but today the reactors will operate 50 or 60 years and this may be even longer, so this (indistinct) significantly contributes to the (indistinct) waste, but on the other hand the burn up of the spent fuel has increased, so that decreases to some extent (indistinct) and so that this is a big complex issue.

MR JACOBI: I will come in detail to the particular elements of the barriers that are part of the repository concept, but I just want to come at the present time in very simple terms for you to explain to the Commission what the repository concept is. I think we're going to bring up a slide, slide number 5.

MR HAUTAKANGAS: Yes, so in the slide you can see there is mainly four main barriers to seal the radioactive nuclides from the nature or from the environment and the first one is the disposal canister. In the disposal canister you have an iron cast inlet where you put the spent fuel and this iron cast is covered with copper, copper capsule, and this canister is then placed in the deposition hole in the deposition tunnel and the canister itself it's surrounded by a bentonite buffer and after all - when the canister and bentonite has been put in the depositional hole the whole tunnel itself will be packed with the back fill blocks and finally the fourth barrier would be the bedrock itself.

MR JACOBI: I just want to pick up in terms of the repository concept we've understood something from our reading that there's a Swedish concept. I'm just interested to understand the origins of the Finnish concept that's been used in relation to what's been done in Sweden.

MR HAUTAKANGAS: In principle you can say that because of this (indistinct) Sweden company SKB and this is done in cooperation (indistinct) and SKB has done this in cooperation, so the both companies have the same concept, yes.

MR JACOBI: I'll come back to dealing with each of the barriers in due course, but the Commission is concerned to understand the siting process and perhaps we can turn to that. We're just interested to understand what was the siting process that was used for the repository and how it ended up at the location that was ultimately selected in 1999?

MR AIKAS: If I may explain the facts of the siting process. First of all the only choice we have in Finland is a (indistinct) crystalline bedrock, which is very old and the bedrock has (indistinct) shield as we call it, has undergone several phases of (indistinct) during this time and typically our bedrock structure tectonically is broken down to a kind of (indistinct) in which the large (indistinct) break the bedrock to large blocks of rock and inside these blocks you can find very good quality (indistinct) rocks in terms of construction and also in terms of the (indistinct) at the sufficient depth of bedrock and the approach we selected in 1982-83 of locating the potential site (indistinct) investigation was a kind of tectonic approach. To locate these large blocks the size of 700 square kilometres and by more careful studies looking into them and locating these potential sites and this approach indeed produced lots of candidate areas and in the process (indistinct) 85-86 we contacted municipalities where these kind of sites actually were located and identified and sent a letter to each community asking for their interest to discuss and that process with the communities led to a kind of volunteer number of communities and with more detailed and careful discussions with the communities we were able to pick five sites in 1987 for practical (indistinct) including the field investigations.

MR JACOBI: How did you move from the many, many sites, that is, as I understand it, you identified more than a couple of hundred potential areas where the facility could be sited. How did you move from that to the five particular locations? What were the bases for choosing between them?

MR AIKAS: First of all, Finland is a fairly large country, not to compare to your country, but still in European dimension a large country, but we are only five million people, so we have lots of forests and wilderness where nobody lives. Because this approach was entirely geological, so quite many sites were in such areas where there are very poor roads so there is no possibility for heavy transportation of spent fuel (indistinct) or there is no industrial infrastructure, or there would be no sufficient population for running a facility, so when taking that into consideration this is what we call "other criteria" than geological.

We kind of were ruling out a great number of these potential candidates. Then of course when we were coming to a smaller and smaller numbers of these potential candidate sites, the attitude of the locality was pretty important because we knew that the local community has a veto right at the end when we are proposing the site, so we were mostly looking at those communities with (indistinct) other criteria which were also positive in their attitudes at that time to possibly accept the repository within their area, so it was a kind of very close consultation of the communities at the time and the public participation in that sense because everything was open and discussed with the elected council of the community, with local politicians.

MR JACOBI: You've spoken of the right of veto that is held by the community. Is that the right of veto that is to be exercised at the point of the decision in principal?

MR AIKAS: Yes, that happens when the application presents that the potential candidates or potential candidate, so the process of the decision in principal the government has to ask the community whether they accept it or not, and this is fully political decision. When making this veto decision, they don't have to make any arguments why they do it, it's just sheer political decision making.

MR JACOBI: I think the slide picks up the idea of there being a preliminary site characterisation and a detailed site characterisation. I'm just wondering perhaps whether you can just explain just in very broad terms the distinction between those two phases.

MR AIKAS: Preliminary characterisation concentrates more on the structure of the bedrock, because if we're looking at the important issues in terms of the disposal, so crystalline fracture of bedrock which has some (indistinct) in hydraulically active fractures is fairly simple in terms of the (indistinct) which are taking place. If one approaches (indistinct) chemical interactions between the crystal and rock and the (indistinct) but locating a repository and looking at how it (indistinct) the structure of the site is pretty important.

