Nuclear Energy Research Strategy

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NUCLEAR ENERGY RESEARCH STRATEGY GROUP (YES)

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MEE set up a working group in January 2013 to prepare a research strategy for the nuclear energy through 2030. This was based on the report of the Committee for Nuclear Energy Competence in Finland. One of its recommendations is: "The needs and areas of focus of Finnish nuclear research must be specified, and a long-term strategy for the development of research activities needs to be drafted. This requires a separate project that is shared by the research organisations and other players in the field."

The work was done in the steering group of the YES project and subgroups that it assembled. Herkko Plit was named chairman of the committee, Jorma Aurela as its secretary-general, and Jussi Leppänen as its secretary. The divisions of the working group were the following (heads of the divisions in parentheses). 1) Nuclear Safety (Riitta Kyrki-Rajamäki, LUT), 2) Nuclear waste management (Kari Rasilainen, VTT), 3) Researcher training in the nuclear field (Filip Tuomisto, Aalto), 4) Future nuclear energy technologies and basic physics (Kristiina Söderholm, Fortum), 5) Nuclear energy research in the social sciences (Eeva Kalli, Finnish Energy Industries) and 6) From research into business in the nuclear energy field (Liisa Heikinheimo, TVO).

More than 100 people took part in the work of the committee in all of the divisions, groups and two organised extensive seminars. The vision of the strategy is that *Internationally high-quality Finnish expertise and research will secure the safe, sustainable, and competitive use of nuclear energy and promote business opportunities*.

The recommendations of the strategy are the following: 1) The areas of focus in nuclear energy research must be compiled into wide-ranging national programmes. 2) The scientific level of Finnish nuclear research needs to be raised. 3) Active participation is needed in international research that is important for Finland through broad-based national multidisciplinary collaboration. 4) To secure the quality and quantity of researcher education, a broad and comprehensive doctoral programme network needs to be established for the nuclear energy field. 5) Building, maintaining, and utilising infrastructure requires coordination at the national level. Financing needs to be considered strategically and the roles of national financiers need to be clarified. 6) In research activities input is needed into the development of innovations. The growth of business and internationalisation are supported by bringing the players together under Team Finland. 7) It is proposed that an advisory committee be set up in connection with MEE linked with nuclear research and operation as a permanent expert body to support decision-making in national questions related to the nuclear energy.

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Foreword

The level of nuclear energy competence has been excellent in Finland for decades. The forerunners in the field, who built nuclear power in the 1960s and 1970s, are now entering retirement age. The new generation is even more involved in the field's development. The first nuclear plants and test facilities are also coming to the end of their operating life. In addition to the new generation's Olkiluoto Unit 3, other infrastructure is also being built in Finland.

When the Parliament confirmed the government's Decisions-in-Principle in favour of new nuclear plant projects, the Parliament stipulated that the government, for its part, create the conditions required for utilising Finnish labour, expertise and business knowledge as broadly as possible in nuclear energy projects. Based on this, the Ministry of Employment and the Economy appointed a committee to prepare procedures to ensure nuclear energy competence in Finland. The committee submitted recommendations for procedures up until the 2020s. One of the recommended procedures was the drafting of a nuclear energy research strategy.

At the beginning of 2013, work began on a strategy that would span to 2030. Over 100 of the field's experts were successfully engaged in the project. This work was never a "secret project" by the ministry, as is sometimes said about the ministry's operations, but rather had broad representation from all Finnish actors in the field. We have once again demonstrated that one of our key strengths is pulling together in the national interest.

Normally, a strategy is an outline of focus areas and cannot examine all important issues; it must focus on the correct points of emphasis and prioritisation. This holds true in this instance as well. Additionally, we must take into account that this is a national strategy. The proposed and recommended activities within will be divided between the field's actors, and these actors will have their own focus areas that have not been highlighted at the national level, but which are of importance for the actors themselves.

In order to support and expand the social significance of the issue, the working group not only took the technology viewpoint into account but added a new element, by also examining the social science perspective of the matter in the scope of their work. As with any other strategy work, we all had to often think out of the box in order to be able to create something genuinely new.

The working group has managed to work with good team spirit, and at least the steering group has taken on the attitude "although we are doing serious work, let's not take it too seriously". The views of different sectors were skilfully combined into a balanced strategy after in-depth discussions and brainstorming. The drafting of the strategy was facilitated by the broad and varied group of people, who took part in the work. Even good strategies go to waste if they are not implemented. Therefore, this is the next step and challenge for all actors in the field.

In conclusion, I would like to express my sincere thanks to everyone who has participated in this work. Special thanks go out to the members of the steering group, who gave their all to a precise run through of the strategy in its final stage. The results of this joint effort can now be read on the following pages.

HERKKO PLIT
Chairman of the Working Group

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Introduction

In January 2013, the Ministry of Employment and the Economy (hereinafter the MEE) appointed a working group to prepare Finland's new nuclear energy research strategy. The appointment of this working group was based on the report submitted in March 2012 by the Committee for Nuclear Energy Competence in Finland. One of the report's recommendations was:

"The needs and focus areas of nuclear energy research in Finland should be specified, and a long-term strategy must be drafted in order to develop research activities. This will necessitate a separate shared project between the field's research organisations and other actors."

In its letter of appointment, the MEE specified the working group's tasks as follows:

- to define trends for nuclear energy research in Finland (vision for 2030, road maps, nuclear energy research, nuclear safety research, research of new types of reactors, fusion research)
- to recognise the focus areas of research, while taking the future needs and competence of the nuclear energy field into account
- to define the needs of the actors in the nuclear energy field with regard to research infrastructure
- to optimise the administration and funding of national research programmes
- to facilitate increased participation by Finland in international research

Based on completed investigations, the working group was to give recommendations for procedures to be carried out until 2030.

The working group's work was carried out in the steering group and divisions that it called to session as stated in the original decision of appointment. Deputy Director General Herkko Plit was appointed Chairman of the working group, Chief Engineer Jorma Aurela was appointed Secretary General and Senior Adviser Ville Niemi was appointed the group's Secretary. At a later stage, Specialist Jussi Leppänen was appointed as the new Secretary for the working group. All the aforementioned persons work for the MEE. The steering group met 13 times and it had presentations from five specialists in its specialist hearings. The members of the steering group and the working group's six divisions, as well as the names of specialists heard by the working group are listed in Appendix 1. The working group was divided into the following divisions (head of division in parentheses):

1. Nuclear safety (Professor Riitta Kyrki-Rajamäki, LUT)
2. Nuclear waste management (R&D Manager Marjut Vähänen, Posiva, later Research Team Leader Kari Rasilainen, VTT)

3. Researcher training in the nuclear field (Professor Filip Tuomisto, Aalto University)
4. Future nuclear energy technologies and basic physics (Professor Ari Jokinen, University of Jyväskylä, later Safety and Licensing Manager Kristiina Söderholm, Fortum)
5. Nuclear energy research in the social sciences (Director, Communications and Public Affairs Eeva Kalli, Finnish Energy Industries)
6. From research into business in the nuclear energy field (Head of R&D Liisa Heikinheimo, TVO)

In addition to this, the working group organised workshops on 17 January 2013 and 28 November 2013 at which the working group's recommendations were selected and streamlined. Approximately 50 experts took part in each workshop. A so-called editing team, made up mostly of the steering group, was appointed to complete editing work on the report. A total of 78 persons took part on the working groups work as members of its divisions, groups and teams.

During the work to formulate the working group's report, the format of the report was established as the following short nuclear energy research strategy, which will be published in print as part of the MEE Publications series. The English translation of the strategy will also be published as part of the MEE Publications series. Additionally, the report will also be published online in the same layout, which will present the current state of the areas worked on by each division and the background materials for the actual strategy.

The strategy is made up of a vision, a description of the current state, the target state in 2030, a set of possible scenarios and seven recommendations. The recommendations are the following:

1. The focus areas for nuclear energy research shall be combined into broad-scoped national programmes. Different areas and perspectives shall be emphasised in programmes according to their national target and significance.
2. The scientific standard of Finnish nuclear energy research shall be improved, as this will improve Finland's international competitiveness and visibility.
3. We shall actively participate in international research that is of importance to Finland, by conducting broad-scoped and interdisciplinary national cooperation.
4. A broad and comprehensive national doctoral programme network shall be established in order to secure the quality and quantity of researcher education in the nuclear energy field.
5. Coordination of the construction, maintenance and utilisation of infrastructure shall be handled at the national level. Funding shall be ensured in the long-term and the roles of national financers shall be specified.

6. The key focus of research activities should always be innovation development. Growth and internationalisation of business are supported by gathering all actors under the Team Finland umbrella.
7. We propose that an advisory committee on nuclear energy research and utilisation be established at the MEE, as a permanent expert body to support decision-making in matters related to the national nuclear energy field.

VISION FOR THE NUCLEAR ENERGY RESEARCH STRATEGY:
Internationally high-quality Finnish expertise and research will secure the safe, sustainable, and competitive use of nuclear energy and promote business opportunities.

1 Description of the operating environment

1.1 Current state

If society is to function, a stable and reliable energy system is essential. Electricity's share of total energy production continues to grow. Of the electricity produced in Finland, approximately 30% is produced using nuclear energy. It is estimated that in the future this share will grow to over 50 per cent.

There are many social challenges and expectations related to access to energy and the functionality of the energy system. These include energy self-sufficiency, competitiveness of industry, national wellbeing, a decrease in emissions and versatility of energy production. The special characteristics of nuclear energy production, such as the great capacity of its production plants, predictability of production or the primary importance of safety have brought the terminology "overall good of society" into Finnish legislation. All the aforementioned expectations are assessed on the basis of this overall interest in decision-making on nuclear power plants.

Broad-scoped, interdisciplinary energy research is needed not only for developing the field, but to support and provide background information for decision-making, as well as to provide varied perspectives for social debate on the field. Nuclear energy is an important part of the energy system, and, for this reason, it is important that any issues related to the field are included in national and European energy research and research programmes.

The use of nuclear energy is an exceptionally long-term process beginning with the colossal investments for nuclear plants, the frontloaded nature of funding and the long-term planning necessary for realisation of projects. The requirements for sustainable nuclear waste management, including final disposal of spent nuclear fuel and restoration of plant sites, must be taken into account from the very initial stages of nuclear energy use. As the operating life of nuclear power plants is currently 60 years, the field's expertise and activities must be utilised and ensured for a span of over 100 years.

Image 1. The TVO Olkiluoto 3 reactor's pressure vessel being set in place in the reactor hall. In 2002, Finland's government issued a Decision-in-Principle on Olkiluoto 3, which was then approved by Parliament. The over 1,600 megawatt pressurised water reactor received a construction licence in 2005. The plant's estimated operating life is at least 60 years. (Source: TVO)

The primary benefit of nuclear energy use, with regard to the development of competence and research, is the lengthy and stable process related to its use, as this facilitates predictability and planning. The requirements for basic production of energy in Finland do not fluctuate abruptly with changes in the economy. The technological solutions of nuclear power plants and changes to these are secured in accordance with the industry's safety regulations, as a result of which abrupt and unexpected changes are not typical.

