Next Target Operating License: Challenges in Building Facilities for Spent Fuel Disposal in Finland - 14544

Erkki Palonen and Timo Äikäs
Posiva Oy, Olkiluoto, 27160 Eurajoki, Finland

ABSTRACT

After receiving the construction license granted by the Finnish Government the next milestone in the spent fuel disposal process is the submission of the application for operation license in 2020. This is a major target not only for construction and civil works but also for the research, technical design and development activities conducted by Posiva. After receiving the construction license, and parallel to the testing and demonstration, the activities related to the construction of the first repository panel will be implemented. The procurement of equipment needed for construction and also for operation in the repository, e.g. canister transfer and installation vehicle, buffer and backfill emplacement vehicle, shall be initiated. Nuclear facilities are designed, constructed and operated under a strict scrutiny by the regulator and according to the high demands of quality assurance. The current challenge is that, unlike the building of new nuclear power reactors, deep repositories have not been licensed for their intended purpose yet and each repository is a first-of-a-kind. One of the best benefits gained constructing underground characterisation facility in Olkiluoto has been ability to excavate specific delicate way. Nonetheless additional development work will be carried out before the maturity for operating license will be achieved. In order to receive a license, it must be ensured that the protection of workers, safety and environmental protection have been taken into account in the design as well as in its implementation as appropriate. To fulfill these demands, commissioning tests of the spent fuel-encapsulation plant and the repository will be performed first without the spent fuel and finally with it.

INTRODUCTION

The program for direct geological disposal of spent fuel in Finnish bedrock started in the early 1980's as a response to the Government’s decision in 1983 on the principles and time schedule for nuclear waste management. This decision set a goal to start the disposal activities in the early 2020s. In 2001 the Finnish Parliament approved the so-called Decision-in-Principle (DiP) on siting a KBS-3 type repository for spent fuel in an area near the Olkiluoto nuclear power plant (Fig. 1). After this decision Posiva Oy started the detailed design and construction of an underground rock characterisation facility (URCF) at the Olkiluoto site named as "ONKALO". In December 2012 Posiva submitted an application for the construction license of a disposal facility for spent fuel (SF) consisting of an above-the-ground encapsulation facility and an underground repository. The time schedule presented in the application aims at fulfilling the original goal set in 1983 by submitting the operational license application in 2020. Assuming that the construction of Posiva's facility can be started in 2015, the facility could be in operation in the early 2020s and continue to operate some 100 years.

As provided in nuclear energy legislation, Posiva's plant complex will consist of two separate nuclear facilities, the encapsulation plant and the disposal facility, which will be presented as one entity for licensing purposes. This disposal facility will also be referred to as "ONKALO" because with time the URFC has become a brand name for disposal. Commencement of the operation will require that the licensing of all key systems in the plants has been appropriately taken care of and that their operability has been demonstrated in joint operating tests and in trial operation.

Fig. 1. Map of Finland. Locations of nuclear power plants in Olkiluoto and Loviisa.

Before commencing the disposal operations, the production facilities required for producing the different components of the disposal system will also be built. These include the canister assembly plant and the production plants for the bentonite buffer and backfill material. The availability and procurement chain of raw materials must also be secured for the needs of the disposal process. The preparations for fuel transports will require the procurement and licensing of fuel containers and transport equipment as well as taking care of the safeguards-related details of transports [1].

DESCRIPTIONS AND DISCUSSIONS

Licensing System

The licensing procedure for a nuclear facility in Finland has three steps. These are defined in Nuclear Energy Act (990/1987) and Degree (161/1988):

- DiP is required for a nuclear facility having considerable general significance. This is essentially a political decision: the Government decides if the construction project is in line with the overall good of society. The host municipality has a veto right and the Parliament has the choice of ratifying or not ratifying the decision.
- Construction License is granted by the Government and authorizes the construction of the disposal facility. The actual construction is regulated by Finnish Authority for Radiation and Nuclear Safety (STUK).
- Operational License is granted by the Government and authorizes the operation of the facility for a certain period under the supervision of STUK.