Therefore, in the beginning we were looking at the fracture zones and the general fracturing of the site and the conditions of hydrochemical conditions in general. In the detailed case, when we had picked up a few sites then we were looking in more detail at the properties of these fractures and what kind of properties the hydraulically active fractures have, what is exactly the picture of the hydro chemistry. The variable hydrochemical conditions are the key for safe disposal, and especially that the conditions are reducing so that there would be no oxygen present in the ground water system.

It's a level of detail which is a more important distinction between two phases because we need this detailed information to make the decisions of the (indistinct) site specifically, and also about the (indistinct) of the repository and then of course the safety assessment.

MR JACOBI: Was the information that you collected at the time of those characterisation analysis, was that made available to the municipalities for the purposes of them making decisions?

MR AIKAS: Yes, all the time. We had local offices at each community and these were open for public, and there were exhibitions on our work and we presented results. We publicly published everything, so we had the kind of report (indistinct) the scientific rules of publishing science, although it's scientifically maybe called a grey area, but still its purpose was to make everything open so that whoever would come and review our results and give his or her criticisms.

MR JACOBI: Did those interactions with the municipalities throw up challenges that you hadn't expected or issues that you needed to resolve that hadn't arisen specifically in the technical process?

MR AIKAS: Yes, they had because pretty much the issues involved with, for instance, have we ignored the ore potential of the area, because what you would like to have in geological disposal is that type of bedrock which is as general as possible that it would have no future use for anything, but very often people came and said that, "Okay, we have found some ore minerals there and there, and you have neglected that. Have you considered that this site might not be suitable at all?" Then we directed some work to go and look at some (indistinct) mineral that they had found and did our work, so it had an influence.

MR JACOBI: Can I move from there. I want to deal with what was phase 4, I think, on the slide and look at what was done once the particular site was selected, what was done for the purposes of further site confirmation after 2001.

MR AIKAS: Yes, if I may explain. The original requirement the sighting process to comprise the four phases, in which we would study the selected site very carefully and assess that our conclusions and results hold good from the site investigation phase. Already in the program report which was drafted in 1982 and submitted to the government as an appendix of the (indistinct) operation licence application, already that report stated that this confirmation stage would be conducted in such a way that the underground facility would be constructed at the selected site, so this kind of idea was already put out in 1982-83 when the problem started.

All the time through the program, we thought it's a good idea, and once the decision in principal was made we also proposed in the application that if the decision will be positive the (indistinct) would go underground for testing characterisation and demonstration. When discussing the decision in principal, the parliament also said in the statement of one of the committee that (indistinct) go underground to continue the program so that everybody agreed that this is a good idea. The purpose of this underground work was that we had to acquire very detailed information for detailed design of the facility, especially for the systems design, and also we had to collect detailed information (indistinct) because it's terribly difficult to collect representative groundwater samples from the ground surface with the help of deep bores, and to assess the favourable chemical environment has been one of the many issues now under this characterisation work for site continuation. And also one big issue has been rock mechanical behaviour of the (indistinct) water bedrock, because rock mechanics is also an issue which is difficult to cover with the help of the bores when you have to have access to large bases of rock where you actually can see how it behaves (indistinct) the temperature lowering itself.

MR JACOBI: It might be convenient at this point, given we're at the point about talking about the facility itself, to actually get you to explain from some images that we've got. Picking up from slide number 12, I think we have a surface view of the facility that was constructed, and perhaps, Mr Hautakangas, you can explain to us what it is we're looking at in slide number 12.

DR HAUTAKANGAS: Yes. This is the construction area of the aboveground facilities of Onkalo and the repository, and in the middle of the picture you can see the driving tunnel inside the Onkalo facility and the coming repository. From the access tunnel, right there is a shed for machines and other equipment, and if you go up the green, greyish--

MR JACOBI: Tall building, yes.

DR HAUTAKANGAS: Yes, tall building, it's a ventilation building. And then from that to the right side you can see barracks and other - it's just for office purposes.

MR JACOBI: Is there in due course proposed to be any other facilities, such as a packaging facility, on that site?

DR HAUTAKANGAS: Yes. There will be eventually, when the construction licence has approved and then there will be construction for an encapsulation plant right beside the ventilation building.

MR JACOBI: Perhaps just before we move no, in terms of the construction activities and the activities that were carried out for the purpose of the laboratory, were they regulated as if it was a nuclear facility even though, as I understand it, it wasn't being used to dispose of waste?

MR AIKAS: Well, yes. Since the decision in principal is the first licencing step, and in our application we had said that once we go underground we would build an access tunnel and shafts for ventilation and systems purposes, but that space would only be used for characterisation, but not disposing of the waste, but that this access tunnel and shafts would be part of the future repository as an access way. So in 2001, the regulator, STUK, made a decision that they will supervise the construction of what we call Onkalo as if it would be a nuclear facility, and so Posiva has been under the kind of nuclear scrutiny after 2001, and indeed, STUK supervised all the construction and all the quality and also safeguarding the facility since 2001.

MR JACOBI: I think perhaps if we can then move to slide number 13, I think that might take us onto the driveway, the kerb segment we'd seen previously. Do you have any observations to make there, Mr Hautakangas, in terms of what we're looking at in slide number 13?

