PREPARING TO CONSTRUCT A DISPOSAL FACILITY POSIVA APPROACHING THE SUBMISSION OF A CONSTRUCTION LICENSE

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ABSTRACT

Posiva Oy's (Posiva) last leg of the journey to submit a construction license for a deep repository and an encapsulation plant at the Olkiluoto site in Eurajoki, Finland has started. The forty year´s journey towards operating a disposal facility in 2020 is about to reach the second important legal milestone towards the facility implementation, the submission of the construction license in 2012.

The starting words of Posiva's waste management programme were published in the "Activity plan and timetable for TVO's nuclear waste management" in 1982 by the Nuclear Waste Commission of Finnish Power Companies. The essence of the plan became a Government decision in 1983 stating that the disposal operations of spent fuel could be started in 2020 and a site suitable for the construction of a repository should be selected by the end of 2000. The Government's Decision-in-Principle (DiP) that was ratified by the Parliament in 2001 enabled Posiva to proceed to site confirmation studies. As a major part of these studies it enabled Posiva to construct the underground rock characterisation facility (URCF) ONKALO on the site according to the regulatory requirements despite the fact that ONKALO is not a nuclear facility.

Posiva's programme after about ten years of confirming site studies and learning underground construction according to regulatory requirements is currently aiming at submitting a construction license application for the Olkiluoto deep repository and encapsulation plant in 2012.

According to the Government's decision in 2003 a pre-licensing documentation was submitted to the responsible ministry TEM (Ministry of Employment and the Economy) and the state-of-the-art documentation related to the safety case for the disposal facility was submitted to the overseeing authority STUK (Radiation and Nuclear Safety Authority Finland).

Prior the decision in principle application in 1999, Posiva also carried out the Environmental Impact Assessment (EIA) programme as a pre-requisite of the application. The EIA programme and report were also pioneering actions at the time, since after Finland joined the European Union this programme was the first project for which the new EIA legislation adopted after the EC's EIA directive was applied in Finland. The EIA process was updated in 2008 for the nuclear plant expansion programmes of Posiva's owners TVO and Fortum Power and Heat. Also new Decision-in-Principle applications were submitted for the new nuclear power plant units.

Posiva now proceeds according to its latest research, development and demonstration (RD&D) plan "TKS-2009", taking into consideration the statement by the responsible ministry TEM and the comments received from STUK on the pre-licensing documentation with the 2012 goal in sight.

This paper discusses the licensing process of Posiva's facilities within the Finnish regulatory environment from the implementer's point of view.

1. INTRODUCTION

1.1 Nuclear waste management in Finland

The Finnish nuclear power plants have been in operation for more than 25 years. Two BWR units are operated at Olkiluoto (2 x 860 MWe) by Teollisuuden Voima Oy (TVO), and two PWR units at Loviisa (2 x 488 MWe) by Fortum Power and Heat Oy (Fortum). One PWR unit (1600 MWe) is under construction at Olkiluoto [1]. Two new units had favourable Decisions-in-Principle in 2010. One of these new units will be constructed in Olkiluoto by TVO.

According to the Nuclear Energy Act, all nuclear waste generated in Finland must be handled, stored and permanently disposed of in Finland. TVO and Fortum established a joint company, Posiva Oy, in 1995 to implement the disposal programme for spent fuel, whilst other nuclear wastes are handled and disposed of by the power companies themselves (Figure 1). Posiva's owners TVO and Fortum are responsible for the safe management of the waste produced by their nuclear power plants and for all associated expenses.

Posiva is in charge of all the research, development and planning work required for final disposal of spent fuel for these two owners, as well as of the construction and operation of the final disposal facility in the future. Based on this the company will apply for the necessary licences and will later construct and operate the disposal facility.

Posiva possesses top expertise in Finland in the field of nuclear waste management and maintains extensive contacts with international organisations working in this field. Research and design related with nuclear waste management is carried out in universities, research institutes and consulting companies that represent state-of-the-art competence in various fields.

