# Developing regulatory framework for SMRs in Finland

M. TUOMAINEN

STUK

Vantaa, Finland

Email: minna.tuomainen@stuk.fi

E. AHONEN

STUK

Vantaa, Finland

T. ROUTAMO

STUK

Vantaa, Finland

A. VALKEAPÄÄ

STUK

Vantaa, Finland

**Abstract**

The current regulatory framework in Finland is designed to regulate large light water reactors intended for electricity production, located in relatively remote areas and constructed and operated by well-established nuclear power companies with extensive in-house competence. However, the growing interest in Small Modular Reactors (SMRs), particularly for district heating purposes, challenges the validity of these assumptions.

The regulatory framework is being developed to serve varying approaches to deploy nuclear energy and to enable emerging technologies, when demonstrated to be safe. A comprehensive reform of related legislation is currently in progress. Both the licensing process and safety requirements are under thorough review and will be adjusted as needed. Concurrently, STUK is adapting its oversight practices accordingly.

The paper outlines how SMRs are considered in the reform. It includes examples to illustrate the work. The first example discusses the utilization of design evaluations to support the development of the regulatory framework. The second example involves revising regulations to permit a case-by-case definition of emergency planning zones. The third example addresses development of seismic design criteria.

## INTRODUCTION

Emergence of SMRs does not mean only new reactor designs or new technologies, but other new approaches as well. Instead of established nuclear power companies, vendors can be start-ups, and licensees can be municipal power companies or industrial enterprises, for which producing nuclear energy is not their core business. New applications like district heating or providing energy for industrial processes necessitate new kind of locations, close to population centers or next to industrial facilities. Serial production – not only of some components but of main components, as well, and even the reactor vessel and integrated primary circuit – challenges the accustomed oversight model where both the licensee and the regulator oversee the quality of the main components starting from the manufacturing phase.

The nuclear field in Finland has recognized the need to develop the regulatory framework to enable feasible licensing of new solutions and approaches if their safety can be demonstrated. The Government has announced promoting SMRs as one of its objectives. A fundamental reform of the related legislation has been launched to fulfill the society’s expectations.

For the regulatory body, competence building and updating regulatory requirements and guidelines are the main elements of the work.

## Reform of the regulatory framework

Emergence of SMRs was not the only reason for starting the reform. In 2019, the Ministry of Economic Affairs and Employment (MEAE) appointed a working group to identify needs for changes in the legislation concerning the use of nuclear energy. As one reason for renewal, the group identified the significant changes in the operating environment since implementation of the original Nuclear Energy Act in 1987, but also pointed out that the current legislation is complex and difficult to understand and not completely in line with the principles laid down in Constitution of Finland [1].

Since then, MEAE has launched the reform of the Nuclear Energy Act and Nuclear Energy Decree. In parallel, STUK is reforming its regulations and regulatory guides. MEAE and STUK work in close cooperation as the legislation under MEAE’s responsibility and the regulatory requirements published by STUK are closely linked.

The reform addresses the findings of the working group. Emergence of SMRs is accounted for, but no SMR-dedicated requirements will be drafted. The aim is to have one set of goal-setting requirements that can be applied for different reactors, for different uses of nuclear energy and for different business models. Reducing the prescriptiveness that appear in some current requirements will help the licensing of different solutions. Regulatory guides may be drafted e.g., to advice in application of the requirements for different solutions.

The new legislation is due to be in force at the latest in the beginning of 2028. The time schedule is largely dictated by the general process for drafting legislation.

### Competence building in STUK

SMR designs can significantly differ from traditional nuclear power plants. SMRs comprise novel and distinct design characteristics, technical solutions, and deployment approaches, which are something new and different from the current large NPPs for the regulator. Enabling these through regulatory reform requires knowledge, design familiarization, and enhancing understanding.

Furthermore, Generation IV reactor technologies are increasingly prominent in the context of SMRs. Finland does not have a substantial amount of knowledge, expertise, or experience regarding Generation IV technologies.

STUK has established an SMR road map. “The road” should lead to regulations that are applicable to SMRs and to sufficient competence to perform safety assessments. However, it is not possible to familiarize oneself with everything. Society’s expectations and industry’s plans primarily provide outlines for directing the focus of familiarization. STUK’s priorities in competence building lie within the designs and technologies that, based on indications from the industry, could potentially be realized in Finland in the near-term future. For other technologies, STUK aims in obtaining basic understanding of the technologies and the related safety issues.