The primary importance of nuclear safety is a precondition for the use of nuclear energy in Finland. The national interest and international agreements Finland has committed to stipulate a high level of national competence in the field. Maintaining nuclear safety and continuous improvement in this area necessitate an in-depth understanding of safety principles, safety evaluation methods and technology, which can be achieved through long-term research.

In addition to the use of nuclear energy, Finland does not have large-scale industry based on nuclear engineering competence, which means that research related to the use of nuclear energy is centred on supporting the use and safety of power plants, as well as nuclear waste management. Finnish approach to safety has from the very start been based on a desire to build strong domestic expertise. We have achieved a national ability to use nuclear energy independent of the plant vendor, as well as the ability to make decisions related to the field. Finnish research that is based on domestic needs and the competence provided by this are also internationally recognised and, in this way, do their part to promote safe use of nuclear energy worldwide.

The importance of research has also been clearly highlighted in legislation. The Nuclear Energy Act stipulates that the safety of nuclear energy use shall be maintained at as high a level as practically possible and that for the further development of safety, measures shall be implemented that can be considered justified considering operating experience and safety research and advances in science and technology. Additionally, the act provides that the party holding the licence for a nuclear power plant is obligated to take part in the funding of national nuclear safety research. There are also similar requirements for nuclear waste management research.

Nuclear safety and nuclear waste management research programmes are imperative in securing national competence. These are realised as four-year long programmes, the content of which is outlined at the beginning of the research programme term. It is not our intent to repeat these findings in this report.

In addition to research related to the use of nuclear energy and waste management at existing and planned nuclear power plants, other related research is also carried out in Finland. Basic research in nuclear engineering and radiochemistry takes place at Finland's universities and research related to the health impacts of radiation, the environmental monitoring of radioactive materials, emergency readiness and safety procedures and monitoring of nuclear materials is carried out by various actors.

1.2 Development of nuclear energy production in Finland

Finnish energy policy is based on long-term planning. Nuclear energy has been a part of our energy system from the early 1970s. The operating capacity of Finland's nuclear power plants has been very high, and our plants have been consistently modernised.

At this time Finland has four functioning nuclear reactors: Fortum's Loviisa 1 (LO1) and Loviisa 2 (LO2), as well as Teollisuuden Voima's Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2). Both sites have interim storages for spent nuclear fuel and the facilities required for processing and final disposal of nuclear waste. Additionally, the Olkiluoto 3 reactor unit (OL3) is presently under construction and two new units are in the planning stages: Olkiluoto 4 (OL4) and Fennovoima's Hanhikivi 1 (FH1).

Fundamental solutions related to production of nuclear energy are related to nuclear waste management and especially being able to organise the final disposal of nuclear waste. In Finland, these issues have been the responsibility of the corporations that hold the licences for plants. Licences and inspections related to plants are carried out accordingly by power companies and authorities. The design and construction of a facility for the final disposal of spent nuclear fuel is underway in Olkiluoto. The objective is to complete construction of a final disposal facility by 2020, and ensure it is at operational readiness within a few years following this. This means that Finland would be the first country in the world to begin final disposal of spent nuclear fuel.

As Finland is building new production capacity and has developed solutions for the final disposal of spent nuclear fuel, our country is of key international interest due to its large projects and versatile expertise.

1.3 Development of international nuclear energy

There are currently 135 functioning nuclear power plants in Europe in 14 EU member states. A total of 28% of the EU's electricity production is based on nuclear energy, which accounts for 60% of the EU's low-CO_2 electricity production. In 2013, there were four nuclear power units under construction in the EU and several in the planning stages. In all, over 800 companies located in the EU operate in the nuclear energy industry covering all its processes from fuel production to production of electricity, and from decommissioning of nuclear power plants to nuclear waste management; the industry provides nearly a million jobs. It is estimated that the annual volume of activities is 70 billion euros.[1] Additionally, in the EU's neighbouring areas, especially Russia and Turkey, are actively building new nuclear power.

1 Poncelet, Foratom 03.2013

There are a total of 437 functioning nuclear power units in 31 countries worldwide. At present there are 68 nuclear power units under construction in 14 countries.

In addition to this, there are currently 110 new nuclear power units in the planning stages in 20 different countries. Many countries are also in the process of planning significant projects for the modernisation of plants and the extension their operating life. Planning and realisation of nuclear waste solutions is progressing in numerous countries.

The Fukushima Daiichi nuclear power plant accident that took place in Japan after an earthquake and tsunami had a global impact on construction of nuclear power and its social acceptability. After the accident, the use of nuclear energy has grown slightly more slowly than was estimated in 2010. The IAEA still predicts that global production of nuclear energy will grow according to previous scenarios: a growth rate ranging from 25% to 100% by 2030.

Based on the IAEA's projection, European industry linked to nuclear energy now has the opportunity to have great growth potential during the next 10-30 years. Finland's participation in the construction of new nuclear plants in Europe necessitates national competence and resources. The same also applies to ongoing projects aiming to extend the operating life of power plants and the maintenance of plants.

Image 2. The Loviisa power plant has operated since 1977. Unit 1 has a valid licence until the end of 2027. Unit 2's licence is valid until the end of 2030. Fortum has not yet decided what will happen after these deadlines, i.e. will it seek an extension to the operating licences. (Source: Fortum)

1.4 Research, competence and innovation activities

The most significant public financers of nuclear energy research are the VYR (Finnish State Nuclear Waste Management Fund), Tekes, Euratom and the Academy of Finland. Other financers include VTT, STUK, universities, utilities, as well as the EU's different funding channels. Research in Finland has an investment volume of approximately 75 million euros annually. The research activities funded with this sum include research related to nuclear engineering and radiochemistry carried out by universities, as well as radiation safety research by STUK.

The research area of largest scope is nuclear waste management and the second largest is nuclear power plant safety. At the moment, the only form of future technology that has secured research funding is fusion research. Funding has been provided by Tekes-Euratom and now by the new EUROfusion consortium. We must still develop funding models for the research of new types of nuclear power plants.

Production and construction of nuclear energy, as well as development and realisation of waste solutions necessitate a significant amount of competence, expert resources and varied skills. This challenge has been described in the MEE's Committee for Nuclear Energy Competence in Finland's report (OTR 2012), which found that Finland will need 2,400 new nuclear energy professionals by 2025. National nuclear energy activities also have significant potential in the field's technological development both for the domestic market and export.

The results of safety research can be utilised in the form of products and services in all stages of the nuclear energy production lifecycle, but this necessitates productisation which in turn requires investment in innovations and technology. One of the objectives of the nuclear energy research strategy project is to help select those focus areas of research in Finland that should be invested in to produce the best results nationally and in future export projects.

Currently, Finland's international research cooperation in the area of safety at nuclear power plants is centred on OECD/NEA test projects. Other areas of cooperation include the EU's Euratom projects and the IAEA's activities. In addition to these, Finland has bilateral cooperation projects with other countries that have nuclear vendors, use nuclear energy or are planning to adopt the use of nuclear power in electricity production. Particularly, participants in OECD/NEA projects and Euratom projects are primarily countries that have utilised nuclear energy for a long span of time. The industry's actors in the Nordic countries work in close cooperation with one another. This cooperation is supported by the Nordic Nuclear Safety Research programme, which encompasses reactor safety and emergency readiness procedures. Cooperation with Russia has, as of yet, been in the form of individual research projects.

The IAEA also carries out educational cooperation with new and potential nuclear energy countries. This cooperation focuses on establishing of competence by educating the first professionals in countries planning to adopt use of nuclear energy, as well as creating national infrastructure.

This strategy work reviews national research and its applications in six areas:

1. Nuclear safety
2. Nuclear waste management
3. Researcher training in the nuclear field
4. Future nuclear energy technologies and basic physics
5. Nuclear energy research in the social sciences
6. From research into business in the nuclear energy field

Image 3. In winter 2014, construction of the VTT's Nuclear Safety Building began in Otaniemi. The building will have modern hot cell laboratories, and in 2017 will have work facilities for 150 researchers. Some of the building's structures have been designed to endure 100 years of use. (Source: VTT)

2 Target state in 2030

In 2030, safety and the overall good of society will continue to be the key prerequisites for the use of nuclear energy. This will mean that regardless of the development of national and global use of nuclear energy there will still be a demand and need for research focused on nuclear safety. Strong areas of competence include evaluation of nuclear plant safety and the licence process for nuclear power plants, research of the basic phenomena that can impact safety, research related to nuclear waste management, as well as cross disciplinary competence to combine new and old technologies. Research of systems engineering, as well as safety critical organisations, products and activities are areas of growth.

A high standard of research related to the safe use of nuclear energy and sufficient resources for this are of principal importance to nuclear energy research. Our areas of strong competence are considered top-of-the-line by international standards. The field has a broad variety of university studies and an up to date data, as well as a research infrastructure in which ambitious research projects are carried out both for domestic needs as well as in the form of international cooperation.

Finland would be the first country in the world to realise final disposal of spent nuclear fuel. Development of nuclear waste management and Finnish competence in new nuclear waste management solutions will continue to be important strengths in the future. As new types of plants are designed, international cooperation in these areas of expertise will be developed. From Finland's perspective, small modular reactors (SMR) are an essential development area. GEN4 nuclear power plants and fusion reactors are also development areas.

A critical volume should be required for active participation in multicultural and especially European research cooperation. Finnish specialist competence is based on research that combines the technologies of various plant generations and on research of safety critical technical science operations. The target state has been achieved through recognition of key competence and international cooperation.

Nuclear engineering products and services developed in Finland are internationally well-known and the industry continues to grow. Increasing the innovativeness of research as a whole and, in this way, commercialisation of research is an important part of the target for 2030. International partners are selected on the basis of Finnish business targets.

In addition to research related to the operating life of nuclear energy production and nuclear fuel, other areas in which Finland has strong competence are research and development activities related to radiation safety, safety procedures and emergency readiness as well as monitoring of radioactive materials. National research utilises synergy benefits of European and global research.

Nuclear energy from the perspective of the social sciences is needed not only to help the field develop, but also to support and provide background information for decision-making, as well as to highlight content and provide different perspectives for social debate on the field. Nuclear energy research in the field of social sciences is needed especially with regard to decision-making related to energy policy and the evaluation of the impact of steering. Research from the perspective of social sciences is also needed to increase the public's energy knowledge, impact the public's attitudes and secure the visibility of energy matters in education and in public eye.

The way in which current topics in the field's research are handled, evaluation of strategy is implemented and development is steered, as well as the way in which issues are prepared for decision-making are all managed and administered at the national level.