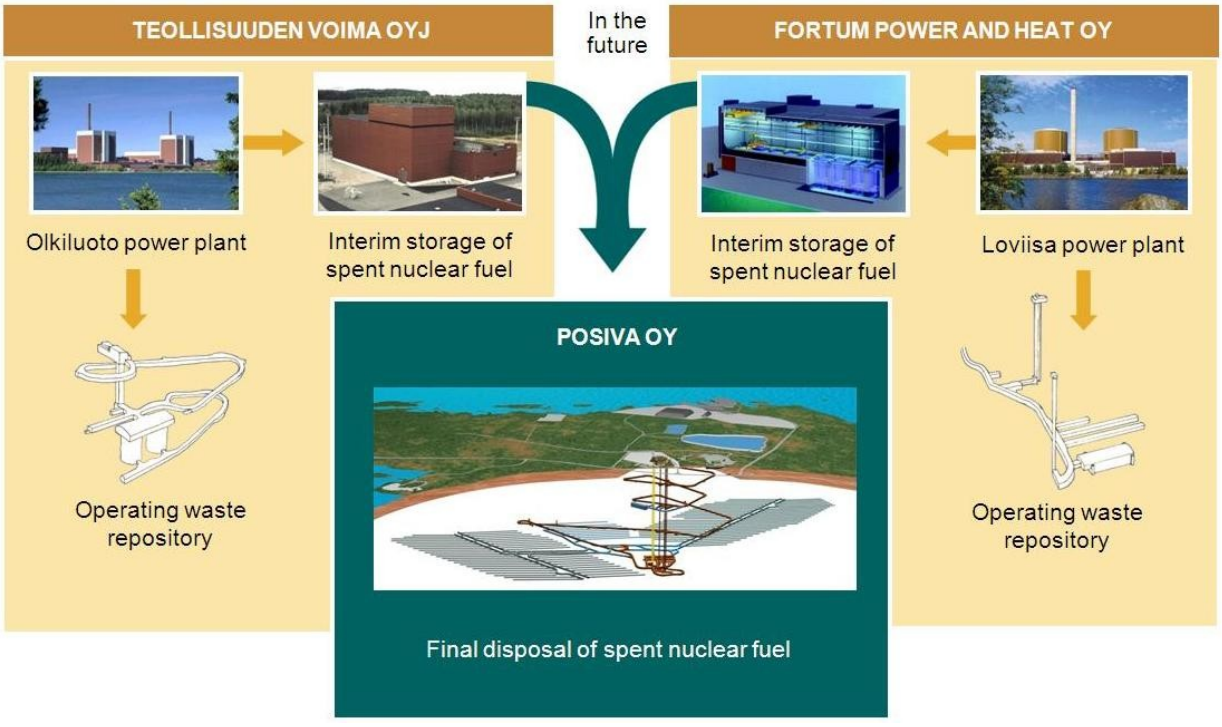

Figure 1. Organisation of nuclear waste management of the current NPP's in Finland.

1.2 Posiva's disposal concept

The plans for the disposal of spent fuel are based on the KBS-3 concept, which was originally developed by the Swedish waste management organisation SKB (Svensk Kärnbränslehantering AB). In this concept, the spent fuel elements are isolated and contained in copper - cast iron canisters with a long expected lifetime, and emplaced at a depth of several hundreds of meters. A bentonite clay buffer is installed between the rock and the canisters and the disposal tunnels are backfilled. After the emplacement of spent fuel canisters has been completed, all access routes from the surface to the disposal tunnels are backfilled and sealed, after which the repository requires no further control or maintenance.[2]

The deep geological disposal system comprises both natural and engineered barriers that will isolate the spent fuel so that it can never harm the living environment nor be accessible to people. The bedrock protects the disposal system against external influence, creates mechanically and chemically stable conditions in the repository and restricts the amount of water that can come into contact with the engineered barriers. The depth of several hundreds of meters also guarantees sufficient protection against the influence of any future ice ages. Should the spent fuel for some unforeseeable reason come into contact with groundwater, any releases from the spent fuel would remain in the bentonite and in the bedrock surrounding the canisters.

1.3 Overall schedule of Posiva's programme

The Government decision in 1983 set a target schedule for nuclear waste management. The selection of the spent fuel disposal site was scheduled for year 2000, the construction of the disposal facility for the 2010s and the start of disposal for 2020 (Figure 2).