Posiva filed an application for the Government's DiP for the first time in the year 1999 to be able to build the disposal facility at Olkiluoto in Eurajoki municipality. Since the host community Eurajoki was in favour for the disposal facility, as well as STUK, the Government made the

positive decision in 2000 and the Parliament ratified the decision in 2001. In 2002 a new DiP was made to join the new reactor (Olkiluoto 3) to be built in Posiva's future scope for disposal. The third DiP, as well to enlarge the repository for the needs of a new reactor (Olkiluoto 4), was taken in 2010. Based on these decisions the total scope for preparing the application for construction license has been 9000 tU of spent nuclear fuel.

The Ministry for Labour and the Economy is in charge for the handling process of Posiva's application for the construction license. The safety evaluation of STUK plays the key role in the process. In parallel of delivering the actual application to Ministry, a large package of technical and safety documents was delivered to STUK linked directly to the application. This documentation covers e.g. safety case for long-term safety, preliminary safety assessment report (PSAR) and several topical reports.

Since each repository is unique and first-of-a-kind due to the geological environment and nuclear waste inventory, a significant effort of research and development is needed after granting the construction license. This particular question has been recognised and it will mean that there will be some open issues in the licensing process which have to be solved by the time when Posiva will submit the application for operation license. This sets challenges to implementation since the new information emerging from RTD activities has to be taken into consideration in the implementation design and have to be approved by STUK. During the implementation STUK conducts its supervision in accordance to its guidelines for nuclear facilities. For this purpose Posiva has drafted and maintains a licensing plan.

The next target for Posiva in terms of licensing is to get prepared for applying the operation license. The time for this has been set to the year 2020. By this time the construction of the facilities above and underground should have advanced to such a maturity that the application is possible to submit to Government.

ONKALO as a Training Platform for Implementation

The idea of underground characterization as a final, confirming phase of the site selection process has been included in the plans since the early 1980's and the construction of an investigations facility was one of the main objectives set in the long-term RTD program Posiva published in 2000. From the early on it was considered natural to design the ONKALO in a way that it could later be used as an access way to the repository as well. It was understood that this would cause additional complexity in the actual construction work, since the design and construction of the facility should comply with nuclear regulations.

The principal objectives set to the ONKALO were to enable the underground characterization of the actual host rock of the repository, and to enable in situ testing and demonstration of repository technologies and work processes in realistic conditions. During the use of ONKALO as an underground rock characterisation facility there would be no radioactive substances handled and most of the structures and systems needed would not have any bearing on nuclear operational safety of the repository. Therefore the main nuclear and radiation related safety issues have been concerned with long-term safety and, particularly the issue of how to minimize the negative disturbances to the host rock influencing the favourable conditions for safe disposal. These disturbances have been recognised as safety critical functions and monitored during the construction and operation of ONKALO. They have formed an important part of quality assurance and decision making process during the construction. These functions are related to groundwater leakage, use of foreign materials, excavation damage and deep boreholes. [3]

ONKALO consists of access tunnel and vertical shafts and has planned to be part of the future repository (Fig. 1). The excavation of the access tunnel was started in 2004 and it reached the target depth in June 2010. The remaining auxiliary rooms and test galleries will be excavated while constructing the licensed repository after 2014. The purpose of excavation work that has taken place is in order to assess that it is possible to construct deposition tunnels according to stringent requirements set. The excavation tolerances, smoothness of the excavated surfaces, excavation damage, for example, are key parameters to manage in the production process. The demonstration has included also boring of the vertical deposition holes as an ultimate evidence of the capability to construct repository rooms and manage the quality. After this exercise Posiva has collected sufficient experience to go forward for licence application and implementation.

The Finnish authority for radiation and nuclear safety (STUK) has supervised the construction of ONKALO as if it would be a nuclear facility under construction. ONKALO has provided thus an opportunity to authorities to develop their procedures in this area of nuclear technology.