Image 4. Fennovoima initiated its nuclear power plant project in 2007. In 2014, the company submitted an application requesting a supplement to a 2010 government Decision-in-Principle, as the reactor unit now to be used is the Russian-made Rosatom AES-2006-pressurised water reactor, which has 1,200 MW of electric power. Construction of the plant is expected to be completed in 2024, and its estimated operating life is 60 years. (Source: Fennovoima)

3 Recommendations

This chapter includes the working group's key results and recommendations, which aim to secure long-term research and education in the nuclear energy field as well as their development.

1 Transforming focus areas of nuclear energy research into programmes

RECOMMENDATION:
The focus areas for nuclear energy research shall be combined into broad-scoped national programmes. Different areas and perspectives shall be emphasised in programmes according to their national target and significance.

Large national entities in research programmes facilitate the examination of broader topic areas, as well as participation in larger international research programmes. In the future, Finland must gain a larger role, especially in European research projects. Coordination of research in specific selected areas facilitates a better focus on relevant topics, as well as helps in utilisation of synergy benefits.

The nuclear energy field must be viewed as a part of the solution for energy supply, as well as Finnish energy research programmes. Nuclear energy research must also be included in national energy system studies. There is a social need for research related to nuclear energy especially with regard to decision-making related to energy policy and evaluation of the impacts of steering, as well as the public's energy knowledge and attitudes as well as the visibility of issues related to energy in public and in education. Nuclear energy research is carried out in research programmes, as well as by universities, research institutes, power companies and other organisations.

A. CURRENT NATIONAL RESEARCH PROGRAMMES ON NUCLEAR SAFETY AND NUCLEAR WASTE MANAGEMENT

Strong national research programmes in the areas of nuclear safety and nuclear waste management that are based on the Nuclear Energy Act and decrees continue to form the foundation for nuclear energy research.

The Finnish Research Programme on Nuclear Power Plant Safety SAFIR2014 will come to an end in 2014 and preparation and planning of the SAFIR2018 programme will begin after the working group's work is completed. An international assessment of the SAFIR2014 programme was also carried out in spring 2014. A similar development activity for the KYT2014 Programme (national programme for research of nuclear waste management) is also underway. The interfaces and synergy benefits, as well as international cooperation of research programmes will continue to be inspected.

B. NATIONAL RESEARCH IN RADIATION SAFETY

The radiation safety research programme will ensure national competence and a knowledge base in radiation safety and will secure the information requirements of national authorities, as well as integrate research with education and innovation activities. A network-like consortium between universities, institutions of higher education and STUK will be realised in accordance with the government's sector based reform of research institutions.

The research programme will produce new information on risks related to radiation and new tools for management of risks. The use of radiation is constantly increasing especially in the areas of healthcare and industrial applications. New information is needed for instance on the impact mechanisms of radiation and its health risks. Finnish business life and various authorities need up to date information on acceptable levels of radiation both in the scope of normal activities and in emergencies, as well as on exposure to natural radiation for example in mining activities. Technological innovations in the measurement of radiation will enhance radiation and nuclear safety and create a foundation for international business.

The national research programme will be linked to European research on radiation safety (Euratom/Fission).

C. RESEARCH PROGRAMME IN FUTURE NUCLEAR ENERGY (FISSION AND FUSION)

Future nuclear energy technologies will be an important part of future research activities both nationally and internationally. The research programme on future reactor technologies should include a significant portion on fission and fusion research. Portions of the study dedicated to different reactor technologies (Small Modular Reactors, GEN4, fusion) should be divided according to the concepts that are of most importance nationally. Combination of research areas will create synergy benefits and improve the quality and impact of research. In addition to research that emphasises traditional nuclear safety, recognised interdisciplinary topics include: materials, remote handling/operation, modelling, nuclear technological diagnostics, practices and procedures used by authorities and radiation safety.

The adequacy of personnel resources and expansion of the competence field will be important themes with regard to both the level of national competence and international competitiveness.

2 International excellence and visibility

RECOMMENDATION:

The scientific standard of Finnish nuclear energy research shall be improved, as this will improve Finland's international competitiveness and visibility.

A high scientific standard in research is a prerequisite for acting in the international environment. This level is typically assessed by the number of international scientific publications produced and PhDs acquired. The focus of nuclear energy research publishing will now shift from technical reports to international publications.

In addition to increasing the scientific standard these publications will also naturally increase the recognisability of Finnish research work and in this way facilitate international marketing of Finnish services and products.

International cooperation is an excellent way to educate open-minded new professionals and create a premise for international business.

3 International cooperation in research

RECOMMENDATION:

We shall actively participate in international research that is of importance to Finland, by conducting broad-scoped and interdisciplinary national cooperation.

As Finland is a small actor, we must be an active participant in international activities, focus on strategically important topic areas, as well as maintain and create research frameworks, in order to ensure that research can be the key focus of Finnish nuclear energy in these areas. Key cooperation fora for promoting international activities are the IAEA, Euratom, the OECD/NEA and the NKS. The main focus of bilateral cooperation should be on countries that develop and use nuclear energy, such as Sweden, Russia, France, Great Britain, the United States and China as well as possibly other Asian countries. Cooperation opportunities with countries developing new types of nuclear power plants are currently being investigated. In addition to the aforementioned countries, countries in the process of discontinuing the use nuclear energy, such as Germany and Switzerland, may be partners in bilateral cooperation in the area of nuclear waste management.

More so than previously, actors expect international cooperation to have an impact regardless of the form of cooperation or who the partners are. The issue has become more emphasised in connection with the government's structural reform of research institutes, as funds have been transferred from key actors to new Finnish research instruments. Regardless of whether cooperation is with a country that is using nuclear energy or a country planning to adopt its use research will focus on topics that are strategically important to Finland. In Europe, Finland will carry out cooperation primarily in those projects and with countries that can offer added value to Finnish research. Finland should investigate more extensive cooperation possibilities with Great Britain, Eastern Europe and Russia.

Asia is a growth area in the construction and use of nuclear energy and a multitude of cooperation opportunities are evident there with countries providing and planning delivery of nuclear power plants as well as with countries planning to adopt the use of nuclear power. Traditional nuclear energy users and plant vendors include Japan, Korea and Russia. New countries aiming to participate in international vendor markets of nuclear plants include China and India.

International cooperation in nuclear energy is especially imperative for a small nuclear energy country such as Finland. Cooperation can offer access to larger cooperation projects in Europe and elsewhere in the world, and, in this way, help increase the critical mass of competence to a sustainable level. Additionally, cooperation can help Finland supplement its own competence or acquire resources it lacks. Supplementary resources can help Finland acquire the use of devices, equipment and software the operating capacity of which would be minimal in Finland or the maintenance of which would not be possible. Targeted and goal-oriented cooperation comprises a well-planned mixture of international cooperation projects (IAEA, OECD/NEA, EU, NKS) and bilateral projects.

Finland has a good basis on this, as we have already developed many globally unique test facilities and computational methods in the area of nuclear safety, some within the framework of research, but others have been funded by end users. In the future, we must continue to ensure that Finland continuously has ongoing nuclear energy research projects that are considered unique, and in which other countries will want to take part as significant financers.

4 National doctoral programme network

RECOMMENDATION:

A broad and comprehensive national doctoral programme network shall be established in order to secure the quality and quantity of researcher education in the nuclear energy field.

We shall get universities, research institutes, authorities and industry to commit to support and fund the operations of a multidisciplinary and interdisciplinary doctoral programme network, as well as long-term funding of further education. Cooperation between these organisations in matters related to education, as well as in research work that aims at a doctoral thesis, and in providing assistance in organisation of a relevant researcher exchange programme is of key importance.

Coordination at the national level must be efficient and visible so that national and international researcher exchange and research cooperation can be organised in the best way possible. Finland's national Doctoral Programme for Nuclear Engineering and Radiochemistry (YTERA Programme 2012-2015) can act as a model more extensive activities. The Ministry of Education and Culture no longer directly funds doctoral programmes, and universities are now responsible for providing their funding.

5 Development and efficient utilisation of Finnish infrastructure

RECOMMENDATION:
Coordination of the construction, maintenance and utilisation of infrastructure shall be handled at the national level. Funding shall be ensured in the long-term and the roles of national financers shall be specified.

During the SAFIR2014 Programme, the government began to fund the development of research infrastructure more visibly with VYR funding. The objective is to achieve a diverse, long-term framework for research. Current projects receiving funding are the thermal hydraulic test facilities at the Lappeenranta University of Technology, as well as the Nuclear Safety Building being built in Otaniemi. Infrastructure is further developed whenever new needs and opportunities come up.

In upcoming years, the field's most important infrastructure project will be construction of the Nuclear Safety Building in Otaniemi. Due to age, usability and radiation safety a complete overhaul of present test facilities and equipments is imperative. The Nuclear Safety Building will contain modern hot cell facility that will be utilised in the research of reactor materials, as well as separate laboratories for material and nuclear waste research, radiochemistry, dosimetry and filter testing.

The opportunity to utilise foreign infrastructure in research and education shall be secured when Finland lacks the infrastructure in question. The most important ongoing project that Finland's VTT is participating in is the operations of the international JHR research reactor being constructed in France. Decommissioning of the FiR-1 research and training reactor will leave a void in educational opportunities at the national level, which must be filled with international cooperation.

Planning and realisation of Finland's own infrastructure must be in the long-term. When we want to ensure the efficient utilisation of infrastructure, the nuclear energy's time span that stretches over decades can pose a challenge. Participation in national and international cooperation can help increase the operating capacity of infrastructure throughout the entire life cycle.

The roles of financers and division of work in funding and maintenance of infrastructure must be specified, so that funding is targeted at key projects that benefit the entire nuclear energy field. Current public bodies that provide funding include the Academy of Finland, Tekes and VYR. Investments by actors in the research field must be based on social points of emphasis, as well as strategic targets. Additionally, these activities must focus on attaining new and international funding.

6 From research into business

RECOMMENDATION:
The key focus of research activities should always be innovation development. Growth and internationalisation of business are supported by gathering all actors under the Team Finland umbrella.

In order to develop and expand nuclear energy business related to research, we shall remodel products and services into clear entities and functional networks. Innovations created from research should be aimed at the international market.

The expertise found in Finland should be viewed broadly over organisation boundaries and combined under appropriate umbrellas. These can be Strategic Centres for Science, Technology and Innovation (SHOK companies), FinNuclear cooperation and Team Finland. Areas of strength include assessment of nuclear plant safety, licensing procedures, materials engineering and nuclear waste management. Lifecycle services for power plants, modelling of current and future reactor concepts, systems engineering and safety critical procedures can be produced.