Potential sites for the disposal of spent fuel were screened in the 1980s, followed by preliminary and detailed site investigations in the 1980s and 1990s. In 1999, Posiva submitted an application for a Decision-in-Principle to choose Olkiluoto as the site of the disposal facility. The Government issued a DiP in favour of the project in December 2000, and the Parliament ratified the decision in May 2001.[2]

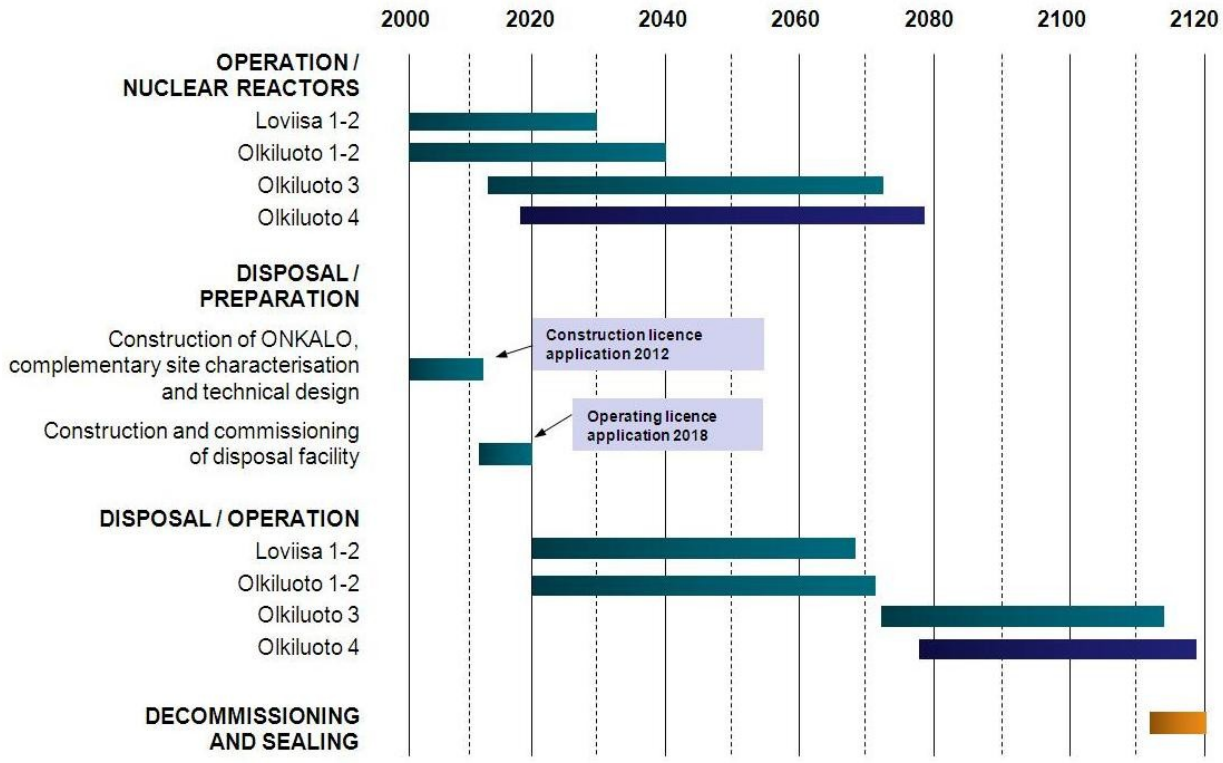

Figure 2. Schedule for the disposal of spent fuel.

The next milestone in the spent fuel disposal is the submission of an application for the nuclear waste facilities construction license in 2012. This is a major target for research, technical design and development (RTD) activities in Posiva at present.

The encapsulation plant and the first part of the repository will be constructed and commissioned in 2014–2020. The operating license application will be submitted to the Government in 2018 and the disposal operations are scheduled to start in 2020.

Disposal tunnels will be excavated in several phases during the operation of the repository. The spent fuel from the existing NPP units, the Olkiluoto 3 unit under construction and future Olkiluoto 4 unit will be disposed of by 2120. After that the encapsulation plant and the repository will be dismantled and the repository backfilled and sealed if no new power plant units are constructed.

2. LEGAL FRAMEWORK

The Nuclear Energy Act regulates the implementation of nuclear waste management in Finland. According to the Act, the operators of the NPPs bear the responsibility for nuclear waste until final disposal has taken place. All nuclear waste generated in Finland, including spent fuel, must be handled, stored and permanently disposed of in Finland.