STUK is using different opportunities to familiarize with the designs. In addition to studying publicly available information, STUK utilizes the discussions with different stakeholders to increase its understanding of the SMR design features. Some of these discussions are described further in Chapter 4. The primary emphasis is particularly on aspects common to many SMR concepts. For example, these include modular construction, soluble boron free reactor core and TRISO fuel.

The opportunities for international cooperation and pre-licensing engagement activities support design familiarization activities. The aim of competence building is to support consideration of SMR perspectives in the regulatory reform and to provide STUK with capabilities to address novel designs and technologies to an appropriate extent.

## Developing the licensing process

The licenses in Finland are granted by the Government. STUK provides safety assessment for the decision-making. By the law, the Government is obliged to take STUK’s conclusions on safety into account in its decision. The current licensing model is depicted in Fig. 1.



*FIG. 1. The current licensing model for nuclear facilities in Finland.*

The Governmental program, published in summer 2023, asks for development of the licensing process considering SMRs. From STUK’s point of view, the licensing process should enable licensing safe designs, and should have provisions for identifying safety issues timely.

### Challenges of the current licensing model to SMR projects

The current licensing model has worked relatively well but has some challenging issues which may be highlighted in SMR projects.

In the current licensing model, the first actual licensing step is Decision-in-Principle (DiP). The Decision-in-Principle is a political decision, made by the Government and ratified by the Parliament, on whether the proposed nuclear facility is for the overall good of the society. While DiP has been useful in ensuring political commitment and societal acceptance for projects and in identifying potential licensing challenges early on, it on the other hand requires significant resources without any certainty of the result. For example, the Environmental Impact Assessment (EIA) must be completed before submitting the DiP application. Furthermore, DiP includes preliminary safety assessment of the reactor. To be able to provide necessary information about the facility, the applicant must have at least preliminary agreement with the vendor. In DiP application, it is possible to present several site and reactor candidates. Especially for smaller companies, maybe planning to build one SMR, carrying out EIA and making the agreements with the vendors for DiP application may be too heavy an investment before having certainty that they can continue with the project.

Second challenge is that the site-specific design bases are not approved by the regulatory body until the construction license phase. In the construction license phase the basic design and partly also detailed design are already completed and if not in line with the site-specific design bases, the needed safety improvements may have a severe impact to the feasibility of the project. This question may be highlighted with SMRs for which new sites are probably proposed. The licensing process should provide for solving safety issues timely.

Thirdly, the current legal framework does not unambiguously offer possibility for pre-licensing evaluations, nor a process for those. Pre-licensing evaluations would offer early feedback on major safety issues and licensing challenges, before the future license applicant needs to make larger commitments.

### Planned changes to the licensing model

In the regulatory reform, changes will be made to address the challenges. The following changes are envisaged:

* DiP will be more generic, it will not include preliminary safety assessment of the reactor candidates;
* EIA is not required for DiP. It is planned that EIA would be required before the construction license;
* Approval of the site-specific design basis is required before construction license phase;
* Provisions are made for pre-licensing evaluations. A separate safety assessment of the conceptual design is added, independent of the DiP and open also to the vendors.



*FIG. 2. Outline of the new licensing model under discussion*

One aim of the changes is to make the licensing process more flexible. The site evaluation and the safety assessment of conceptual design are not bound to the DiP. They can be applied for before, parallel or after the DiP. The applicant for these may be different, too. The DiP is applied for by the future licensee, but for the safety assessment of the conceptual design, the applicant can also be for example the vendor or some consortium of interested parties. The approval of the site-specific design bases can be applied for example by the municipality. In the construction license application, the applicant must show it has the right to use the approval of the site-specific design bases and the safety assessment of the conceptual design.

#### Developing the safety assessment of the conceptual design

Objectives of the conceptual design safety assessment are the following:

* Identify potential safety issues and licencing challenges early before the actual license application;
* Recognize the main principles and plant level solutions that steer the detailed design;
* Allow STUK to familiarize with the design and ensure it has needed competence for the construction license safety assessment;
* Provide others than the future license applicant the possibility to ask for the assessment;
* Facilitate involving regulators of other countries in the assessment.