One of the key factors that have significantly hindered the creation of business has been the differing focus areas of research and business activities, as the focus areas do not overlap at all in the current situation. Industry has been most interested in areas in which business can be generated immediately or on a considerably short-term planning. The research sector, on the other hand, has focused on the study of basic phenomena and the discovery of technological solutions, and this has not included innovation development.

Providing funding for research, development and innovation activities (RDI) is a national asset and obligation. Products and services that are created during these activities must be commercially viable. The early stages of an RDI project shall focus on establishing systematic evaluation and monitoring of business opportunities at different stages throughout RDI activities. Conceptualisation of competence, development of service business, sufficient expertise and resources, as well as cooperation that recognises different perspective shall be taken into account when identifying business opportunities.

Business activities aim to achieve both national and international success. The growth areas for international business are the same as for international research cooperation. Additionally, new markets may arise as Finnish expertise can provide a comprehensive service infrastructure from design to nuclear waste management in countries just adopting the use of nuclear energy.

The nuclear energy industry requires expertise and data on research results in many traditional fields of science. These will provide uniqueness to the research. Key competence is born from an ability to combine versatile, interdisciplinary knowledge into entities. In order to support international business, the top actors in Finnish nuclear energy business must be clearly visible to the outside world through brands, for example in storage facilities: “Designed for ONKALO, approved by STUK”.

7 Continuous control of steering strategy and activities

RECOMMENDATION:

We propose that an advisory committee on nuclear energy research and utilisation be established at the MEE, as a permanent expert body to support decision-making in matters related to the national nuclear energy field.

An advisory committee on nuclear energy industry research and utilisation must be established at the MEE, as a permanent expert body to consider policies and approaches in matters related to the national nuclear energy field. The advisory committee’s task would be to support the MEE in matters related to nuclear energy (Section 54 of the Nuclear Energy Act), and establishing the advisory committee would require an amendment to the Nuclear Energy Act.

In recent years, the MEE has utilised and established national networks and working groups for nuclear energy topics, but these have been temporary and their task has been very limited. This has meant that they have not had the opportunity to effectively participate in the coordination of national activities in the areas of nuclear energy expertise, research and utilisation. The task of the advisory committee would be to present recommendations in the use of nuclear energy, while supporting Finland’s energy policy. In addition to this, the advisory committee would for its part make sure that recommendations by the Committee for Nuclear Energy Competence in Finland and those in this text will be implemented.

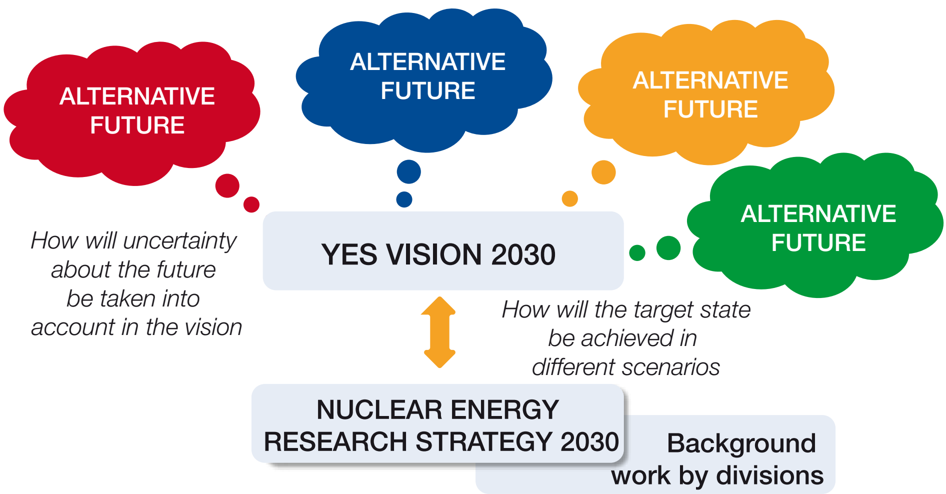
STUK’s other advisory committee shall be taken into account in this committee’s work. When selecting the members of the advisory committee and its focus areas, it would be a good idea to not only consider expertise but connections to the rest of society.

Image 5. The research laboratory of heat transfer and fluid flow of Nuclear Engineering Laboratory at Lappeenranta University of Technology is one of the corner stones of Finnish nuclear energy research. The laboratory began its operations in Skinnarila in 1975. In the photo (from left) Professors Juhani Hyvärinen and Riitta Kyrki-Rajamäki as well as Research Director Heikki Purhonen. (Source: LUT)

4 Future scenarios in use of nuclear energy

The working group has aimed to take in account any doubts related to the nuclear energy research strategy, which spans until 2030 by reviewing alternative future scenarios. In addition to setting objectives and planning procedures for the most likely outcome, taking other scenarios into account will mitigate risks related to strategic choices. In its independent scenario work, the working group has focused on nuclear energy. Similar results have also been achieved in the VTT's more extensive strategy project on Finland's future energy solutions.[2]

Image 6. Establishing scenarios are part of the YES report



Nuclear energy will be utilised in Finland during the entire span of time this report covers. Regardless of Finland's development, the use of nuclear energy is expected to grow in our neighbouring areas and worldwide. The need to develop national expertise and continue research will remain. Formulating a strategy comprises the selection of focus areas for research and establishing their relation to overall requirements.

Two key questions have been proposed as a foundation for the construction of scenarios and to make it easier to differentiate between alternative future scenarios from one another:

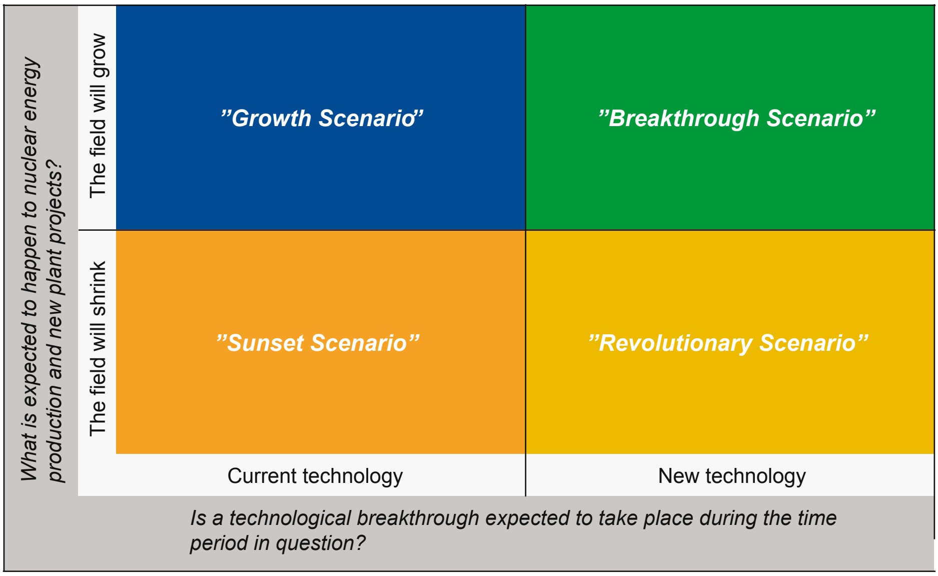
- How is the use of nuclear energy expected to develop worldwide and what is expected to happen with regard to new nuclear plant projects in Finland?

2 Low Carbon Finland 2050, VTT clean energy technology strategies for society, VTT Vision 2, 2012, VTT Technical Research Centre of Finland, ISBN 987-951-38-7962-4 (print), ISBN 978-951-38-7963-1 8 (online)

- Is a technological breakthrough expected to take place during the time period in question?

By combining these expectations in different ways, the working group came up with four future scenarios, which have been used to support work on the strategy. The working group has selected the IAEA's low and high nuclear growth projections as the premise for worldwide development of nuclear energy. Technological breakthroughs may take place in reactor technology, as well as in nuclear waste management.

Image 7. The four scenarios outlined in the YES report



The working group's most essential conclusion was that, regardless of scenario nuclear energy research will be imperative in Finland in the future. The scope of research and partly also its emphases will be determined according to the selected scenario. It is important to remember that this approach of reviewing scenarios is a tool for predicting the future and needed procedures. The created scenarios represent extreme circumstances and actual future will very probably fall between these scenarios. Research must be able to flexibly adjust to prevailing circumstances.

All the scenarios require that there shall be basic prerequisites for research, which are necessary for ensuring the safe use of nuclear energy and socially acceptable final disposal of nuclear waste. Participation in international cooperation is also necessary in all the scenarios. Broad-scoped cohesive visibility in the international market is important, so that Finland can participate in larger European cooperation projects and so that Finland also achieves large projects for itself. The new advisory committee on use of nuclear energy is also seen as a necessity in all scenarios. Its role is emphasised in the Growth and Breakthrough Scenarios.

Finland has a good reputation with regard to the nuclear energy field worldwide. The safety record of our plants is positive, and their performance capacity is high (partly the world's leading) by international standards. Finland has aimed to keep its legislation and YVL guides up to date learning from world incidents. The potential of our high level research and expertise are also utilised in business.

4.1 Sunset Scenario

The Sunset Scenario describes a situation in 2030 in which nuclear energy is a declining industry worldwide. The reason for this may be the significant decline of its social acceptability and the end of current licences. No such breakthrough is expected in nuclear energy use that would change the field's present focus areas.

The key hypotheses of the Sunset Scenario are:

- Finland will have only one functioning reactor unit (Olkiluoto 3)
  - There are no new plants under construction or being planned.
  - Finland's old reactor units have been decommissioned permanently in the 2020s.
- Generation III+ technology light water reactors are the dominant plant types worldwide, but the industry's growth has remained in the post-Fukushima low projections.
  - Global growth is 150 GWe (+36 %) and 90 plants, of which two-thirds are in the Far East.
  - A dramatic decline in nuclear capacity in Western Europe to 83 GWe (-33%), some individual nuclear plant projects in Eastern Europe.
- The final disposal of spent nuclear fuel has begun in Finland in the early 2020s based on the KBS-3 concept.
  - There are no unanswered questions with regard to nuclear waste management.

Scope of research is the most important aspect of focus in the Sunset Scenario. One key question will be how much research is required to support the operation of Finland's one reactor unit and the safe final disposal of nuclear waste.

The Sunset Scenario shall focus on maintaining theoretical, computational and empiric basic competence. Research linked to the one operating plant shall be secured, and we shall be able to solve problem situations also by utilising test facilities and experimental competence. Access to international research services may be limited in acute situations.

Finland shall seek out international cooperation in order to increase its volume of research. Demand from the international market may help in securing versatile research competence. There is a demand for Finnish specialist knowledge of different plant types (PWR, BWR and VVER). Maintaining research activities in the nuclear energy field may also be justified in a country that does not itself produce nuclear energy. An example of this is Italy. Research has remained active in Italian universities and research institutes, and the country is host to the EU's research institutes.

Demand for expertise in nuclear waste management is growing and offers a diverse field for export of research.