The principles of the policy on nuclear waste management were originally defined in a Government decision in 1983. This decision and the subsequent decisions of the Ministry of Trade

and Industry (KTM) provide a basis for both the practical implementation of nuclear waste management and for research and development related to the eventual development of a repository for spent fuel.

The Government grants the construction and operation licences for nuclear facilities but, before actual licensing can take place, a policy decision referred to as the Decision-in-Principle (DiP) needs to be approved by the Parliament. The Government will only accept the application provided the Finnish Radiation and Nuclear Safety Authority (STUK) issues a favourable safety statement and the municipality where the disposal facility is to be built consents to it. STUK is responsible for the control and supervision of nuclear waste management activities.

The financial side of final disposal is also covered by legislation. The assets required for the management of wastes produced in nuclear power plants are collected in advance from the waste producers and transferred to the State Nuclear Waste Management Fund. The Fund is a reserve for future costs. It is not included in the budget of the state, but is an external fund controlled by the Ministry of Employment and the Economy (TEM).

3. MAKING OF THE DECISIONS-IN-PRINCIPLE

In May 1999 Posiva filed an application to the Government for the policy decision, Decision-in-Principle (DiP), on the disposal facility for spent nuclear fuel, planned to be located at Olkiluoto. The original application was for 9,000 tons of uranium (tU) but before the application processed by the Government; Posiva decreased the amount to 4,000 tU.

STUK reviewed the application for the responsible ministry (then KTM) and stated that there were no safety issues that would prevent a positive decision as the suitability of Olkiluoto for disposal had been confirmed by investigations. Eurajoki municipal council also supported the selection of Olkiluoto for the disposal site.

In December 2000 the Government decided in favour of the DiP, with the justification that the disposal facility serves the overall good of the society. In their decision the Government limited the amount of spent fuel to 4,000 tU and postponed the remaining 2,500 tU to be dealt with in connection with the DiP for a new power plant unit (Olkiluoto 3). The Parliament ratified the decision by 159 votes in favour and 3 against in May 2001. For the remaining 2,500 tU the favourable Decision-in-Principle was made in January 2002 and the Parliament ratified it in May 2002.

In April 2008 Posiva filed an application for DiP in connection with TVO's application for Olkiluoto 4 power plant unit and later in 2009 and application for extension in connection with Fortum's application for Loviisa 3 power plant. The extensions of the disposal facilities were from the present 6,500 tU capacity to the total of 9,000 tU, which would enable the disposal of the spent fuel from the Olkiluoto 4 unit [3] and further extension from 9,000 tU to 12,000 tU for the spent fuel from Loviisa 3 [4].

The Government made a favourable decision in principle for Olkiluoto 4, but not for Loviisa 3 new builds and for the extension of Posiva's facility for the Olkiluoto 4 spent fuel. These decisions were Parliament ratified it in July 2010 and the current and former DiPs for spent fuel

disposal cover the existing four power plant units and the new Olkiluoto 3 and Olkiluoto 4 units, in total 9,000 tU.

4. PRESENT ACTIVITIES AT OLKILUOTO DISPOSAL SITE

The confirmation of the suitability of the site through underground characterisation of the intended host rock of the repository is essential to fulfilling the regulatory requirements. After the DiP was ratified in May 2001, Posiva took the next step based on the decision to excavate a site specific underground rock characterisation facility, ONKALO, at the Olkiluoto site. The ONKALO URCF is constructed in such a manner that it allows further characterisation and research work to be carried out simultaneously without jeopardizing the long-term safety of the repository site. ONKALO URCF is also constructed in such a way that based on an oversight agreement with STUK be integrated as a part serving the licensed repository.

More than 4.5 km of tunnel has been excavated by May 2011, and the implementation of the underground research and investigation programme is underway. The target depth of the repository's characterisation level is about 400 meters and it was reached in summer 2010. The present design of ONKALO URCF is presented in Figure 3. The total excavated rock volume of ONKALO is 300,000 m^3.