The safety assessment focuses on safety principles and conceptual design. The topics to be included are:

* Plant level design basis: safety objectives for design, initiating events and internal/external hazards, practically eliminated events and their justification;
* Implementation of safety functions and application of safety principles in their design (Defense-in-Depth, redundancy, diversity, separation);
* Principles and design rules for structural radiation safety;
* Considering security and safeguards in the design;
* Considering the needs of emergency organisation in the design (needed space, information transfer etc.)
* Principles of operation (plant autonomy, control room concept etc);
* Design provisions for radioactive waste management;
* Considering decommissioning in the design;
* Main standards to be applied in design and in manufacturing;
* Plans for safety demonstration;
* Vendors Management System (design process, management of supply chain etc.).

When potential needs for design modifications are recognized early, it is easier to design them to be compatible with the overall design and safety philosophy. Similarly, if a need for further experimental demonstration is recognized, it may be easier to allocate time for carrying out the experiments than during the construction license phase.

The current legislation allows anyone who is planning to use nuclear energy, to submit their plans to STUK for preliminary review. However, the legislation leaves room for interpretation and is not easily recognized to provide the opportunity for preliminary safety review. In the reform, this option will be made unambiguous, and the process will be formalized.

One considered aspect is to facilitate involving regulators of other countries in the assessment and making the safety assessment report easy to use for other regulators licensing the same design later. Involvement in international cooperation (e.g. IAEA’s Initiative for Nuclear Harmonization and Standardization and Joint Early Review of Nuward SMR) provide valuable input for the work.

The outcome of the safety assessment of the conceptual design also facilitates the safety assessment in the following licensing phases. It is expected that the safety assessment of the construction license documentation is more fluent when the driving principles and top-level safety solutions are familiar to the regulator already.

## experiences from design reviews

To increase its understanding of SMR design features, STUK has utilised different opportunities to familiarise itself with the designs more deeply than is possible just by studying the publicly available information. The cases have provided opportunity to test the planned regulatory requirements and licensing process. Three examples are given below.

### Review of individual design features

A Finnish Licensee, Fortum Power and Heat Oy, is performing a feasibility study of new nuclear build in Finland and Sweden. The feasibility study looks at SMR and large NPPs for energy production. As part of the feasibility study, Fortum has requested that STUK review certain features of the designs that they are considering.

The legislative framework for this work is the current Nuclear Energy Act Section 55 paragraph 4. It allows STUK to review plans and give preliminary guidance for a requesting party that is considering using nuclear energy.

So far, STUK has reviewed 3 features in 2 separate designs. The first feature was overpressure protection concept in BWRX-300. The next reviews were about use of passive systems on several DiD levels in AP1000 and in-vessel retention of core melt in AP1000. The work is continuing with new requests by Fortum to review additional topics of various plant designs.

The reviews have enabled STUK to consider the impact of new and innovative features on regulations. It has enabled us to identify and reconsider some of the underlying assumptions and core tenets behind our regulations, some of which are not necessarily explicitly mentioned in the regulations.

### Observing Generic Design Assessment Process

Rolls-Royce, as a reactor vendor, approached STUK and regulators of other states in late 2023, offering an opportunity to participate as external observers in Step 2 of the British Regulator’s Generic Design Assessment (GDA) for Roll-Royce SMR design. During the observation, STUK and the other international regulators don't influence the GDA process or its outcome. A joint review of the involved regulators is not to be conducted in this context.

The observation has given STUK the opportunity to familiarize itself with the design and to increase its understanding on novel design characteristics, technical solutions, and deployment approaches in Rolls-Royce SMR. Of a special interest was modular construction, which has been emphasized in the Rolls-Royce’s design and which is new to STUK and challenges STUK’s current oversight practice. Furthermore, new insights and perspectives have been explored from the UK's GDA Process, to support the development of the STUK’s safety assessment for conceptual design.

### Pilot for a safety assessment of a conceptual design

A start-up company, Steady Energy Oy, is developing a district heating SMR, LDR-50, in Finland. STUK and Steady Energy have agreed to apply the conceptual safety assessment process to the LDR-50 as a pilot case. From the pilot, STUK will gain valuable experience on applying the process and the designer will get feedback on their design. As the legislation reform is still underway, the lessons learned can be considered in drafting the process.

The international aspect will be one topic in the pilot. A few regulators from other states are invited to observe the assessment and STUK’s conclusions on safety. The assessment report will be written in English, and feedback is expected on how the report would best support potential assessment by other regulators.

## Changing requirements for Emergency Planning Zone sizes

The first modification to the legislation was to change the way how the sizes of emergency planning zones, Precautionary Action Zone (PAZ) and Emergency Planning Zone (EPZ) are defined. The modification was published and took effect in February 2024. According to the new requirements, the size of PAZ and EPZ are defined on case-by-case bases. Before the change, fixed sizes, 5 km for PAZ and 20 km for EPZ were set in Regulation on Emergency Arrangements of a Nuclear Power Plant.