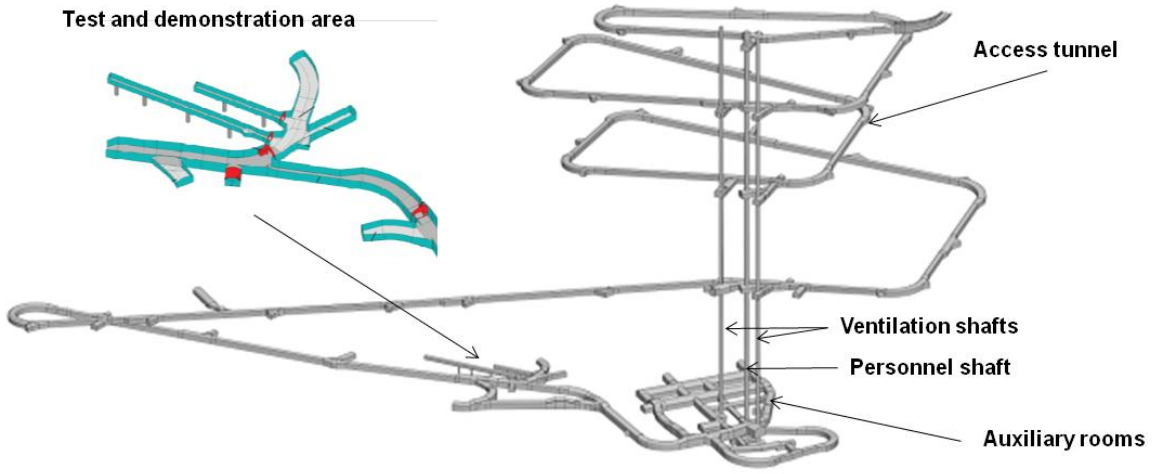
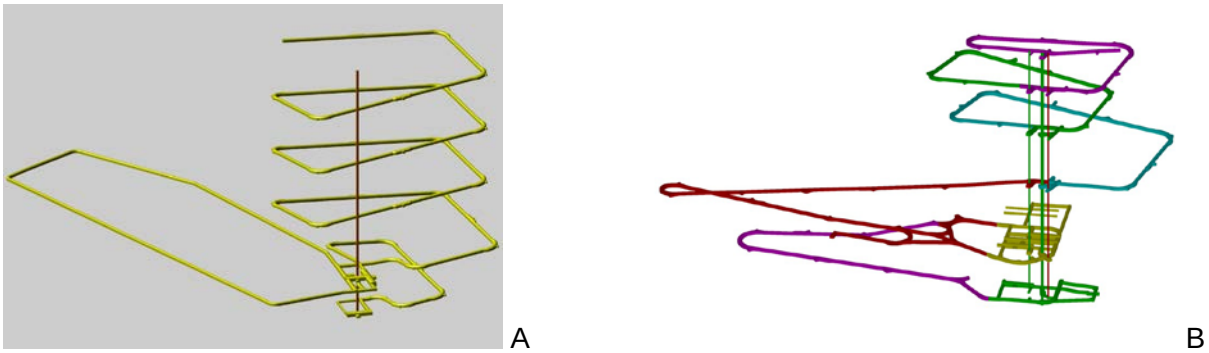


Fig. 2. ONKALO at Olkiluoto.

ONKALO as presented in Fig. 2 is a result of significant development. In Fig. 3 there are some examples of earlier versions for ONKALO layout. On the other hand the ONKALO has been designed as part of the future repository, and on the other hand as an underground research facility to bring information for intended purposes. This means that during the time flexibility is needed to accommodate the various changes in the layout and in the implementation design.



A B

Fig. 3. Examples of the ONKALO layout in 2003 (A) and in 2007 (B).

Disposal Facility at OLKILUOTO

The design of the disposal facility is based on the KBS-3V concept (vertical disposal). Long-term safety concept is based on the multi-barrier principle i.e. several release barriers, which ensure one another so that insufficiency in the performance of one barrier doesn't jeopardize long-term safety of the disposal. The release barriers are the following as shown in figure 3.: canister, bentonite buffer and deposition tunnel backfill, and the host rock around the repository. The canisters are installed into the deposition holes, which are bored to the floor of the deposition tunnels. The canisters are enveloped with compacted bentonite blocks, which swell after absorbing water. The surrounding bedrock and the central and access tunnel backfill provide additional retardation, retention, and dilution.