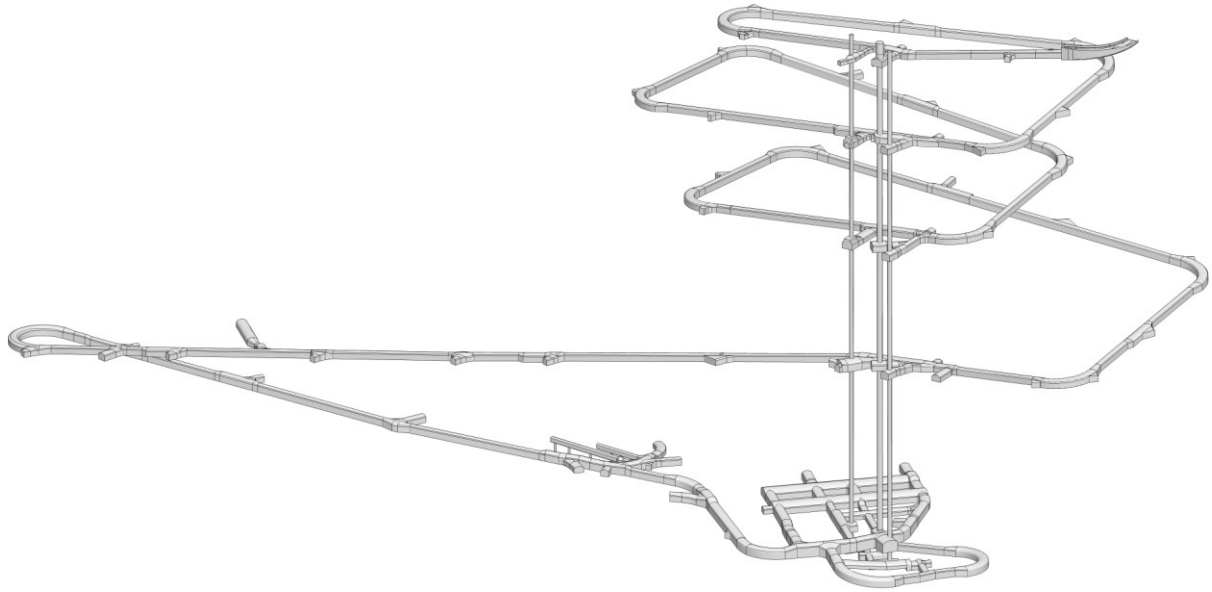

Figure 3. ONKALO Underground Rock Characterisation Facility.

5. DEVELOPMENT NEEDED FOR CONSTRUCTION LICENSE APPLICATION

Under the Nuclear Energy Act, Posiva and its owners regularly submit to TEM a report detailing the responsible parties' plans concerning the implementation of the measures associated with

nuclear waste management and the preparation of these measures. Currently the plan is submitted every three years and the activities are reported annually to the Ministry [5],[6].

The RTD plan outlines the main RTD work at Posiva aiming at submitting the license application and it has and continues to concentrate on following items:

- Design and technical demonstration of reference disposal technologies;
- Development and application of the rock suitability criteria for the Olkiluoto site conditions;
- Further development and deepening of the Olkiluoto site understanding;
- Design of a repository layout adapted to the Olkiluoto site features at the planned repository depth;
- Design of an encapsulation plant process and systems, and
- Development of the safety case for the application of the construction license.

