ALFRED LICENSING PREPARATORY STAGE

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Abstract

ALFRED (Advanced Lead-cooled Fast Reactor European Demonstrator), as the demonstrator of the lead-cooled fast reactor technology (LFR) is considered the necessary first step in the European LFR roadmap, to bridge the gap between the research achievements and the commercial application. When ALFRED implementation in Romania was decided, the existing Romanian regulation framework hadn't been explicitly applied yet to advanced reactor systems, and demonstrator-type reactors. To enlarge on one hand the applicability of the existing regulations and to include on the other hand the specificities of innovative technologies, both parties, CNCAN and FALCON Consortium, convened about the benefit of adding a preparatory phase to the authorization process (in anticipation to the classical licensing process). The paper presents the activities performed on licensing preparation, under the PRO-ALFRED project umbrella, highlighting the main conclusions. The elements of the envisaged project licensing process will drive towards recommendations to achieve an efficient ALFRED deployment.

Keywords: *ALFRED, licensing preparatory stage, PRO ALFRED project*

Introduction

Nuclear energy development should be in compliance with the existing requirements stipulated in the regulations specific to nuclear domain. Demonstrating the implementation of an adequate level of safety by any nuclear installation is a prerequisite and a key-point condition for obtaining a nuclear license.

While the basic safety principles governing the design of nuclear reactors are the same, regardless of the type of involved technology, the differences between the existing and advanced reactors count more when the regulatory requirements are prescriptive, in terms of the design and performance of certain safety systems and/or components having the function to prevent and/or to reduce the consequences of accident scenarios that are specific to each type of reactor. As the existing regulatory requirements are mainly based on LWR technology, it becomes necessary to put in place a revised and improved regulatory framework that takes into account the specific characteristics of innovative reactors also.

Even if at international level there are some plans or intentions to amend the regulatory framework and address the development of the new generation of reactors, within the broader umbrella of improving nuclear safety, up-to-now the licensing requirements specific for Generation IV reactors are not included in the existing regulatory framework. In the process of licensing the new generation of reactors, it is therefore necessary to capture and integrate in national legislation the international experience [3].

Lead-cooled Fast Reactors (LFR) are considered at international level as one of the most promising nuclear technologies able to meet the goals set forth by the Generation IV International Forum (GIF). At European level, the Sustainable Nuclear Energy Technology Platform (SNETP) has been supporting the LFR technology, recognizing also the need to develop a demonstrator reactor for the technology. ALFRED (Advanced Lead-cooled Fast Reactor European Demonstrator), as the demonstrator of the lead-cooled fast reactor technology, represents the first step in the LFR deployment strategy, with the intent to bridge the gap between the research findings and recommendations and the commercial application [1].

An international Consortium Fostering ALFRED Construction (FALCON), including as partner organizations Ansaldo Nucleare (Italy), ENEA (Italy) and RATEN ICN (Romania), has been established in 2013, with the aim to implement ALFRED as the prototype of a viable LFR technology, in Small Modular Reactor (SMR) segment, by 2035-2040 [1]. Based on its activities, FALCON represents a central point for gathering European organizations aiming to implement ALFRED as cornerstone of the LFR technology.

Considerations for Licensing Preparatory Stage

The licensing process of a nuclear installation is governed by the existing legislation and regulations, and although the licensing basis is quite similar between different countries, the whole process and licensing approach may vary quite widely.

There is a mandatory part and a flexible part in the regulatory framework, and the separation between the mandatory requirements (stipulated in laws or decrees) and other safety recommendations should be clearly understood, to obtain a clear image about which rules of the authorization process are not flexible and which parts of the process can be modified to reflect the specifics of innovative reactors.

Recent initiatives aimed at reviewing the design criteria to cover advanced technologies are on-going, trying to address early in time the technology-specific elements in the mandatory part of the regulatory framework. For those countries, including Romania, fully endorsing a prescriptive regulatory framework, this task is more extensive, since the prescribed mandatory part is much larger than in other countries where different regulatory approaches are established. The Romanian experience of both the safety authority and the technical support organization is typically related to CANDU or light-water-reactors, which is reflected in the current orientation of the regulatory framework, not dealing with innovative reactors licensing.

When ALFRED implementation in Romania was decided, the existing Romanian regulation framework hadn't been explicitly applied to advanced reactor systems, and demonstrator-type reactors. Before issuing the new elaborated norm about reactor licensing, the acceptance of a proposed design by Romanian Regulatory Authority in Nuclear - National Commission for Nuclear Activities Control (CNCAN) has only occurred upon issuance of the construction license, the norms stipulating the typical route of submittal, by the applicant, of Safety Analysis Reports (first Preliminary one, then Final). This was somehow logic since until now CNCAN has approved for construction only commercial reactors, with prior validated designs.

To enlarge on one hand the existing regulation applicability and to include on the other hand the specificities of innovative technologies, both parties, CNCAN and FALCON Consortium, convened on the benefit of adding a preparatory phase to the authorization process (in anticipation to the classical licensing process) [3].

Following this agreement, the ALFRED licensing process will consist of two main stages: a pre-licensing phase, followed by the well-known, traditional licensing steps.

In order to receive the authorization for construction and for operation, a comprehensive safety assessment of the nuclear facility must be carried out to confirm that the design considered for manufacture, construction and operation meets the safety objectives and requirements set out at the beginning of the design process.