National nuclear safety and nuclear waste management research will continue in the Sunset Scenario in a smaller scope than presently. Although, there are no unanswered questions with regard to nuclear waste management, research is necessary to secure long-term safety. Only the radiation safety research programme is necessary of the recommended new research programmes.

A national doctoral programme network is possible in this scenario, but the lack of a national motivation will cause a decrease in funding and interest. Doctoral candidates are only educated for the needs of Finland's nuclear energy industry.

4.2 Revolutionary Scenario

The Revolutionary Scenario describes the year 2030 with a globally declining nuclear energy industry, while the industry is simultaneously going through a technological revolution. The ongoing technological revolution is shifting the focus areas of both use of nuclear energy and nuclear waste management to new areas. New solutions are being designed for energy production, including modular reactors, units solely focused on production of heat, fourth generation reactors, the use of thorium as a fuel. Nuclear waste management closed fuel cycles and new types of final disposal solutions. The pace of the technological revolution will not be sufficient to turn development to a swift growth.

The key hypotheses of the Revolutionary Scenario are:

- Finland will have a total of five functioning reactor units (Loviisa 1 and 2, Olkiluoto 1, 2 and 3).
  - There are no new plants under construction or being planned.
  - The licences for the old reactors at Loviisa and Olkiluoto will not be renewed after 2030.
- Adoption of new reactor technology is beginning worldwide, but the industry has remained at low trajectory growth post-Fukushima.
  - The focus areas of new construction are in the Far East and Russia.
  - From 2025, there will no longer be any new projects for the construction of the current light water reactors. Instead, SMR and GEN4 type solutions will move forward.
  - ITER is living up to expectations and DEMOs are being designed.
- Adoption of a facility for the final disposal of spent nuclear fuel in Finland in the early 2020s based on the KBS-3 concept.

– Technological breakthrough is taking place in the management and final disposal of spent nuclear fuel.

If significant technological advances take place in the nuclear energy industry, Finnish research must support current nuclear plants, nuclear waste management and be prepared for realisation of new types of nuclear power plants.

The Revolutionary Scenario is the most research oriented of the looked into scenarios, as so much of it deals with the application of new types of technology. According to the scenario, the reactors in use and the reactor technologies of the future are most important areas of research related to energy production. It is estimated that the situation of nuclear waste management will change. Direct disposal will no longer be an option thus creating a demand for new research.

With regard to this scenario, it is important that research supports the imposing of safety requirements for new types of reactors and the development of licensing procedures. The licensing procedures currently in place have conformed to be strictly in line with the characteristics of large light water reactors.

Due to our high level of expertise, research in Finland can become competitive in the international market creating new business.

4.3 Growth Scenario

The Growth Scenario describes a situation in 2030, where nuclear energy is a globally growing industry. Growth is faster than that which was predicted after Fukushima which was based on the world's energy demands and simultaneous requirements for a decrease in carbon dioxide emissions. These two targets could not be met in a sustainable manner without significant utilisation of nuclear energy. In this scenario the industry's growth depends, on technologies that are already in use today, and there is no significant technological breakthrough in sight that would change the focus area from the present one.

The key hypotheses of the Growth Scenario are:

- Finland will have at least seven functioning reactor units (Loviisa 1 and 2, Olkiluoto 1–4 and Hanhikivi 1).
  - There may be new plants under construction or being planned.
  - The operating life of the old Loviisa and Olkiluoto reactors has been extended to at least 2040.
- Generation III+ technology light water reactors dominate the industry worldwide, and the industry's growth has returned to the high level it was at preceding Fukushima.
  - Global growth is at 380 GWe (+103 %) and 350 plants, of which half are in the Far East while Europe and the United States are also in the process of building more.

    - The number of technology options will shrink, but LWR technologies will retain their position.
    - ITER has not met the expectations set for it.
- The final disposal of spent nuclear fuel has begun in Finland in the early 2020s based on the KBS-3 concept.
    - There are no unanswered questions with regard to nuclear waste management, but its volume poses challenges.

If the nuclear energy industry grows, but does not reform, the most important issue of the research strategy is maintaining the broad-scoped and high standard of Finnish research.

The key hypothesis of the Growth Scenario, a strong worldwide increase in the use of nuclear energy, will facilitate expansion of international research activities to new nuclear energy countries. This is both a challenge and an opportunity for Finland's research strategy.

In this scenario, it is presumed that despite the unchanging nature of technology, it will be necessary to maintain sufficient scientific ambition and Finland must be able to attract international research. Our expertise will ensure that we can have access to international research projects.

There is a demand for nuclear safety and nuclear waste management expertise developed in Finland. International competition will do its part to ensure that the field continues to develop.

The large volume of activities will help maintain the interest of the younger generation in the field. The field's university professorships are on firm base and there are also many people interested in becoming nuclear energy researchers.

4.4 Breakthrough Scenario

The Breakthrough Scenario describes a situation in 2030 in which nuclear energy is simultaneously a globally growing industry and experiencing a technological breakthrough.

The key hypotheses of the Breakthrough Scenario are:

- Finland will have at least seven functioning reactor units (Loviisa 1 and 2, Olkiluoto 1-4 and Hanhikivi 1).
    - New plants are in the planning stages and possibly under construction.
    - New construction is planned also at new plant sites and in new applications.
- New technologies are playing a larger role in upcoming reactor projects.
- Adoption of new reactor technology is beginning worldwide and the industry's growth has returned to the high level it was at preceding Fukushima.

    - Global growth is 380 GWe (+103 %) and 350 plants, and construction is taking place worldwide.
    - Technological development is fragmented.
    - ITER is living up to expectations and DEMOs are being designed.
- In the early 2020s, preparations are underway to initiate the use a facility for the final disposal of spent nuclear fuel in Finland based on the KBS-3 concept.
    - New reactor technologies and fuel cycles are little by little bringing about a technological breakthrough in the management of nuclear fuel (LWR).
    - the need for geological repositories remains, but the technological breakthrough will lead to changes in final disposal concepts.
    - growth of nuclear energy production also impacts the realisation methods for nuclear waste management and final disposal of nuclear fuel

The important question with regard to research strategy in the Sunset Scenario is the ability of research activities to facilitate a shift to adoption of new technology in Finland.

A predicted strong increase in global use of nuclear energy and new technologies entering the market enable the expansion of international research activities to new countries. This is both a challenge and an opportunity for Finland's research strategy.

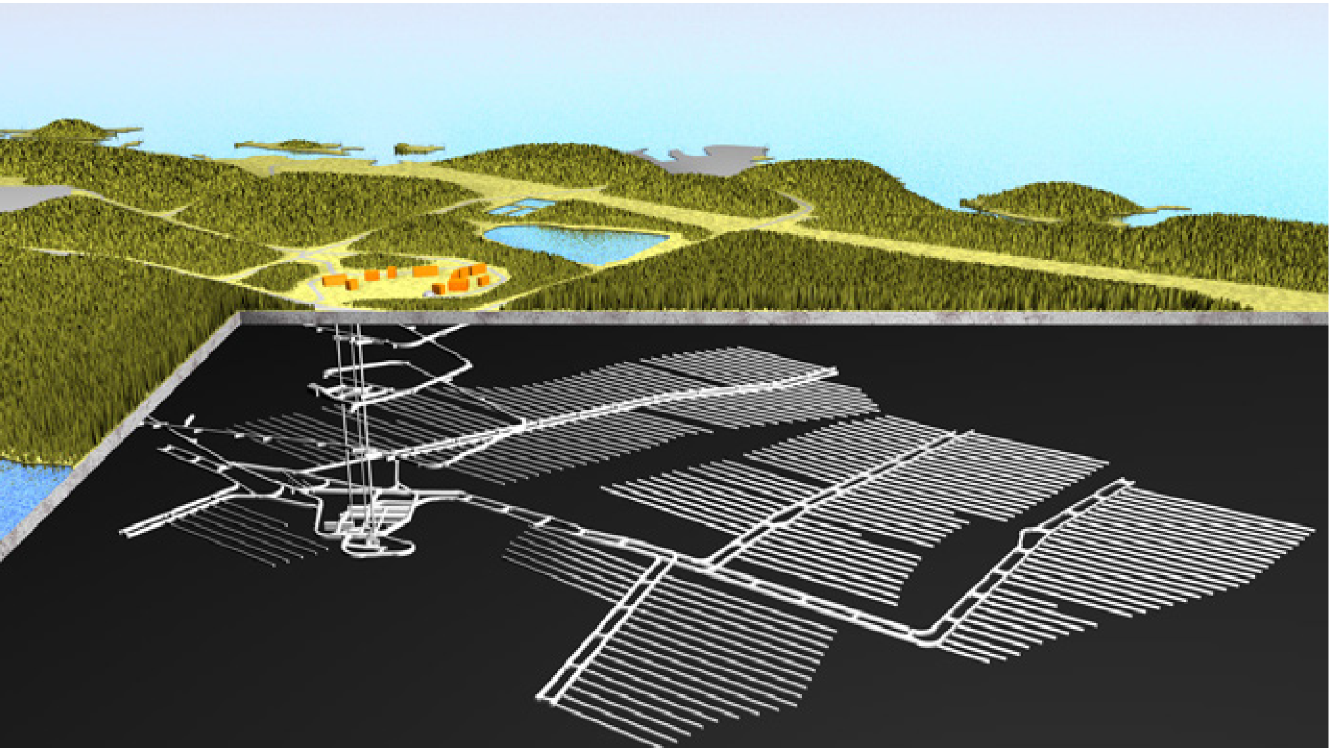
The safe use of traditional nuclear plants must continue to be secured in this scenario, and at the same time we must be prepared for the development and adoption of new reactor technologies in the 2030s. Circumstances of this scenario require experimental and computational/theoretical research that is suited for safety evaluation of different types of nuclear power plants.

A fundamental point of this scenario is to ensure that safety requirements also apply to new technologies, as well as maintain pre-normative research i.e. research that precedes legislation. Current legislation and the YVL guides pertain to large light water reactors.

There is an international demand for nuclear safety and nuclear waste management expertise developed in Finland.

All the listed new research programmes are realised in this scenario. This scenario's challenges are related especially to the need for research of numerous technologies, the great cost and volume of research, as well as organisation of funding for different types of research needs.