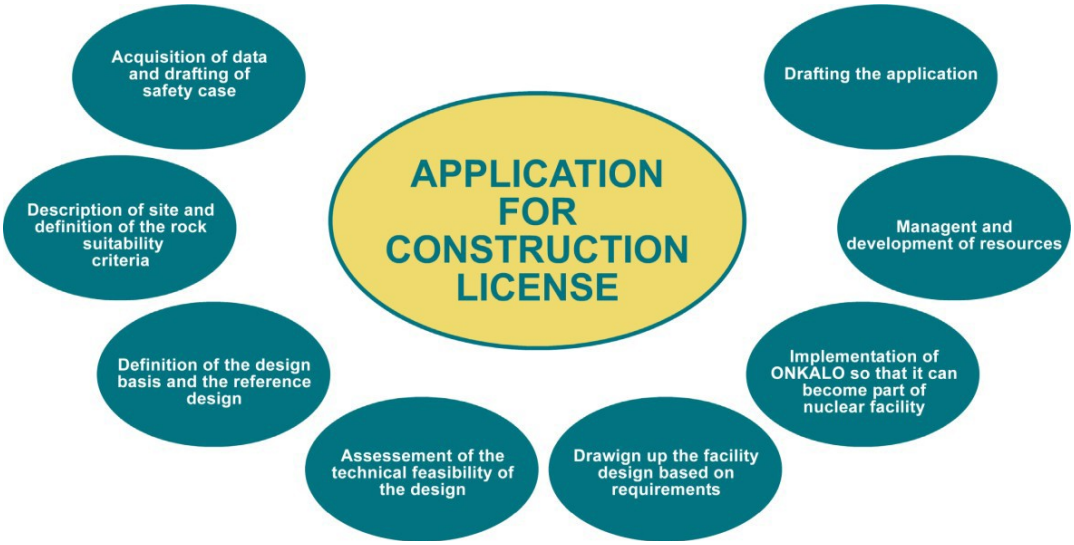

Figure 4. A strategic map for the construction license application process [5].

5.1 Development and demonstration of disposal technology

Development and demonstration of disposal technology is mainly targeted to design the appropriate parts of EBS system like canister, buffer and backfill [5].

The basic function of the canister is to be leak tight with high probability in postulated repository circumstances for at least 100 000 years. The design criteria of the canister include initial integrity, mechanical strength and chemical resistance against corrosion in the repository circumstances. Copper tubes for canisters have been fabricated on a trial basis using different methods, such as extrusion, pierce-and-draw processing and forging. Various methods for casting the inserts are also being tested and evaluated. The reference sealing method in Posiva´s

canister concept is electron beam welding (EBW). Friction stir welding is an alternative sealing method. [5]

The current target for the development of inspection technologies and procedures is to be able to rule out the possibility of penetrating defects. The aim of the inspection technology programme is to select or define practical examination methods, equipment and procedures to fulfil the verification requirements of the flawlessness and dimensions of the canister components, including the sealing weld, as well as identification of components and end products. [5]

Concerning the long-term safety, the main function of the buffer is to contribute to canister's expected life-time, protect it from harmful THMBC (thermo-hydro-mechanical-chemical) processes and to limit and retard the release of any radionuclides from the canisters, should any be damaged. [5]

The buffer shall be plastic enough to protect the canister from rock movements. The buffer shall be also stiff enough to support the weight of canisters and maintain their central vertical positions in the deposition tunnel in the long term. In addition the buffer shall be dense enough to achieve and maintain sufficient swelling capacity and limit both potential erosion and microbial activity. [5]

Before the year 2012 the technology development is concentrated on development and testing of the buffer design related topics. It will include the reasoning of design specifications, investigation on manufacturing methods for buffer component, like uniaxial or isostatic compaction, and study the emplacement related questions. [5]

The tunnel backfill design consists of pre-compacted blocks and pellets emplaced on the foundation bed. The role of the backfilled tunnels is to support the safety functions of buffer, canister and bedrock. In practice there are limits for hydraulic conductivity and compressibility in order to avoid the water movement through the backfilled tunnels onto the deposition holes. Also some swelling of the backfill material is needed to keep tight contact with roof and walls, which is needed for the low hydraulic conductivity and for keeping the tunnels mechanically stable. [5]

The needs for development of backfill design are related to the design basis and selection of suitable material and composition of backfill components. The manufacturing of components and emplacement of them in the tunnel needs to be tested. The tests are mainly done in simulated conditions above surface or in small scale below surface. Also the processes in the backfilled tunnel during operational phase like piping and erosion, self sealing, swelling ability and factors (interruptions in tunnel, inflow, hydrostatic pressure, water chemistry etc.), which might influence to the behaviour of the backfilled system need to be studied in detail. These types of studies will be done in laboratory conditions or in situ testing below surface. [5]

5.2 Development of site characterisation

The further investigations to be carried out in ONKALO aim at further characterisation of the bedrock properties and groundwater characteristics and to help support decisions for selecting the most suitable locations for the first deposition tunnels and deposition holes for spent fuel canisters. Characterisation of the rock mass is already taking place using pilot holes core drilled

along parts of the tunnel axis, prior to its excavation, by tunnel mapping and by monitoring the impact of excavation works and in special investigation niches.

These studies aim to assess how the increased knowledge and experience gained from the construction of the ONKALO has enhanced the level of site understanding and the predictive capability of the modelling teams, as well as providing input and testing of the developing Rock Suitability Criteria (RSC).