MR AIKAS: Yes. This is 13.

MR JACOBI: Yes.

MR AIKAS: This is the access in front of the access tunnel.

MR JACOBI: And then perhaps on to slide 14.

MR AIKAS: Number 14 is a kind of view from the access tunnel from - it's a few hundred metres depth. So what you see is actually an excavated tunnel; the height is 6.5 metres and it's 5 metres wide. So it's a very large tunnel to our extent, not to compare with tunnels of the mines, but for this purpose, it's fairly large. The size of the tunnel accounts that it would be possible to transport the spent fuel cask containing the disposal canister also down through the access tunnel. That's the dimension requirement. And what you see also in this picture is the bedrock quality, which is quite good, and you can see also that it's (indistinct) dry, so that the volume of Onkalo is very large, but the ingress of water in total is only a few hundred metres per minute, which is a small amount, to the underground excavation of this site.

MR JACOBI: If go to slide number 15, perhaps, Dr Hautakangas, you can explain to us what we're looking at in slide 15.

DR HAUTAKANGAS: Yes. There's an experiment area to find out - I think there is - yes, a deposition hole can be seen at the end of the tunnel, so this is - as a matter of fact, slide number 16 is from the same tunnel but from a different direction, and this has been in order to make the deposition hole for the canister and to study how to make the deposition hole.

MR AIKAS: In addition to that, what has been studies in this particular niche is the effect of elevated temperature of rock, because the rock mechanical analysis showed that there is a possibility of stalling of the walls of the deposition holes due to the stresses created by temperature, and this particular excavation was made to study this phenomenon. What you see also in this picture is that there are lots of reinforcing bolts attached on the roof, and a design like Onkalo is a hundred years, so all the bolts are of stainless steel, which is also the nuclear quality again, you see.

MR JACOBI: I was going to come to the chamber, and I was interested to ask whether that's typical. - I understand this is an experimental facility for the purposes of research.

MR AIKAS: This is an experiment.

MR JACOBI: But is that typical of the type of tunnel facility that's expected ultimately to be constructed?

MR AIKAS: No. The typical is slide number 17.

DR HAUTAKANGAS: Yes, and as you can see, the dimensions are a little bit different. They're really much smaller, the deposition tunnel itself, and this is - slide 17 is presentation about this - real size deposition tunnel where at the end, the deposition holes will be bored in the bottom of the tunnel. Now there is not any of them in the picture.

MR JACOBI: We've already had a discussion about watering ingress. We can actually see a little bit of water in the tunnel that we're looking at there. Is that hydrogeology of the rock being studied?

MR AIKAS: Yes. Yes, it has been very carefully studied. There are some fractures which actually produce water in the demonstration tunnel which was excavated for the experimental purposes also, but I guess that the water you see on the floor is not only from the bedrock itself but it remains from the work. You will see that in slide number 17 the floor is very smooth.

MR JACOBI: Yes.

MR AIKAS: There has been used a mechanical method to even the floor after excavation. When you're (indistinct) heavy packages (indistinct) canisters, we need very even and smooth floor for installation purposes, and one part of this R&D conducted at this underground facility has been to develop these techniques for excavation and mechanical working with the rock to make the installation possible. The part of the water is probably still remaining from the washing all surfaces of the tunnels.

MR JACOBI: I want to come to the principles of the design before we move to the barriers and their functions. I just want to come to the principles that they're directed at soothing. I'm just wondering perhaps whether you can explain what are the principles that underpin the design of the repository concept. I think there's a slide that picks this up, slide number 10.

DR HAUTAKANGAS: Yes, of course the basic requirement for the safety disposal system is to maintain all the radioactivity and radioactive nuclides inside the facility for the designed lifetime, and this of utmost importance to have. Basically, it's done by developing multiple barriers for this purpose. One of the aspects is that it has to be somehow reliant on the proven technology, so any predictions for the coming you mentioned. It mentions it has to be able to implement in new day technology.

One of the concepts is that it should be constructed and operated that the geological conditions will retain their isolation properties. The robustness, of course, always nice to have in order to keep the design understandable and easy to implement. Retrievable concept is also important to have so that if there's any case in future need for pick up the fuel back to the repository up to ground level it should be possible, so this is also included in this concept.

MR JACOBI: I'm interested to understand when was the requirement of retrievability. We've heard concepts of geological disposal that don't include concepts of retrievability, and I'm just interested in understanding why retrievability was something that was built-in to this particular concept.

MR AIKAS: Actually, the regulatory requirement doesn’t say, "I require retrievability," but it's more like a political issue. When the decision in principal in 2001 was made by the government and ratified by parliament, the politicians wanted that the decision in contains a kind of sentence which deals with retrievability and also the (indistinct) should also in the future look into that the system is retrievable. For instance, when (indistinct) submitted the application for construction licence there was a separate chapter in the application dealing with retrievability and (indistinct) of retrievability, and this specific chapter was required by the decision in principal made in 2001.