Image 8. Posiva submitted a construction licence application in 2012 for the construction of an encapsulation and final disposal facility at Olkiluoto, in order to secure final disposal of spent nuclear fuel. Preparations for this began in the 1970s. Finland would be the first country to begin final disposal of spent nuclear fuel at this facility in the early 2020s. (Source: Posiva)



Appendix 1

Persons and organisations that have participated in the YES work in 2013–2014

STEERING GROUP FOR THE NUCLEAR ENERGY RESEARCH STRATEGY GROUP

Name	Organisation	Title
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Liisa Heikinheimo	Teollisuuden Voima	Head of R&D
Ari Jokinen	University of Jyväskylä	Professor
Marja-Leena Järvinen	STUK - Radiation and Nuclear Safety Authority	Deputy Director
Eeva Kalli	Finnish Energy Industries	Director, Communications and Public Affairs
Riitta Kyrki-Rajamäki	Lappeenranta University of Technology	Professor
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Saila Seppo	Academy of Finland	Programme Manager
Kari Rasilainen	VTT – Technical Research Centre of Finland	Research Team Leader
Kristiina Söderholm	Fortum	Safety and Licensing Manager
Filip Tuomisto	Aalto University	Professor
Marjut Vähänen	Posiva	R&D Manager
Ville Niemi	Ministry of Employment and the Economy	Senior Adviser
Jussi Leppänen	Ministry of Employment and the Economy	Specialist

The following persons participated in expert hearings:

Director General Tero Varjoranta (STUK), Executive Vice President Kari Larjava (VTT), Vice President Ilkka Niemelä (Aalto-University), President Heikki Mannila (Academy of Finland) and Professor Sisko Salomaa (STUK).

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Markku Kataja	University of Jyväskylä	Professor
Jukka Lehto	University of Helsinki	Professor
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Mia Ylä-Mella	Fennovoima	Nuclear Waste Manager

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Name	Organisation	Title
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Jarmo Ala-Heikkilä	Aalto University	Research Fellow
Juhani Hyvärinen	Lappeenranta University of Technology	Professor
Jaakko Kujala	University of Oulu	Professor
Jaakko Leppänen	VTT – Technical Research Centre of Finland	Senior Scientist
Kai Nordlund	University of Helsinki	Professor
Risto Raiko	Tampere University of Technology	Professor
Kaisa-Leena Hutri	STUK - Radiation and Nuclear Safety Authority	Development Manager
Jukka Juutilainen	University of Eastern Finland	Professor
Kaisa Koskinen	STUK - Radiation and Nuclear Safety Authority	Development Manager
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Name	Organisation	Title
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Appendix 2

List of abbreviations

The text's abbreviations have been explained and translated in relation to their scope of importance. Some of the abbreviations have been explained in the main body of the text. Not all the abbreviations used in the text, such as the names of individual projects, have been included in this list. Some of the listed abbreviations are from the report by the Committee for Nuclear Energy Competence in Finland.

3S – Safety, security and safeguards

5S – Safety, security, safeguards, sustainability and society

ADS – Accelerator-driven system

ANDES – Accurate Nuclear Data for nuclear Energy Sustainability

Andra (France) – Agence nationale pour la gestion des déchets radioactifs; nuclear waste management organisation of France

APROS – Advanced Process Simulation Software; Finnish modelling tool for power plant process simulation

AREVA – A French conglomerate that supplies nuclear power plants

ATHLET – Analyse der Thermohydraulik von Lecks und Transienten, (Analysis of THermal-hydraulics of LEaks and Transients)

AUG – Asdex Upgrade; fusion reactor in Germany

AVERKO – On-line distance learning system of Central Ostrobothnia University of Applied Sciences

BAT – Best Available Technology

BBA – Bachelor's degree: Bachelor of Business Administration

BELBaR – Bentonite Erosion: effects on the Long-term performance of the engineered Barrier and Radionuclide Transport; EURATOM research project

BENTO programme – Development programme of competence concerning bentonite

BMWi – (Germany) – Bundesministerium für Wirtschaft und Technologie

BNCT – Boron Neutron Capture Therapy; treatment method used at the Otaniemi research reactor

BOA project – Assessment of bentonite buffer properties

BWR – Boiling Water Reactor

CABRI – Research facility for severe reactor accidents at Cadarache, France

CAMP – Code Assessment and Maintenance Program; software codes (thermal hydraulics)

CATHARE – Code for Analysis of THermalhydraulics during an Accident of Reactor and safety Evaluation; software code (thermal hydraulics)

CEA – Commissariat à l’Énergie Atomique et aux Énergies Alternatives; nuclear research centre of France

CEID – The Centre of Computational Engineering and Integrated Design

CEMIS – Centre for Measurement and Information Systems

CENTRIA – R&D and supplementary education unit of Central Ostrobothnia University of Applied Sciences

CERN – Particle physics research centre in Geneva, Switzerland

CFD – Computational Fluid Dynamics

CFM – Colloid formation and migration project

CIEMAT (Spain) – Centro de Investigaciones Energetícas, Medioambientales y Tecnológicas; Spanish research centre

CINCH – Cooperation in education In Nuclear Chemistry

CLEEN – Cluster for Energy and Environment funded by Tekes

CNRA – The Committee on Nuclear Regulatory Activities CNRA; OECD/NEA committee

CNS – Center for Nuclear Safety of VTT

COOLOCE – Coolability of Cone; experimental facility (severe reactor accidents)

Covra – COVRA N.V.; nuclear waste management organisation of the Netherlands

CROCK – Crystalline rock retention processes, sorption of radionuclides

CSARP – Cooperative Severe Accident Research Program, US NRC

CSC – IT Center for Science

CSNI – Committee for Safety for Nuclear Installations, OECD/NEA Nuclear Safety committee

CST – LUT Chemistry’s Centre for Separation Technology

CTBT – Comprehensive Nuclear-Test-Ban Treaty

DEMO – Demonstration Power Plant

DNS – Direct Numeric Simulation

DP – Deployment Plan

DTP2 – Divertor Test Platform

ECTS – European Credit Transfer and Accumulation System

ECVET – European Credit system for Vocational Education and Training

EdF – Electricite de France; French utility

EERA – European Energy Research Alliance

EERRI – Eastern European Research Reactor Initiative

EFDA – European Fusion Development Agreement

ELFORSK – Svenska elföretagens forskning och utveckling; R&D organisation of Swedish electricity companies

ENEN – European Nuclear Education Network; an education network initiated by the EU

ENRESA (Spain) – Empresa Nacional de Residuos Radiactivos, S.A.

EnSTe – Finnish Doctoral Programme in Environmental Science and Technology

EPR – European Pressurised Reactor, such as Olkiluoto 3

ESNII – European Sustainable Nuclear Industrial Initiative

ESRF – European Synchrotron Radiation Facility

EURADOS – European Radiation Dosimetry Group

EURATOM – The European Atomic Energy Community

FAIR – Facility for Antiproton and Ion Research

FEBEX – Collaboration in the Full-Scale Engineered Barrier Experiment in Crystalline Host Rock

FEG-STEM – Field emission gun scanning transmission electron microscope

FH1 – Fennovoima's Hanhikivi NPP unit 1

FiR 1 – Triga research reactor operated by VTT

Fluent – Software code (thermal hydraulics)

GAP – Greenland Analogue Project

GEN4 – Generation 4, nuclear reactor concepts in development phase (GEN4 or GENIV)

GEN4FIN project – Finnish research network for GenIV energy systems

GETMAT – EU project on Gen IV and transmutation materials

GFR – Gas-cooled Fast Reactor

GIF – Generation IV International Forum

GTK – Geological Survey of Finland

HALDEN – Reactor Project - OECD Research Programme in Halden, Norway

HAMLAB – Research Laboratory in Halden, Norway (MTO)

HECLA – Thermo-chemical interaction between metallic melt and concrete

HORIZON 2020 – The EU Framework Programme for Research and Innovation

HPLWR – High Performance Light Water Reactor (EU project); reactor type

HRP – Halden Reactor Project

HYRL – University of Helsinki, Laboratory of Radiochemistry

IAEA – International Atomic Energy Agency

ICNIRP – International Commission on Non-Ionizing Radiation Protection

ICRP – International Commission on Radiological Protection

IGD-TP – Implementing Geological Disposal of Radioactive Waste Technology Platform (Euratom)

ILL – Institut Laue-Langevin

ILW silo – Intermediate-level operating waste silo at Olkiluoto

IRSN (France) – Institut de radioprotection et de sûreté nucléaire

ITC-School (Switzerland) – International Training Centre School for Underground Storage and Disposal - association

ITER – International Thermonuclear Experimental Reactor; fusion reactor in Cadarache, France

JAEA (Japan) – Japan Atomic Energy Agency

JET – Joint European Torus; fusion reactor in Great Britain

JHR – Jules Horowitz Research Reactor in Cadarache, France

JHR MTR – Jules Horowitz Materials Test Reactor

JYFL – Department of Physics at the University of Jyväskylä

JYFLTRAP – Penning ion trap, at the University of Jyväskylä

KBS-3, KBS-3H – Concepts for spent fuel disposal applied by Posiva

KYT2014 – Finnish Research Programme on Nuclear Waste Management

LCS – Long-term Cement Studies

LES – Large Eddy Simulation

LFR – Liquid Lead Reactor; reactor type

LISSAC – Pressure vessel head model specimen tests

LLW silo – Low-level operating waste silo at Olkiluoto

LO1, LO2 – Fortum's Loviisa NPP units 1 and 2

LONGLIFE – Treatment of long term irradiation embrittlement effects in RPV safety assessment (EU project)

LUT – Lappeenranta University of Technology

LWR – Light Water Reactor

MATTER – Materials testing and rules (EU project)

MEE – Ministry of Employment and the Economy

MELCOR – Software code (severe reactor accidents)

MELODI – Multi-disciplinary European Low Dose Initiative

MENA – Middle East and North Africa

Nagra (Switzerland) – Nationale Genossenschaft für die Lagerung radioaktiver Abfälle; nuclear waste management actor of Switzerland

NDA – Nuclear Decommissioning Authority; nuclear waste management actor of Great Britain (authority)

NDC – Nuclear Development Committee; OECD/NEA committee

NDT – Non-destructive testing

NEA – Nuclear Energy Agency; OECD agency in Paris

NEPTUNE CFD – A new software platform for advanced nuclear thermal hydraulics

NERIS – European Platform for European Nuclear and Emergency Preparedness and Response

NETNUC – New Type Nuclear Reactors; Finnish Gen IV project

NKS – Nordic Nuclear Safety Programme

NOG – Nordic Owners group

NPP – Nuclear Power Plant

NPSAG – Nordic Probabilistic Safety Assessment Group

NRC – Nuclear Regulatory Commission of the USA

NRI – Nuclear Research Institute Rez plc, UJV (Ústav jaderného výzkumu Řež); nuclear research institute of the Czech Republic

NSC – Nuclear Science Committee; OECD/NEA committee

NUCPRI – Power Research Infrastructure: Lappeenranta University of Technology project funded by the Academy of Finland

NUGENIA – Nuclear Generation II & III Association

NULIFE – Nuclear plant life prediction, EU project

NURES – Nuclide removal system for radioactive liquid purification by Fortum

NURISP – NUclear Reactor Integrated Simulation Project; EU project

OECD – Organisation for Economic Co-operation and Development

OKM – Ministry of Education and Culture (former OM)