The RSC is identified to develop a classification scheme to be applied for the repository layout, for defining suitable rock volumes for the repository panels, for assessing whether deposition tunnels or tunnel sections are suitable for deposition holes and for deciding whether a deposition hole is acceptable for disposal [5]. The developed criteria should be based on observable, measurable properties of host rock, which together with interpretation, modelling and general understanding of the site properties can be used to show that the requirements set on the rock can be fulfilled.

By applying the classification scheme the aim is to avoid features that may be harmful for the safety of the repository. Based on the current understanding, the bedrock in general will provide suitable and sufficiently stable conditions for a repository, but there are certain site specific features, e.g. extensive deformation zones, volumes of relatively low mechanical strength in relation to the rock stress, sparse occurrence of highly transmissive fractures or saline groundwater that may affect the safety of the repository.

5.3 Disposal facility design, demonstrations and construction

The *Outline planning stage* of the repository has been reported in 2009 [7]. The following *Main drawings stage* will contain the optimization of the layout, detailed plans for the disposal facility and optimization of operations in disposal facility. One target is also to develop the facility documentation and safety classification to be used during the operational phase. Testing and demonstration of the selected techniques will be started before submitting the license application in 2012.

The main rock construction activities needed for the repository implementation are excavation of tunnels and shafts and boring of deposition holes. Significant experience has already been gained from construction of the access tunnel and the shafts of ONKALO, which will work as access routes of the repository in future.

The ONKALO URCF will serve a good basis to test and demonstrate the selected design for engineered barriers. The section of the deposition tunnel and hole for demonstration purposes has been characterized and excavated with requirements set for disposal conditions. This offer a representative test place to train in the emplacement methods and initially also personnel for the future repository. Optimization of the selected concept and prototype equipments are among key items. The monitoring of the tests and development of methods to follow up the EBS performance will also been developed. The quality management with assurance and control methods can be practiced in real disposal conditions excluding spent fuel.

Parallel to the testing and demonstration the activities related to the construction of the first repository panel will be implemented. The procurement of needed equipments for construction and also for operations in the repository like canister transfer and installation vehicle, buffer and

backfill emplacement vehicles shall be initiated. The organization towards to the disposal start will be created. The operation license is planned to be submitted in the end of 2018. [5]

5.4 The development of the Safety Case

The long-term safety section supporting the license application is based on a safety case, which, according to the internationally adopted definition, is a compilation of the evidence, analyses and arguments that quantify and substantiate the safety and the level of expert confidence in the safety of the planned repository both at the initial state and in the long-term.

The Safety Case production process (Figure 5) is divided into four main sub-processes in Safety Case plan [8].

The *conceptualisation & methodology* sub-process defines the framework for the assessment.

The *critical data handling and modelling* sub-process links Posiva's main technical and scientific activities to the production of the Safety Case and the grounds of Models and Data is presented as a separate report in the Safety Case.

The *assessment* sub-process analyses the consequences of the evolution of the disposal system in various scenarios, classified either as part of the expected evolution or as disruptive scenarios.

The *compliance & confidence* sub-process is responsible for final evaluation of compliance of the assessment results with the regulatory criteria and the overall confidence in the Safety Case.