What (indistinct) it does design a system which is for permanent disposal, and all the requirements are set for permanent disposal, but it wanted, and if future technological development makes it meaningful, so the system is (indistinct) retrievable, it can be retrieved, but no measures are designed to make it retrievable. It is retrievable, but it's very, very difficult.

MR JACOBI: We've had a brief description of some of the physical properties that there is, but I want to come to each of them in detail. You've already referred to the copper canisters, and I think we've got an image that picks them up in slide number 7, but could you explain to us the physical properties of the copper canister barrier and the insert?

DR HAUTAKANGAS: Yes. As you can see from slide 7, there's a presentation there about a cast iron inlet, and you can see also there in the replica of fuel element sticking out from the inlet, cast iron inlet. This cast iron is just to make the rigidity to the capsule so that it sustains in the repository environment for a long time.

MR JACOBI: I gather it provides the separation between the fuel bundles as well within the canister?

DR HAUTAKANGAS: Yes, that's true as well. The second element of the canister is, of course, copper capsule which is five centimetres thick and is pure copper, meaning, yes, it's pure copper and oxygen free, making it really resistant for corrosion, so it won't corrode because there is no oxygen anywhere around the capsule.

MR JACOBI: I understand that there's some treatment with phosphorus associated with that. Could you explain that?

MR AIKAS: Additional phosphorus is made to make the copper material itself more rigid, because copper is very soft so adding a minor amount of phosphorus material so it makes the copper itself more rigid and so it's easier to handle. Before phosphorus we had a small amount of silver, but the phosphorus is better. It's only to make the five centimetre thick copper canister more better to handle.

MR JACOBI: I understand there's some specifications with respect to the copper itself in addition to the fact that it's pure copper and oxygen free in terms of the grain size. Can you explain?

MR AIKAS: Yes, once the copper billet is cast, so the casting has to be oxygen free so that the billet that is needed originally for manufacturing the copper (indistinct) if you like, there's a special oxygen free copper, and then the billet is taken to a workshop where you can either forge, extrude or pierce and draw the canister, and this working method basically makes the ring size to our desired size, which is 350 micrometres. The original copper material is a big billet, which is about 12 tonnes. The rings are very big, they can be half a metre long and 5 metres in width. So they are more like crystals if you like, and this has to be worked to a desired size to make possible the very good corrosion resistance.

COMMISSIONER: In terms of the corrosion resistance, I've seen some readings. There has been some questions about the ability of copper to last for the sorts of period that it will need to last. How did STUK convince itself, or how did you convince STUK, that copper would last sort of for the thousands of years that it needs to?

MR AIKAS: Well, to put (indistinct) so first of all the current wall thickness is only 5 centimetres. In the beginning it was 20 centimetres, and then it was reduced to 10 centimetres, but now we know that the robust canister can be 5 centimetres, and only 1.5 centimetres are needed for corrosion purposes, and this is based on very careful corrosion studies in Sweden and Finland and elsewhere during the last two or three decades. Then in the late 70s, there was a question raised in Sweden: can copper corrode under anoxic conditions, and especially, can this corrosion produce hydrogen?

Well, this was built in the late 70s, early 70s, and assessed and it's not possible, but then in the early 2000s, this idea jumped back and there were some tests conducted in Sweden, in which small test facilities show that this corrosion under anoxic conditions could be possible and produce hydrogen. And then SKB in Sweden and we in Finland have conducted very careful laboratory studies and put lots of effort in this, and early this year, late last year, the result actually convinced that it's not really a question of corrosion; it's some other phenomenon, which takes place in this test facility under these conditions. So both in Sweden and Finland we can rule out the possibility for corrosion under anoxic conditions, and especially that it doesn't produce hydrogen.

MR JACOBI: Just going back to slide number 7, Dr Hautakangas, we can see a lid. I'm interested in how that lid is secured other canister.

DR HAUTAKANGAS: Yes. There have been, I think, two main welding systems proposed, and one is the friction welding method, which is quite widely used in aviation technology, and it's a really elegant way to seal the lid. The other is electron beam method, where you can also have a really nice result on the welding, sealing really nicely and tightly the lid on the canister.

MR JACOBI: Have you settled on one of the two methods?

DR HAUTAKANGAS: Yes. At the moment, I think Posiva has chosen to have this friction welding method as - - -

MR AIKAS: Yes. The friction stir method has been chosen for the future now, and the reason is mainly that the grain size of the welding seam is smaller and it's easier to make an inspection.

MR JACOBI: I was actually going to come to the inspection. What is the method that's used for the purposes of inspection?

MR AIKAS: Well, of course there are ultrasound, radiographic, and then some surface method (indistinct) can't remember the name of the other inspected terms (indistinct)

MR JACOBI: I want to come to the physical properties. We addressed a number of the others. I think we've already addressed the bedrock. But you referred to bentonite. Are you able to explain what the physical properties are for bentonite?

DR HAUTAKANGAS: Yes. Basically it's a natural clay, which is compressed to design, and the main issue in the clay, this bentonite, is that it is swelling. So under repository conditions, it will melt as well, so that it completes the - - -

MR JACOBI: So it will form a seal?

DR HAUTAKANGAS: Yes, complete the seal.