OL1, OL2, OL3, OL4 – TVO's Olkiluoto NPP units 1, 2, 3, and 4

OMO – Olkiluoto Monitoring Programme

Ondraf/Niras (Belgium) – The Belgium Agency for Radioactive Waste and Enriched Fissile materials; nuclear waste management actor of Belgium

ONKALO – Underground rock characterisation facility at Olkiluoto (Posiva)

OTR – National Competence Committee in nuclear energy sector organized by MEE in 2010-12

P&T – Partitioning and transmutation of spent nuclear fuel

PACTEL facility – Parallel Channel Test Loop; Lappeenranta University of Technology's research facility

PERFORM60 – Prediction of the Effects of Radiation for Pressure Vessel and in-core Materials using multi-scale Modelling – 60 years foreseen plant lifetime; EU project

Petrus network – Programme for Education, Training and Research on Underground Storage

PFL DIFF – Posiva Flow Log, difference flow method

PFL TRANS – Posiva Flow Log, transverse flow method

PINC – Programme for Inspection of Nickel-based components; International US NRC research project

PINC – An Illustrative Nuclear Programme (the abbreviation PINC stems from the French name of the programme, Programme Indicatif Nucléaire de la Communauté). Reference: Euratom Treaty, article 40

POOLEX – Lappeenranta University of Technology's research facility

PORFLO – A mathematical model for fluid flow developed at VTT

POSEK – Pori Regional Development Agency Ltd

Posiva – Posiva Ltd; Finnish expert company of nuclear waste management

PPOOLEX – Pressure POOLEX; Lappeenranta University of Technology's research facility

PRA model – Probabilistic Risk Assessment

PSAR – Preliminary Safety Assessment Report

PURAM (Hungary) – Public Limited Company for Radioactive Waste Management; nuclear waste management organisation of Hungary

PWR – Pressurized Water Reactor

PWR PACTEL – Lappeenranta University of Technology's research facility for EPR design

RAWRA/SURAO (Czech Republic) – Radioactive Waste Repository Authority; nuclear waste management organisation of the Czech Republic

RDI – Research, Development and Innovation

REDUPP – REDucing Uncertainty in Performance Prediction (dissolution rates of spent fuel)

RELAP5 – Software code (thermal hydraulics)

RIA – Reactor-Initiated Accident

RSC – Rock Suitability Criteria

SAFIR – Finnish national research programmes on nuclear power plant safety

SAFIR2014 – SAfety of nuclear power plants – FInnish national Research programme 2014; the ongoing research programme on nuclear power plant safety

SARNET project – Euratom project (severe reactor accidents)

SCIP – Studsvik Cladding Integrity Project; OECD/NEA research programme on fuel cladding

SCK•CEN (Belgium) – The Belgian Nuclear Research Centre SCK•CEN

SCWR – Super Critical Water Reactor; reactor type

SEM – Scanning electron microscope

Serpent – Neutronic calculation code developed at VTT

SHOK – Strategic Centre for Science, Technology and Innovation funded by Tekes

SKB (Sweden) – Svensk Kärnbränslehantering AB; Swedish nuclear waste management company

SMABRE – Software code (thermal hydraulics)

SMR – Small Modular Reactor

SNETP – Sustainable Nuclear Energy Technology Platform; part of Euratom's Fission programme

SRA – Strategic Research Agenda of the above technology platform

STUK – Radiation and Nuclear Safety Authority

STYX (particle bed coolability tests) – VTT test facility (severe reactor accidents)

SusEn – Energy research programme of the Academy of Finland

SWOT – Analysis of Strengths, Weaknesses, Opportunities and Threats

SYTYKE – Doctoral Programme in Environmental Health in Finland

TAGS – Total Absorption Gamma Spectroscopy; analysis method

TASS – Total Absorption Spectrometry

TEF – Technical Evaluation Forum

Tekes - The Finnish Funding Agency for Technology and Innovation Tekes

TKK (current Aalto University) – Helsinki University of Technology TKK

TRACE – Software code (thermal hydraulics)

TUKES – Finnish Safety and Chemicals Agency

TUT – Tampere University of Technology

TVO – Teollisuuden Voima Oyj

TVONS – TVO Nuclear Services

VHTR – Very High Temperature Reactor; reactor type

VLJ Repository – Final disposal facility for operating waste

VTT – VTT Technical Research Centre of Finland

VVER reactor – Russian Pressurised Water Reactor (water-water-energy-reactor)

VYR – State Nuclear Waste Management Fund

WENRA – Western European Nuclear Regulators' Association

WNA – World Nuclear Association

WPDD – Working Party on Decommissioning and Dismantling

YES – National Strategy Committee for nuclear energy research organized by MEE in 2013-14

YK – Finnish national training courses in nuclear safety

YTERA – Doctoral Programme for Nuclear Engineering and Radiochemistry

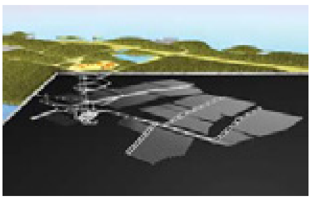
YVL guides – STUK guidelines concerning safety of nuclear facilities, nuclear materials and nuclear waste, as well as safety and security arrangements required by the use of nuclear energy

Äspö International Task Force – International research forum related to SKB hard rock research

APPENDIX 3

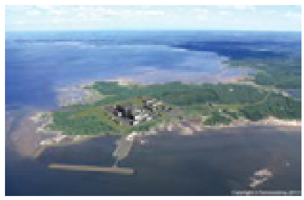
Finnish Nuclear in a Nutshell

Independent republic since 1917
Member State of the European Union since 1995
Capital: Helsinki
Neighbouring countries: Estonia, Norway, Russia and Sweden
Area: 304,600 km²
Population: 5.45 million
Population density: 17.9 persons per km²
Monetary unit: euro (EUR)
GDP per capita (2013): EUR 35,569 (preliminary)
Total primary energy consumption (2013): 32 Mtoe (preliminary)
Energy consumption per capita (2013): 5.9 toe (preliminary)
Total electricity consumption (2013): 83.9 TWh (preliminary)
Electricity consumption per capita (2013): 15,400 kWh (preliminary)
Share of nuclear energy in Finland (2013):
 27.1 per cent of total electricity consumption
 33.3 per cent of domestic electricity production



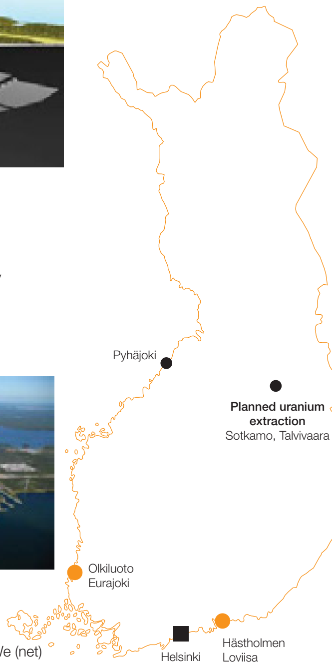
WASTE MANAGEMENT:

- Repositories for LLW & MLW in operation at Olkiluoto and Loviisa
- Initial Decision in principle for spent fuel repository at Olkiluoto ratified by Parliament in 2001
- Confirming underground rock characterisation studies underway in ONKALO facility at Olkiluoto



HANHIKIVEN NIEMI, PYHÄJOKI

Owner: Fennovoima Oy
Planned: Hanhikivi 1



OLKILUOTO, EURAJOKI

Owner: Teollisuuden Voima Oyj
Reactor units 1&2: BWR 2 x 880 MWe (net)
Operation started: 1979, 1982
Production: 14.6 TWh (2013)
Load factor: 95.1 per cent (2013)

Under construction
Olkiluoto 3: EPR (PWR) 1600 MWe

Planned: Olkiluoto 4

HÄSTHOLMEN, LOVIISA

Owner: Fortum
Reactor units 1&2: PWR 2 x 496 MWe (net)
Operation started: 1977, 1981
Production: 8.0 Twh (2013)
Load factor: 92.5 per cent (2013)

Recent licensing processes

The climate and energy strategy adopted by Finland states that nuclear power is an option, with the provision that the initiatives must come from industry. As stipulated in the Nuclear Energy Act, an Environmental Impact Assessment (EIA) process must be completed before an application for a Decision-In-Principle (DIP) can be submitted to the Government.

During 2008-2009 three companies completed EIA processes and applied for DIPs for their new nuclear power plant projects. DIPs were applied for by Teollisuuden Voima Oyj's (TVO) Olkiluoto 4, Fortum's Loviisa 3 and Fennovoima's Hanhikivi 1 reactor units.

The TVO and Fortum EIA processes were completed in 2008, and the Fennovoima process in 2009. The coordinating authority for the EIA processes is the Ministry of Employment and the Economy (MEE).

TVO filed its DIP application for the construction of Olkiluoto 4 in April 2008, and Fortum for Loviisa 3 in February 2009. Fennovoima's DIP application was filed in January 2009. In the same year, upon request of the MEE, Fennovoima's listed candidate sites - Simo and Pyhäjoki - stated their willingness to host the Fennovoima plant. The Radiation and Nuclear Safety Authority (STUK) has since confirmed the suitability of these greenfield sites.

Posiva Oy, the organisation created by TVO and Fortum to manage spent fuel disposal, also filed DIP applications for the enlargement of the ONKALO final repository, to accommodate spent fuel from the proposed new reactors (Olkiluoto 4 and Loviisa 3).

The MEE processed all five DIP applications during 2009-2010, and the Government made its decisions in May 2010. The five applications fulfilled all safety and environmental requirements. The Nuclear Energy Act specifies that DIP has to be based on the "overall good of society". Thus, the DIP decisions reflected national energy needs in 2020, and set the limit of two new nuclear power plants.

TVO's Olkiluoto 4 and Fennovoima's new build projects received positive DIPs, as did Posiva for the repository enlargement project regarding Olkiluoto 4 spent fuel. Loviisa 3, and Posiva's proposal for further expansion of ONKALO to accommodate Loviisa 3 spent fuel got negative DIPs. Positive DIPs were issued to the two utilities (TVO and Fennovoima) that will produce electricity at cost for the needs of the Finnish industries funding these projects. The Government also took Fortum's stake (about 25%) in TVO into account when deciding upon the DIPs.

The positive DIPs for TVO´s Olkiluoto 4 and for Fennovoima were ratified in Parliament on 1 July 2010. Posiva also obtained a ratified DIP on that date on its application for Olkiluoto 4 spent fuel handling.

Changes in Fennovoima's project led the company to apply for a new EIA and DIP. A new Rosatom reactor alternative was not mentioned in the then already ratified DIP and Fennovoima initiated a new EIA-process in September 2013. In March 2014

Fennovoima applied for a supplement for its DIP. Also TVO applied for a supplement for its DIP in May 2014 due to the delay in the OL3 schedule.