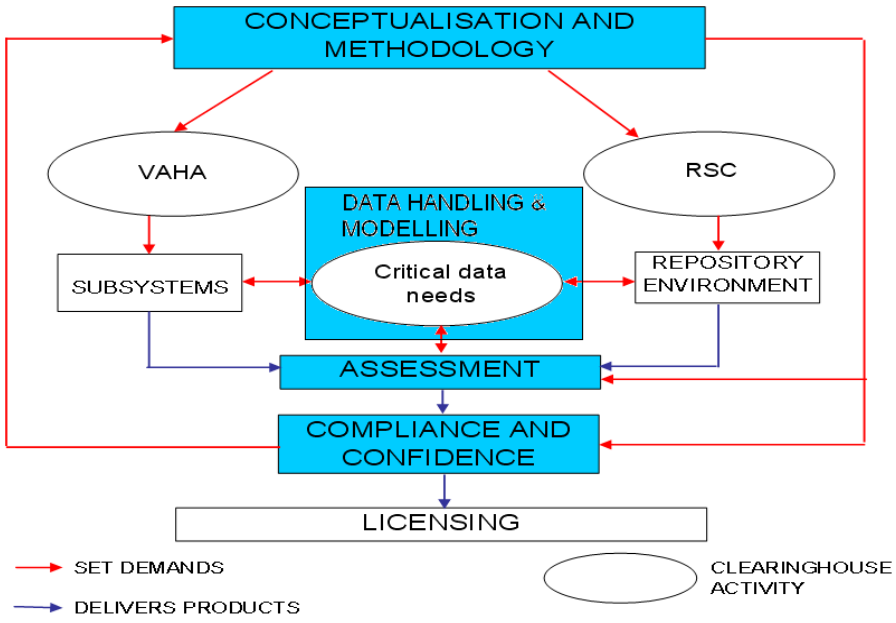

Figure 5. The Safety Case sub-processes in relation to the requirements (VAHA) of the disposal system and the host rock suitability criteria defined for the disposal tunnels (RSC) [8].

The main argumentation for the long-term safety of a spent fuel repository at Olkiluoto will be compiled into the portfolio of Safety Case reports (Figure 6) that are published after a quality assurance review during 2011-2012. The green reports refer to Safety case reports and the blue reports refer to the main supporting reports for the Safety Case.

The main findings of the Safety Case work will be presented in the Synthesis report, which will provide the main input to the Preliminary Safety Analysis Report (PSAR).

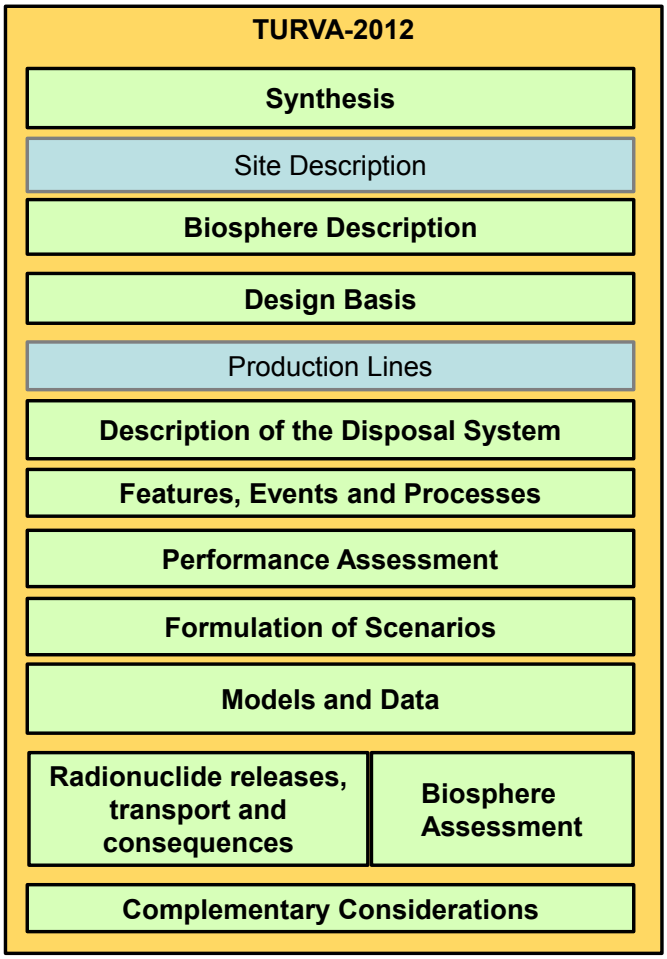

Figure 6. Safety Case reporting structure (updated Safety Case plan 2011).

CONCLUSIONS

The next milestone for Posiva is to prepare the construction licence application. A preliminary state-of-the art license application material was submitted to the Ministry already in 2009. The authorities' feedback on Posiva's readiness to submit the construction license confirmed the items already identified in Posiva's TKS-2009 plan. The studies on these main challenges and key issues need to be finalised and reported within the time remaining before the submissions of the construction and operating license applications. Demonstrations for characterisation and construction of disposal area according to the requirements will be one of the key items on-going

in ONKALO as the excavation of the demonstration tunnels was started in April 2011. The tests and investigations of the EBS system components both small scale and large scale tests in simulated conditions with theoretical considerations are ongoing in several research facilities and laboratories. The safety case reports will be published. The activities will gradually change from small scale into the large scale testing and ONKALO will be the final demonstration place for the whole system behaviour in order to prepare for the disposal operations. The more detailed RTD work before the operating licence application submission is under planning and will be reported in the next TKS-2012.

ACKNOWLEDGMENTS

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