MR JACOBI: And then you've also referred to backfill blocks. What's a backfill block?

DR HAUTAKANGAS: So backfill blocks are used to fill up the deposition tunnel and so not - a backfill block is not intended to be put in - - -

MR JACOBI: If we go back to slide 17.

DR HAUTAKANGAS: Yes.

MR JACOBI: On the next page.

DR HAUTAKANGAS: Yes, exactly. This will be filled up with backfill blocks.

MR JACOBI: So what are we talking about in terms of the material that composes those blocks?

DR HAUTAKANGAS: It's a (indistinct) clay with montmorillonite content. It's also a commercial material. It can be both.

MR JACOBI: I understand it that the purpose of each of these barriers is to contain and isolate the radioactive material. I just want to understand, perhaps going from one to the next, what the safety function is of each of those barriers in terms of what it's designed to achieve. So can we go to the copper canister first?

DR HAUTAKANGAS: Yes. A copper canister, like already discussed, is to protect the fuel from the corrosive effect of the groundwater, so it's purely for that, and so good corrosion resistance is important to have in a copper canister. Then there is of course, which we already discussed about the phosphorous alloying, was that it should have some kind of mechanical resistance.

MR JACOBI: Why was copper chosen as opposed to other materials?

MR AIKAS: Well, in (indistinct) they're a shield, as I mentioned, the crystalline bedrock area. We have native copper in our bedrock, which has been found in conjunction with the oil exploration, and what is also important in terms of the selection of copper is that the groundwaters in the bedrock are usually - they have usually a very low sulphide content, because sulphide is poison to copper, and this low sulphide content enables corrode that copper space intact in the bedrock. So what we have to basically guard the copper is to guard it from sulphide.

MR JACOBI: In terms of the mechanical strength of the canister, is that a consideration that's taken into account?

MR AIKAS: Yes. Somebody mentioned the cast-iron insert, which is basically - it's a (indistinct) cast iron, so it's very strong. Of course the role of the insert is to separate the fuel bundles to prevent the criticality events happening inside the canister, but the main purpose is that we prepare the canister for future evolution in which we have to consider future glaciations, the ice ages, if you like, and in that case, Finland will be covered by a continental ice sheet with a thickness of between two and three kilometres. So the task of the insert is to take care of the mechanical load and hydrostatic load of the increased load you will be increase (indistinct) glaciation, so that's a very important part of the design of the canister, to look into the expected evolution and into the possible changes in the environment.

MR JACOBI: I've raised the question of the inspection of the weld and I'm just interested in terms of the controlling of faults in the manufacture of the canister itself. Is that something that's controlled?

MR AIKAS: Well, it's a very good question, because when manufacturing the canister components, like inspection lids and the copper canister itself, then we are dealing with non-radioactive environment, so we can use effectively more kinds of inspection methods. These components are defect-free, so to speak, but the inspection will be made once the spent fuel is inside the canister, and the inner lid has been attached, so it's a radioactive environment and everything has to be made remotely controlled, and, therefore, it's very, very important that the welding method is good, and inspection methods can detect any defect which is still remaining. Whether it's a kind of pinhole in the weld or if it's a kind of other defect type which can appear in the weld, in conjunction with the weld. So there has been lots of effort put in the inspection of welding.

And today, SKB even claims that there will not be any defects in the weld, but our regulation system starts that there might be some human negligence or other human influenced issues, which might cause and we might have one or two canisters will still have a defect in the welds. Then we have to consider in our safety, long-term safety assessment.

MR JACOBI: So, in essence, your safety system requires you to take into account the possibility of a mistake.

MR AIKAS: For the time being, but we are very confident that we can assess the inspection methods are able to pick all the defective weld seams away from the production line.

MR JACOBI: Can I come to the question of the bentonite? What's the safety function that it serves? Dr Hautakangas?

DR HAUTAKANGAS: Bentonite is meant to, like already discussed, to provide an isolation for the canister itself from the water coming from the bedrock to the canister surface, so it isolates the water and, like heard from Timo, the sulfites to enter in the vicinity of the copper surface. And also Bentonite is expanding material, so that's the main mechanical function, is that it will expand and prevent the water in flow.

MR JACOBI: Does it have a purpose in the event of providing an additional barrier if there was a failure in the case of the canister?

DR HAUTAKANGAS: Of course the whole system works - it's a combination of the safety function of each barrier. So one barrier itself doesn't provide the safety, but it's more or less that the whole system provides the safety. So if one barrier for some reason doesn't work, then the other barrier would take the preventative role of the repository.

MR JACOBI: Mr Aikas, I'm just interested to pick up whether there have been studies done to analyse whether it creates or the bentonite contributes to the creation of a more predictable scenario in which the canister operates?

MR AIKAS: First of all, we have to remember that the multi-barrier system, the barriers, they are not redundant from each other, but they work in concert, so they support each other. So the basic case what we are looking at is the geological (indistinct) continues to be like it is today, so there is some ground water and the ground water will gradually saturate the bentonite swells and actually fills all the area around the canisters and limits the movement around the canisters. The only way how the ground water can enter from rock to the canister itself is deteriorate, which is very, very slow process, and also when it reaches the canister surface the temperature will actually drive it away for longer periods of time.