TVO's OL3

TVO was granted a construction licence for the Olkiluoto 3 pressurised water reactor (type EPR, European Pressurised Water Reactor) in February 2005. The reactor's thermal output will be 4,300 MW, and electric output about 1,600 MW.

Construction of the plant unit started in the summer of 2005, and by the end of 2013 the civil construction works had to a large extent been completed. Pressure tests of the reactor building were executed successfully in early 2014. Automation tests have commenced in 2014 in the Areva-Siemens test facilities in Germany.

The last estimate for the start of operation is 2016. However, The Areva-Siemens Consortium, which is constructing the OL3 plant unit on a fixed-price turnkey delivery contract, has not given the schedule for the commissioning of the unit. Commercial electricity production had originally been planned to start in 2009.

TVO's OL4

TVO has five plant alternatives (ABWR Toshiba, ESBWR GE Hitachi, KHNP APR 1400, APWR Mitsubishi and Areva EPR) and it received the bids in early 2013.

Fortum's LO1 and LO2

Fortum Power and Heat Oy (Fortum) was granted new 20-year operating licences in July 2007 for its Loviisa 1 and 2 PWR units. Fortum is planning a lifetime of at least 50 years for both units, which would mean an end to their operational lifetime around 2030.

Fennovoima's FH1

In June 2007 a new company, Fennovoima Oy, initiated a new build project. This new power company was created by a consortium of industrial and energy companies, with the German company E.ON holding a 34% share. After E.ON's decision to sell all of its ownership and business in Finland, the company sold its stake in the venture in 2013.

Fennovoima chose the municipality of Pyhäjoki as the preferred site in October 2011, announcing that the unit will be named Hanhikivi 1, after the peninsula where the unit is to be situated. Fennovoima invited bids for the power plant in July 2011 from Areva and Toshiba. The bids were received in January 2012. In April 2013 the company announced that it will continue direct negotiations with Toshiba and Rosatom, whose option is AES-2006, 1200 MW PWR (VVER).

In December 2013, Fennovoima made an agreement with Rosatom for the supply of the AES2006 reactor and an ownership of 34% of the shares of Fennovoima. The aim of the company is to construct a new nuclear power plant in Finland that would be operational by 2024.

ONKALO

In 2004, Posiva Oy started excavations of the underground rock characterization facility ONKALO. The rock laboratory is intended to be a part of the final disposal facility of the spent nuclear fuel generated by TVO's Olkiluoto and Fortum's Loviisa. By the end of 2011 ONKALO excavations had reached the final depth of 430 metres and a length of more than four kilometres. Posiva Oy applied for a construction licence for the encapsulation and final disposal facility in December 2012 and the construction works of the facility is expected to commence in 2015, after the construction licence is granted by the Government. Posiva has been conducting research in ONKALO to get further information on, i.e., the bedrock and groundwater conditions of the final disposal site, as well as on the impact of the construction on these conditions. The start of the final disposal of the spent nuclear fuel is planned for the early 2020s.

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Ydinenergia-alan tutkimuksen strategiaryhmä (YES)

Puheenjohtaja Herkko Plit
Sihteerit Jorma Aurela ja Jussi Leppänen

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Ydinenergia-alan tutkimusstrategia

Tiivistelmä | Referat | Abstract

TEM asetti tammikuussa 2013 työryhmän valmistelemaan ydinenergia-alan tutkimusstrategiaa vuoteen 2030 asti. Tämä perustui maaliskuussa 2012 työnsä päättäneen kansallisen ydinenergia-alan osaamistyöryhmän (Osaamistyöryhmä tai OTR) raporttiin. Yksi sen suosituksista kuului: ”Ydinenergia-alan suomalaisen tutkimuksen tarpeet ja painopisteet tulee täsmentää ja laatia tutkimustoiminnan kehittämiseksi pitkän aikavälin strategia. Tämä edellyttää erillistä, alan tutkimusorganisaatioiden ja muiden toimijoiden yhteistä hanketta.”

Työ tehtiin YES-hankkeen ohjausryhmässä ja sen koolle kutsumissa jaostoissa. Työryhmän puheenjohtajaksi määrättiin Herkko Plit, pääsihteeriksi Jorma Aurela sekä sihteeriksi Jussi Leppänen. Työryhmän jaostot olivat seuraavat (suluissa jaostojen vetäjät): 1) Ydinturvallisuus (Riitta Kyrki-Rajamäki, LUT), 2) Ydinjätehuolto (Kari Rasilainen, VTT), 3) Ydinenergia-alan tutkijakoulutus (Filip Tuomisto, Aalto), 4) Ydinenergian tulevaisuuden teknologiat ja perusfysiikka (Kristiina Söderholm, Fortum), 5) Yhteiskuntatieteellinen ydinenergiatutkimus (Eeva Kalli, Energiateollisuus) ja 6) Tutkimuksesta liiketoimintaan ydinenergia-alalla (Liisa Heikinheimo, TVO).

Työryhmän työhön osallistui kaikissa esitellyissä jaostoissa, ryhmissä tai kahdessa järjestetyssä laajassa seminaarissa yli 100 henkilöä. Strategian visio on *Kansainvälisesti korkeatasoinen suomalainen osaaminen ja tutkimus varmistavat turvallisen, kestävän ja kilpailukykyisen ydinenergian käytön sekä edistävät alan liiketoimintamahdollisuuksia.*

Strategian suositukset ovat seuraavat: 1) Ydinenergia-alan tutkimuksen painopistealueet tulee koota laajoiksi kansallisiksi ohjelmiksi, 2) Ydinenergia-alan suomalaisen tutkimuksen tieteellistä tasoa tulee kohottaa, 3) Osallistutaan aktiivisesti Suomelle tärkeään kansainväliseen tutkimukseen tekemällä kansallista laaja-alaista ja poikkitieteellistä yhteistyötä, 4) Ydinenergia-alalle on tutkijakoulutuksen laadun ja määrän varmistamiseksi perustettava laaja ja kattava kansallinen tohtoriohjelmaverkosto, 5) Infrastruktuurin rakentamista, ylläpitoa ja hyödyntämistä on koordinoitava kansallisella tasolla. Rahoituksesta on huolehdittava pitkäjänteisesti ja kansallisten rahoittajien roolit on selkiytettävä, 6) Tutkimustoiminnassa tulee panostaa innovaatioiden kehittämiseen. Liiketoiminnan kasvua ja kansainvälistymistä tuetaan kokoamalla toimijat yhteen Team Finlandin alle ja 7) TEM:n yhteyteen ehdotetaan perustettavaksi ydinenergia-alan tutkimukseen ja käyttöön liittyvä neuvottelukunta pysyväksi asiantuntijaelimeksi tukemaan päätöksentekoa ydinenergia-alan kansallisissa kysymyksissä.

Työ- ja elinkeinoministeriön yhteyshenkilö: Energiaosasto/Jorma Aurela, puh. 050 592 2109

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Arbetsgruppen för en forskningsstrategi för kärnenergiområdet

Ordförande Herkko Plit
Sekreterare Jorma Aurela och Jussi Leppänen

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Forskningsstrategi för kärnenergiområdet

Tiivistelmä | Referat | Abstract

Arbets- och näringsministeriet tillsatte i januari 2013 en arbetsgrupp för att bereda en forskningsstrategi för kärnenergiområdet som sträcker sig fram till år 2030. Detta baserade sig på en rapport från den nationella kompetensarbetsgruppen på kärnenergiområdet (nedan kompetensarbetsgruppen) som slutförde sitt arbete i mars 2012. En av arbetsgruppens rekommendationer löd: ”Behoven av och prioriteringarna för den finländska forskningen på kärnenergiområdet ska preciseras och det ska upprättas en strategi på lång sikt för utveckling av forskningen på området. Detta förutsätter ett separat projekt som är gemensamt för forskningsorganisationerna och andra aktörer inom branschen.”

Arbetet utfördes i styrgruppen för det aktuella projektet och i de sektioner som projektet hade sammankallat. Till arbetsgruppens ordförande förordnades Herkko Plit, till generalsekreterare Jorma Aurela och till sekreterare Jussi Leppänen. Arbetsgruppen hade följande sektioner (sektionsledare inom parentes): 1) Kärnsäkerhet (Riitta Kyrki-Rajamäki, LUT), 2) Kärnavfallshantering (Kari Rasilainen, VTT), 3) Forskarutbildning på kärnenergiområdet (Filip Tuomisto, Aalto), 4) Den framtida tekniken för kärnenergi och grundfysiken (Kristiina Söderholm, Fortum), 5) Samhällsvetenskaplig forskning kring kärnenergin (Eeva Kalli, Energiindustrin) och 6) Från forskning till affärsverksamhet på kärnenergiområdet (Liisa Heikinheimo, TVO).

I arbetsgruppens arbete deltog i alla ovan nämnda sektioner, grupper och vid de två omfattande seminarier som ordnades över 100 personer. Strategin har följande vision: *Den internationellt sett högklassiga finländska kompetensen och forskningen säkerställer säker, hållbar och konkurrenskraftig användning av kärnenergin samt främjar affärsverksamhetsmöjligheterna inom branschen.*

I strategin ingår följande rekommendationer: 1) Prioritetsområdena inom forskningen på kärnenergiområdet ska samlas under omfattande nationella program, 2) den vetenskapliga nivån på den finländska forskningen på kärnenergiområdet ska höjas, 3) Finland deltar aktivt i sådan internationell forskning som är viktig för Finland genom ett nationellt omfattande och tvärvetenskapligt samarbete, 4) ett omfattande och täckande nationellt nätverk av doktorandprogram ska byggas upp med tanke på kärenergiområdet för att säkerställa forskarutbildningens kvalitet och kvantitet, 5) byggandet, upprätthållandet och utnyttjandet av infrastrukturen ska samordnas på den nationella nivån. För finansieringen ska det sörjas på lång sikt och de nationella finansiärernas roller ska klarläggas, 6) Inom forskningen ska man satsa på utvecklingen av innovationer. Affärsverksamhetens tillväxt och internationalisering stöds genom att aktörerna samlas under Team Finland och 7) det föreslås att det i anslutning till arbets- och näringsministeriet ska inrättas en delegation för forskning i och användning av kärnenergi, som ska vara ett permanent expertorgan som har till uppgift att stöda beslutsfattandet i nationella frågor på kärnenergiområdet.

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Nuclear Energy Research Strategy

The Nuclear Energy Research Strategy has been prepared by a working group set by the Ministry of Employment and the Economy. The working group included representatives from universities, research institutes, authorities and industry. The strategy proposes a vision spanning until 2030, and recommendations for procedures that will ensure success in achieving the set objectives. The working group has utilised alternative scenarios on the development of nuclear energy field described in the strategy to evaluate future procedures and focus areas.

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