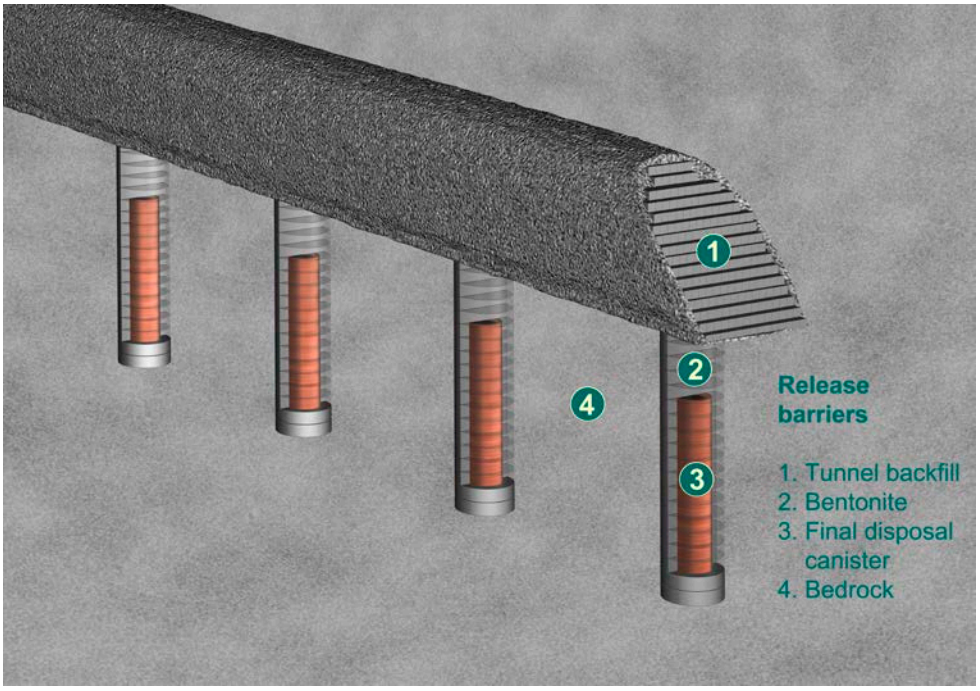


Fig. 4. The release barriers in deposition tunnel.

The nuclear facility consists of an above-ground encapsulation plant and of underground repository including also other aboveground buildings and surface structures serving the facility.

The access tunnel and ventilation shafts to the underground disposal facility and some auxiliary rooms are constructed as a part of ONKALO underground rock characterization and research facility during years 2004–2015. The construction works needed for the repository start after obtaining the construction license. Operating phase begins in the beginning of 2020s after obtaining an operating license. More deposition tunnels as well as central tunnels are excavated as the disposal proceeds. Lay out and proceeding principal is shown in figure 5.