This is a very slow process which takes place thousands of years, and once the bentonite swells it also makes the environment impossible for microbes to grow because of the environment they don't get enough energy to grow. This is important because the groundwater usually contains sulfate, and the microbes can, in principle, produce sulfate to sulfite, which could be potentially harmful. The basic scenario with expected evolution as we study (indistinct) it would be very safe, but then of course when we are looking at the longer time periods when the temperature has cooled down and we're going towards the ice ages, so due to the loading of the earth's crust there could take place (indistinct) movements (indistinct) assume to have them in (indistinct) so that if there would be any nature earthquake the size of 7 or 8 on the Richter scale there might be some effects for the repository.

These effects have been studied very carefully, whether the fractures would move so much that they would actually influence the canister. In those analysis which have been conducted, it's not only the canister which supposed to be influenced by such an earthquake or fault movements, but each (indistinct) it's also important that there would be a huge amount of glacial melt water with a very low (indistinct) almost like distilled water. At the same time with this bedrock movements, this melt water should go down to the repository level and actually that melt water could then cause erosion of the compacted metal which then would be taken away from the canister (indistinct) and actually the density of (indistinct) would decrease.

First, after this process the corrosion for canister could take place and the sulfite could occur on the canister surface. STUK, when they reviewed the safety case which was attached to the construction licence application they also filed - the system is very safe and, if possible, to manufacture the components, as we've said, and install the components, as has been said, and planned and if repository will be closed and sealed as has been planned, the system is very safe (indistinct)

MR JACOBI: Could I quickly come just to the safety function of the backfill blocks. I assume they're being used to fill the tunnel, which I assume is for the purpose of contributing to the structural stability of the repository at the point of closure. Do they fulfill any other purpose?

MR AIKAS: Yes, they do. Of course the feeling of (indistinct) return if the conditions as close to the prevailing conditions before the excavation is one thing, but perhaps the most critical safety function for a backfill is the key (indistinct) like buffer down in the deposition hole, because once the bentonite starts to swell, it also swells upwards, and if the backfill is not able to keep the bentonite down, it will ooze out from the deposition hole, which again causes the upper part of the canister hole with the bentonite - the density of the bentonite will decrease. So the backfill indeed has an important safety function in that sense.

MR JACOBI: So what's the expected length of the effective operation of the barriers in combination at this site?

MR AIKAS: Well, wrong question.

MR JACOBI: Perhaps I can express it this way around.

MR AIKAS: Well, let me explain a bit. Because very often when we talk about the disposal and radiotoxicity of the waste, we look at the spent fuel reprocessing waste, otherwise we tend to look radiotoxicity of the waste, what goes into the repository, but this is not really the issue. The issue is what comes potentially out from the repository. If we look at the different waste types, what comes out is astonishingly similar, because the main problem, if I may so, in the disposal are the fission products and some transuranic element, and twice a week these most harmful elements require different times. Fission products, for instance, they disappear within a few thousand years. In 500 years they already have decayed so much that the gamma radiation is non-existent.

But the longer time periods, to get some exposure to these heavy radionuclides you have to eat the spent fuel of the waste or inhale, and in that sense, the effective operation time of each barrier is (indistinct) the canister design basis, if you like, that's 100,000 years, approximately, so that with a good certainty, the canister has to be able to contain the spent fuel for 100,000 years, but it does that very well, and even longer, but the safety assessment, that is always stretched to a longer period, not only looking for, in our case, one ice age period, but several times. So what would happen if there would be several glaciations, because any nuclides like uranium, plutonium and other transuranic elements, they have a very long lifetime as well as the most difficult nuclide higher than 129.

So we have to look at very long time periods, and look at how the system behaves as a whole and not so much individual barriers, but their operational life can be in terms of the containment and isolation. I hope that I managed to mix you well.

MR JACOBI: Yes. I think you may have answered a better question than I asked. We've spoken a little bit about the studies that were conducted, and I'm interested to get a bit of an understanding about the extent of the analyses that have been conducted on the copper canister, the bentonite, the backfill blocks and the bedrock.

DR HAUTAKANGAS: Yes. In principle, Posiva and SKB have been doing their research, concentrating - providing information for the whole system, including all the barriers, and the idea behind all these studies has been the transparency, so that every study and survey can be read by (indistinct) people, and this means that those companies, they have published almost everything which they have surveyed doing this (indistinct) which they have been doing. For example, Posiva has databank easily to access via the Internet, and also SKB has databank, and with those databanks it could be shown and it could be read by everybody who was interested about the analysis.

MR JACOBI: So the technical analyses that have been conducted have been made available?

DR HAUTAKANGAS: Yes.

MR JACOBI: In terms of the research, is there still an ongoing program of research into the relevant barrier methods that we've discussed?