While the required sizes 5 km and 20 km for the zones have worked well for the current operating units in Finland, they posed a challenge for SMRs to be located closer to population. In Finland, using SMRs for district heating applications is of interest, to replace fossil fuels. Especially small district heating SMRs should be located relatively close to the heat consumers.

To make placing SMRs closer to population possible, if safety can be demonstrated, STUK decided to change the EPZ requirements. The change was made ahead of the schedule of the overall legislation reform, as the zones are needed in land-use planning process for nuclear facilities. The land use planning is usually one of the first steps towards licensing and it can typically take several years. Changing the regulation enabled starting land-use planning processes already before the rest of the new legislation is in force. The principal meaning of the zones, described below, was not changed.

The PAZ is defined in such a way that, in the event of an accident, there is a high probability that there will be no need to evacuate the population beyond the PAZ and that the necessary evacuation measures can be effectively carried out within the PAZ to prevent or limit severe deterministic effects of ionising radiation. To enable effective evacuation, the PAZ is subject to land use restrictions. It must be demonstrated that in any accident situation outside the PAZ the radiation dose to an unprotected person does not exceed 1 Sv within 10 hours from the beginning of exposure. [2] The dose limit is based on the IAEA Safety Standard GSR Part 7.

The EPZ is determined in such a way that, in the event of an accident, there is a high probability that there will be no need outside the EPZ to take urgent protective measure for the population, like sheltering indoors, to limit the stochastic effects of ionising radiation. When determining the size of the EPZ, it must be demonstrated that, in the event of an accident, the radiation dose of an unprotected person outside the EPZ will not exceed 10 mSv within 48 hours of the start of exposure. The dose criterion is derived from the reference level of exposure from a radiological emergency, which has been set by the Radiation and Nuclear Safety Authority. The emergency planning zone can be limited to a maximum distance of approximately 20 km. [2]

It should be noted that the above dose limits are for determining the width of EPZs, especially UPZ, are considering cases where the Defense-in-Depth level 4 has failed to some extent. The actual design criteria for doses, and consequentially releases, defining large releases will restrict doses well below the aforementioned 1 Sv.

## developing seismic design criteria

According to the current regulations in Finland, the license holder must determine the seismic hazard and the seismic design basis for the site. STUK's role is to evaluate and approve the license holder's proposal. In addition, STUK gives general instructions for preparing and presenting the seismic design basis in its regulatory guides. Determining the seismic risk and design basis is laborious.

Determining the earthquake hazard involves several expert assessments and choices. Justifying the choices transparently and considering best available information takes time. In addition, due to low seismicity in Finland, there are uncertainties in the determination. When the uncertainties are large, different expert estimates differ from each other, and different earthquake hazards drawn up for the same area can differ significantly from each other.

New actors planning SMR facilities do not necessarily have the same resources to perform seismic surveys as the current license holders. Although several commercial SMR plants are designed for areas more seismic than Finland and the earthquakes are not necessarily a significant factor, the duration of seismic surveys and the uncertainties of the seismic design basis can slow down projects and weaken their profitability.

In the regulatory reform, the goal is to enable the entry of new operators and new operating models, if safety can be demonstrated. To enable feasible licensing of SMRs, STUK is investigating the possibility for drafting seismic design criteria for Finland. The license holder's own more precise assessment for each site will also be allowed.

Finland has not prepared a nationwide seismic hazard at a level corresponding to the design criteria for nuclear power plants. For STUK to present acceptable seismic design criteria, the seismic hazard must be determined, and maps of the seismic hazard must be prepared. The work started in early 2024. As far as possible, the work will make use of similar work done by relevant authorities in other countries.

## Summary

In developing the regulatory framework for SMRs, the licensing process and the requirements for safety, security and safeguards are reformed. In parallel, STUK is systematically building its competence in SMRs to be able to identify the relevant questions to be addressed in the reform and to be able to perform SMR safety assessments. International cooperation and engagement in pre-licensing discussions provide valuable input for the work.

References

1. LIUKKO, A., SLANT, O., VÄLIMÄKI, M., Developing Regulation to Cover the Life Cycle of Nuclear Facilities, Final Report., Ministry of Economic Affairs and Employment, Helsinki, Finland, 2020.
2. Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant, 2024. www.stuklex.fi/en/maarays/stuk-y-2-2024, 2024.