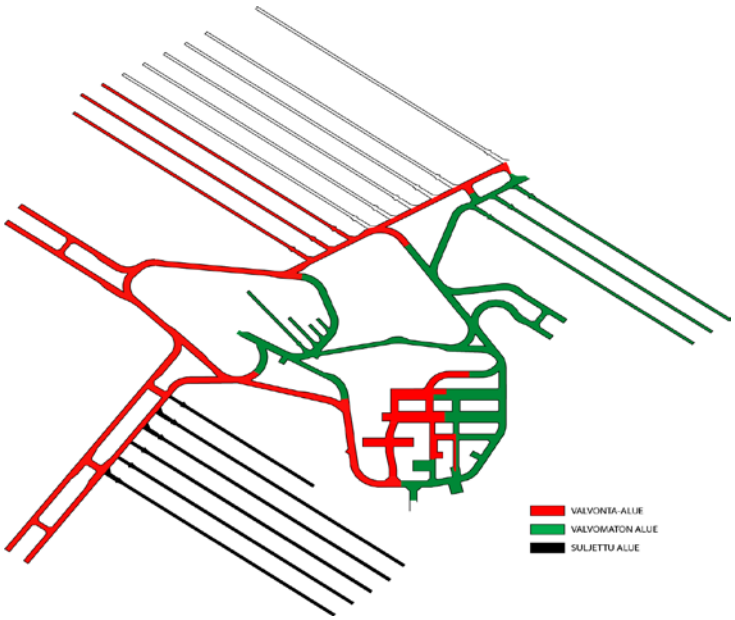


Fig. 5. Deposition tunnels and central tunnels in underground facility.

The spent nuclear fuel from interim storages is encapsulated into canisters in an encapsulation plant and then transferred into the underground disposal facility with a canister hoist. According to the current design, the repository layout is based on one-storey layout altering at the level of -400-450m (Figure 6). The underground disposal facility is accessed by the access tunnel and a personnel shaft, which is located in a hoist building.

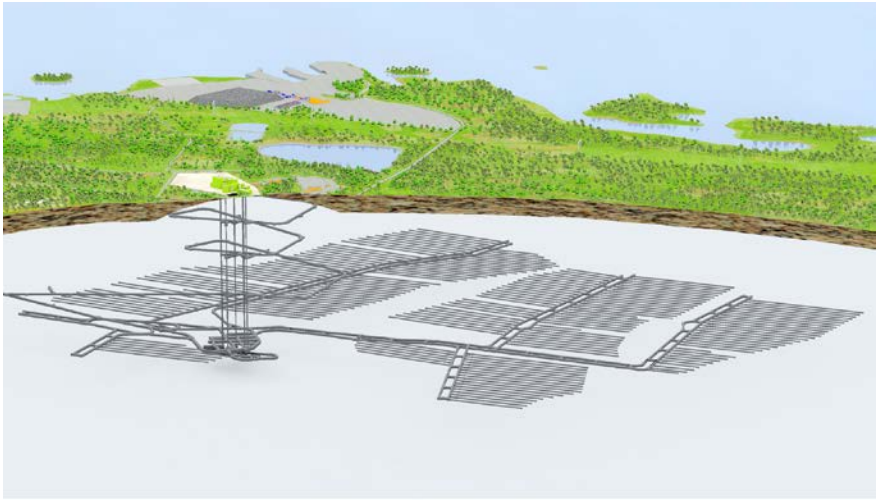


Fig. 6. Repository lay out, access tunnel and shafts connected to above ground facilities.

Spent nuclear fuel is received at the encapsulation plant for further processing before final disposal. The encapsulation plant is connected to the underground disposal facility via the canister shaft. Welded canisters are transported down to the disposal level by the canister hoist. The average encapsulation capacity of the encapsulation plant is 40 canisters per year. The dimensioning number of handled canisters is 100 canisters per year. The encapsulation plant will be planned in compliance with safety regulations so that the release of radioactive material or other releases into the environment in operational transients and accidents remains negligible. It must be possible to carry out all work phases in the encapsulation plant safely without causing significant emissions and radiation doses to the personnel.

Fig. 7. Cross-section of the encapsulation plant. The receiving and storage areas for transport casks and new canisters are seen on the right. To the left of them are the fuel handling cell, the canister welding station, the weld inspection station and the interim storage for bentonite buffer blocks (Kukkola 2012). [2]

Challenges of Implementation

At the end of 2009 Posiva submitted, based on the decision by the Ministry in 2003, an account about its readiness to submit a license application for construction. The documentation followed the structure of license application and used the material and experiences accumulated from ONKALO work. The conceptual design at the time was not mature to be evaluated as a real application but provided a useful exercise to guide the remaining development and design work towards the application. The review process, arranged by the Ministry, provided statements which were helpful in steering Posiva's remaining work to most safety relevant issues and improvement of the structure of the documentation.