MR AIKAS: Yes, very much so, but it's not clear and settled this, what are the material properties and design of the barriers, for instance, and how to manufacture them so that they fulfil all the requirements, but the last step on the way is how to install this multi-barrier system in real conditions so that we can meet the requirements for the installation so that what we can achieve is what is called in our jargon "initial state, kind of - if you like, it's a last (indistinct) action, if you like, so that when information is made following all the requirements so that the canister sits inside the bentonite as it shall be, the bentonite has been placed in the canister hole as it should be.

The canister hole is within (indistinct) of the roundness and the - and it's vertical, and the tunnel fulfils the requirement, and everything is installed as it is, including the massive concrete plug at the mouth of the disposal tunnel. So there we can say that we have reached the initial state and done everything based on the requirements set, so that we can send the system to its long journey into the future and we know that it's safe. This is what is still left of the R&D (indistinct)

MR JACOBI: We've spoken of the studies, but I'm interested to understand, in broad upshot, what those studies have told us about the durability of the barrier. I think you've already expressed it in terms of a period of time, but have they told us anything about the plausibility of particular scenarios potentially emerging?

MR AIKAS: So if there are any doubts that the barrier would not function, or if there are some promises, we would have kind of overlooked, so not properly so that we have neglected them. So that means that we have to kind of go back and do more work. For instance, I mentioned the possible junction of the compacted bentonite due to the ionic groundwater. That was kind of a phenomenon in the process which was not well understood until 2004, 2005. And furthermore, more tricky issues has been the possible disturbances, for instance, what construction materials could influence on bentonite.

Let's take an example. Together with the Swedes, we were pretty uncertain how ordinary portal (indistinct) would influence the compacted bentonite with the high-pH plume which the concrete might create in the groundwater. So we had two alternatives: either launch a research program for, let's say, the next ten years to look into the poor effects and predictable chemistry parts of the high-pH plume on bentonite or smectite clay. This was one alternative. Another alternative was to start to build up a low-pH concrete, which would not create such (indistinct) because we know that in lower pH conditions bentonite survives fine. So when balancing between these two approaches, we selected the low pH concrete development, because that, with a higher certainty, produces a good result and out of a long term research program with lots of work and still uncertainty how too high-pH plume would influence.

The tricky thing in doing this safe disposal is not always technical and develop some new technical solutions. The tricky thing is how to access these technical solutions they are saying, and they are said with long-term.

MR JACOBI: The Commission, in the material that it's been reading, has been asked to consider what the potential effect of, say, something like an earthquake might have on such a facility over the long term. I'm interested to understand how you've approached the question of an earthquake, thinking about the effect of that on the potential damage to either the repository or the container.

DR HAUTAKANGAS: Yes. Like already discussed about the characteristics of Finnish bedrock, it basically is formed with blocks, and the basic idea that when - we know already that the earthquakes in Finland are quite weak or maximum moderate, meaning that those blocks which - they are loose in fracture zones with each other. So in practice it means that those blocks just slightly move towards each other, and so there won't be any big effect from the earthquakes to these blocks itself. So the idea is that to build the repository and the deposition holes in the areas where you have the - or inside these blocks so that the repository won't be affected anyhow from the mild earthquakes.

MR JACOBI: Has consideration been given to the effect of the mechanical cutting of the rock itself and its potential to create faults or fractures in the rock, that is, in the process of actually cutting the tunnels or excavating the driveway?

DR HAUTAKANGAS: Yes. The is also - Posiva has made of course a lot of work, so-called EDZs, excavated damaged zones, so that the - as a matter of fact, during the Onkalo construction, Posiva has developed a method in in order to decrease the EDZ effect of the bedrock and to diminish the fractures from the excavation to the repository and bedrock.

MR JACOBI: Is it proposed to do characterisation again once the tunnels have been cut in order to determine whether, within those particular tunnels, there are fractures or other breakages or weaknesses in the rock?

MR AIKAS: Yes, very much so. So before - because now when the repository construction starts, so Posiva has to characterise the rock volume, where the repository tunnel would be constructed in advance already, and get approval from the regulator to get it constructed. Once the construction proceeds so that the (indistinct) will be built to explore that rock ahead fulfils its target properties, so that will be accessed all the way with the construction and study where there are fractures, should be we really construct this tunnel or not. So it's a gradual process of rock classification and decision making. But could I go back a bit to the earthquake question?

MR JACOBI: Yes.

MR AIKAS: So this was an important question also during the 90s when the safety assessments were conducted, and especially the safety assessment in 96 when lots of so-called scoping calculations were made for the earthquakes. As someone mentioned (indistinct) is a very calm region in terms of earthquakes and seismicity in general, but we cannot rule out that there could be a possible large earthquake (indistinct) sometimes in the future, and therefore, lots of scoping calculations were made so that a lot could be known if it would take place at this site where the repository is located, at that depth where the repository is, and hit maximum number of canisters, and we could see that in spite of the breaking of several canisters by a big kind of guillotine kind of movement, the release still should be and would be very low, because most of the radionuclides, they are not easily soluble in groundwater, and especially if there is more oxygen present.

So there are lots of kind of understanding what would happen if such an earthquake and fall would take place, and later on we have been able to make more careful analysis of individual canisters and fractures and the movement.