The pre-licensing material had been produced in accordance to legislation and regulatory guidelines and the plan was to continue by bringing the documentation to sufficient level to fulfil the requirements of the statutory documents. STUK, however, started the work to develop their own YVL-guidelines. This work has taken place in parallel with the preparation of the license application for construction and preparation for implementation to follow. The tendency in developing the guidelines by STUK is based on the experiences received in the construction of the new reactor OL 3 at Olkiluoto. It will be obvious that formerly planned design degree for the maturity will not be sufficient but the regulator would like see much more detailed designs before the start of implementation.

Since there are still some issues under development regarding the conceptual design and which have to be handled by R&D, set the new modified YVL-guidelines significant pressure to configuration management including the design change management. The role of R&D and its interaction with implementation is presented in Fig. XX. The R&D -work aims at assessing the safety related requirements and installation of KBS-3 -system in a manner where the initial state for safe disposal will be demonstrated to a sufficient level before submitting the application for operation license. The technical development needed for reaching this goal may influence the design of repository layout and systems and may also reflect in changes in planning the future operating scenarios which again may cause needs for changing the designs for above ground facilities.

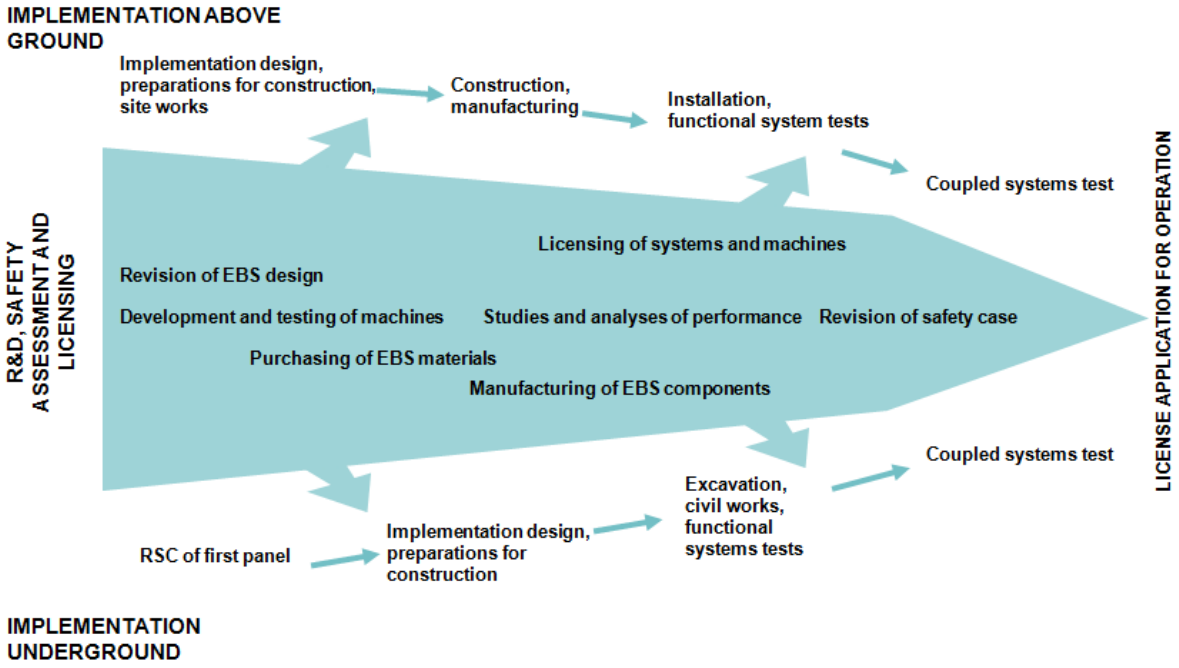


Fig. 8. Key task entities for planning and implementation regarding implementation taking place both above ground and underground for the purpose of achieving readiness for the operating licence application [1].

To accommodate the contents of the regulatory guidelines and to manage the interaction between the R&D and implementation Posiva has initiated the systematic requirement management as the first step of implementation. This work includes the definition of design

requirements for all systems and equipment in a hierarchical manner emphasizing the importance to safety.