MR JACOBI: Was there within the design, and we haven't discussed it, any ability to optimise the design to take into account its economics, that is, the - I noticed on the slides before there was a requirement that it be economically feasible, but was it possible to optimise the design in terms of controlling the overall costs?

DR HAUTAKANGAS: Yes. There has been done optimisation. The main problem with the optimisation is that the fuel itself, it has to cool down for decades. So this is the biggest problem, to do really effective optimisation. We have to just take that as a given, that cooling time. But other ways, of course, the optimisation in a technical point of view has been made. For example, the layout of facilities has been kept as robust as possible in order to keep the design feasible and economical feasibility.

MR JACOBI: Is there anything you want to add?

MR AIKAS: Yes. If you look at some consumables, so what you can do with them - so optimisation is the size of the volume, how much will be excavated and packed down, and as you saw, the demonstration tunnel at Onkalo is as small as it can be to save in the amount of backfill, for instance, because backfilling is expensive, and excavation is expensive. And also if you look at the consumables - so the buffer, you can optimise the design of buffers so that the production and manufacturing method would be most optimal, and also what you can do, you can try to optimise the canister core by the manufacturing method.

People always think that copper is expensive, but copper is only one part of the canister price, and it's about, let's say, one-fourth of the price of the canister. So the manufacturing itself is the most expensive, but if you can streamline manufacturing under nuclear quality, then that's a big optimisation. We have to remember that anything which goes under the safety classification in the nuclear area is unfortunately pretty expensive.

MR JACOBI: I'm wondering, and perhaps I'll invite both of you to speak to this, about why think the key lessons are that have been learned from, I guess, the Finnish experience in developing this repository.

DR HAUTAKANGAS: Well, I think one of the key lessons would be the way how we have worked. So in principle, the research and development work has been done together with other actors, for example, with SKB, and the information exchange has always been quite broad and transparent. I think this is, in our case, really important, at least for Finnish concept to get information from abroad and from other scientific experts.

MR AIKAS: I would add that, first of all, what has been extremely important in dealing with this, that the government decisions have to be stayed (indistinct) have actually stayed the decision from 1983, it's still valid and holds good, which is a very good thing for (indistinct) and the responsible (indistinct) like our countries to give the stability to this scheme to work with so that there are no political surprises on the way. This has been one important thing, to create this policy or strategy on a kind of government level so that you have all keys to work with your technical and scientific issues.

What I would also stress from the acceptance point of view, and from the citizen's point of view and communities, the whole country, it has been important that nuclear regulators, STUK, has been involved in the process from the very beginning and has been at the disposal of the citizens as an independent organisation and giving information and being present if somebody wants them. That has also created some confidence to citizens.

MR JACOBI: Did it provide that information in the period up until the time of the decision in principal? Was it actively involved in providing information to the community prior to 1999?

MR AIKAS: Well, they were not active by the same manner as we were, like, we were kind of having open houses, open offices and so on, but whenever communities wanted they could ask STUK to come and tell them what they think about possible work and the results. I think that this was important in building confidence between all of the parties, not only (indistinct) and people in the community, but also people between the government and the communities. People very often thinks that government doesn’t mind, they just tell us what to do, but in this case it created confidence.

COMMISSIONER: In speaking about the communities, what benefit did the local community, Onkalo, receive for having the repository in their area?

MR AIKAS: There are no direct benefits it doesn’t belong to our culture.

What has been granted, if you like is employment so that there are jobs, some 120 people w1ill work at the facility when it's operational so it creates jobs, and the communities they gain tax revenues in a form of income tax. More so we have another tax which is very important, and that's called real estate tax, and the power plants, especially hydro power plants and nuclear power plants and nuclear facilities, they have a higher taxation percentage as normal buildings so that the community will get as a tax revenue a significant income from the real estate tax.

You already know when Onkalo was being constructed and up until then (indistinct) constructed and operating, so these are the economical benefits the community will get.

COMMISSIONER: In speaking about operation, you have an operation licence approved now, I see.

DR HAUTAKANGAS: Construction licence.

COMMISSIONER: Construction licence?

MR AIKAS: Construction.

COMMISSIONER: I presume you timed your construction to be ready by 2020?

DR HAUTAKANGAS: Around that time, yes, and it was assumed that operation would start in 23, maybe.

COMMISSIONER: Do we assume construction starts reasonably soon?

DR HAUTAKANGAS: Yes, we do. It was on 12 November this year the government approved the construction licence to Posiva, which means that Posiva can now freely begin the construction of all the nuclear facilities, so this is launch for this kind of work.

COMMISSIONER: Gentlemen, thank you very much for that very detailed information, which is very useful for us as we think about the terms of reference that we've been asked to consider. We will adjourn for the day and recommence at 7 o'clock tomorrow morning. Thank you very much, Timo, for joining us so early in the morning.

MR AIKAS: Thank you. Thank you very much. Goodbye.

COMMISSIONER: Thank you.

MATTER ADJOURNED AT 5.15 PM UNTIL TUESDAY, 24 NOVEMBER 2015