A particular challenge to implementation is that each repository is a FOAK, first of its kind and has to be realized under a well-developed safety culture. ONKALO which already exists as an underground rock characterisation facility and has produced plenty of information on geological environment and experiences in implementation makes the future efforts somewhat easier. The experiences obtained can be used as a basis for developing practices for working under the supervision of the nuclear regulator. It is very likely that during the future implementation there will come up questions and issues to which the learning exercise from the design and construction of the ONKALO together with the investigations activities can give answers.

The efficient coordination between R&D and implementation is needed also for decision making procedures. Both R&D and practical implementation aim at safe disposal as the result. To bring together, however, different work cultures is not always easy e.g. the normal underground rock construction culture may not always understand the constraints or strict requirements set for the work and it is task of the management in its decision making to ensure that issues related to safety are considered. The experience from ONKALO shows that the decision making on issues related to long-term safety is demanding since due the uncertainty some negative consequences may remain.

Getting Started

In aim of gaining preparedness to implement facility after receiving construction licence Posiva established preliminary study for main project (construction phase) in 2011. In parallel with preparation of construction license application Posiva named an organization to take care of further preparation to plan and establish an implementation project to design and promote encapsulation plant and final repository. Project for implementation was launched in summer of 2013.

Once Posiva has submitted an application for construction of encapsulation plant and repository to the Ministry of Employment and Economy in the end of 2012 project is planned and scheduled expecting to receive the construction license in early 2015. Within few months after receiving the license start of construction should take place. Project for designing and constructing the encapsulation plant and repository has been accepted by board of directors of Posiva. Before the final investment decision by Posiva´s owners has taken place, the owner of the project is managing director of Posiva who approved the Project plan in August 2013. Project plan has been sent to STUK for information accordingly. Once recruiting human resources and preparing the organization to get ready for implementation and construction phase, Posiva´s Management system and processes need to be developed sufficiently by end of this year. Also, making sure that newly recruited personnel for construction phase under nuclear facility construction license are well prepared and trained qualified for their positions and responsibilities, it needs systematic approach to create applicable training programs to pull through first time ever for this purpose.

In parallel of evaluating Posiva´s construction license application and its main reference reports (e.g. safety case as whole) STUK is running their inspection and supervision program covering all Posiva´s activities, including preparedness for construction. It has been noticed that experiences gained by authorities of OL3-project have been included and implemented in regulatory guidelines given by STUK. What does all this mean in practise once spent fuel disposal facility construction work has never done before and therefore is not well known. The

success in activities during construction phase requires also that the careful interpretation of the regulatory guideline (STUK YVL-guidelines) has been made.

CONCLUSIONS

According to the present plans and expectations Posiva aims at starting the construction of the disposal facility in 2015. To get ready for this, Posiva is preparing the detailed plans and designs for construction.

To reach the next target - the submission of operation license application, Posiva needs to finalise the development of KBS-3, preferably jointly with SKB. This means that R&D and implementation have to be carried out simultaneously, and to avoid complications in the work, an effective coordination will be needed between these two. Configuration management plays in this sense an important role by combining the concept development to requirements for implementation design.

The experiences gained from construction of the ONKALO under the supervision of STUK will provide the way to develop the procedures especially for the implementation of the repository underground. For the encapsulation facility and other above ground facilities a lot of the experience obtained from the ongoing and earlier nuclear facility projects in Finland is available and can be utilized in the design work. The legislation and regulatory guidelines have been written for the nuclear power plants and interpretation is needed how to apply these for Posiva's facility. The situation is complicated by the fact that the all the regulatory guidelines in Finland are under revision and the interpretation is missing so far.

REFERENCES

1. *YJH-2012. Nuclear Waste Management at Olkiluoto and Loviisa Power Plants: Review of Current Status and Future Plans for 2013–2015*. Posiva Oy (2012).
2. *Facility Description 2012, Summary Report of the Encapsulation Plant and Disposal Facility Designs*. Posiva Oy (2012).
3. S. Mustonen , "Underground Openings Production Line 2012 - Design, production and initial state of the underground openings.", Posiva Oy (2012).