The final objective of the pre-licensing phase is to achieve convergence, through an iterative process, on a final concept of the installation, in which the safety and security options have met all the requirements and expectations of the safety authority.

Going through a pre-licensing stage should provide a clear picture of the safety, security, and radiation protection arguments expected to be developed by the applicant in the licensing phase. This period should be used also to establish a well-defined framework for future exchanges between the applicant and the regulatory body.

The pre-licensing phase will be focused on the preparation activities for the ″design validation″ phase. This supplementary phase, although will increase the licensing period, will be very useful both for the designer and for the regulatory authorities to get mutual understanding, respectively, of the licensing specificities and of the technology. In developing the vision on the design validation process of the ALFRED demonstrator, the following elements were considered [3]:
- the parties involved in the whole process;
- the responsibilities assumed by each of them;
- all involved phenomena and important aspects in demonstrating safety;
- definition of the requirements and validation steps for the project.

The ″design validation″ stage is intended to provide a preliminary feedback on the design and to consolidate the RD&Q (Research, Development & Qualification) roadmap for substantiating the safety demonstration programme [3]. It is intended to require the regulatory body to carry out a preliminary review of the innovative reactor design, with the aim to assess its compliance with the national regulatory requirements and to identify any key barriers for authorization. In this way, the overall project will be reviewed and evaluated regarding its suitability for obtaining the construction and operating license, after the site-specific factors will be taken into account.

Some changes can be expected, following discussions, possible comments or requests of CNCAN, on the design itself or on the supporting experiments; whenever the proposed codes and standards fall short in providing the necessary confidence on a specific design detail, dedicated experiments will be agreed upon to produce necessary evidences.

Collaborative efforts to prepare ALFRED licensing

Acting as the demonstrator for the lead-cooled reactor technology in Europe, the ALFRED project has to deal with the peculiar characteristics due to the use of lead as a coolant, representing an absolute novelty for the nuclear field worldwide [1].

FALCON licensing task force experts have agreed that the preparatory phase will focus on the following aspects:
- identification of the international references that might be used to complement the Romanian regulatory framework for an LFR-technology-specific application; this mostly involves analysis of the existing codes and standards, and identification of those requiring adaptation, interpretation and modification in order to address the unique characteristics of non-LWR technology;
- identification of the needs for validation of safety computer codes (new ones that will be developed, or existing ones that will be modified or just applied to new conditions), including any R&D activities associated to cover the gaps;

• identification of those safety relevant phenomena which are connected with the codes and standards proposed as reference, but whose justification is not present in the codes and standards, and development of an experimental programme (″safety demonstration programme″) suited for demonstrating that the provisions in the codes and standards are justified in view of their use in the subsequent licensing;
• qualification, by CNCAN, of all FALCON members quality management systems, depending on their role in the project (e.g., R&D, codes development and/or validation, plant design) and their contribution to the licensing application that will be submitted.

All activities will have to be jointly discussed with CNCAN.

The ALFRED infrastructure implementation in Romania requires synergistic involvement of research organizations, industry and universities in the development of the LFR technology, while contributing to achieving the European Union's objectives on nuclear excellence.

PRO ALFRED project - Activities for the Preparation of the ALFRED Research Infrastructure Development in Romania was financed by the National RDI programme (PNCDI III), Sub-programme 5.5 – The ALFRED Project. The project was launched in September 2019, under the coordination of RATEN (State Owned Company Technology for Nuclear Energy), for a period of 15 months and having a budget of about 2,500,000 euro [2].

PRO ALFRED project was implemented through collective efforts of the following partners [2]:
- RATEN - coordinating organization, participating through its two branches, the Institute for Nuclear Research (RATEN ICN - Pitesti) and the Center of Technology and Engineering for Nuclear Projects (RATEN CITON - Bucharest);
- University Politehnica from Bucharest (UPB);
- University of Pitesti (UPIT);
- National Institute for Nuclear Physics and Engineering - Horia Hulubei , Bucharest (IFIN HH);
- Institute for Economic Prognosis, Bucharest (IPE).

Based on their specific competencies, each partner had well-defined responsibilities in achieving the project objectives. Each organization contribution was integrated at the level of 7 Work Packages (WP) and project deliverables. The project structure is presented in Fig. 1. Both Ansaldo Nucleare and ENEA, RATEN's partners in FALCON, have provided technical assistance for project activities.

In order to achieve the proposed objectives, 44 activities were planned to be carried out by about 116 specialists and administrative support staff. These activities contributed synergistically to the strengthening of the national capacity in the field of advanced nuclear technologies, ensuring the technical-scientific progress in LFR technology. Summarizing project activities and presenting its main achievements, 51 deliverables were developed. More specifically, the activities were dedicated to the following [2]:
- preparation of documentation for research - testing - demonstration support infrastructure installations;
- carrying out elements and preliminary studies for the ALFRED demonstrator licensing;
- development and modernization of the national research capacity for the ALFRED infrastructure implementation;
- preparation of the scientific management of the ALFRED infrastructure;
- establishing measures to ensure the necessary competencies for the implementation and operation of the infrastructure;
- technical-economic evaluation of the LFR technology from the perspective of the future national energy market;
- dissemination of project results, ALFRED infrastructure promotion and project management.

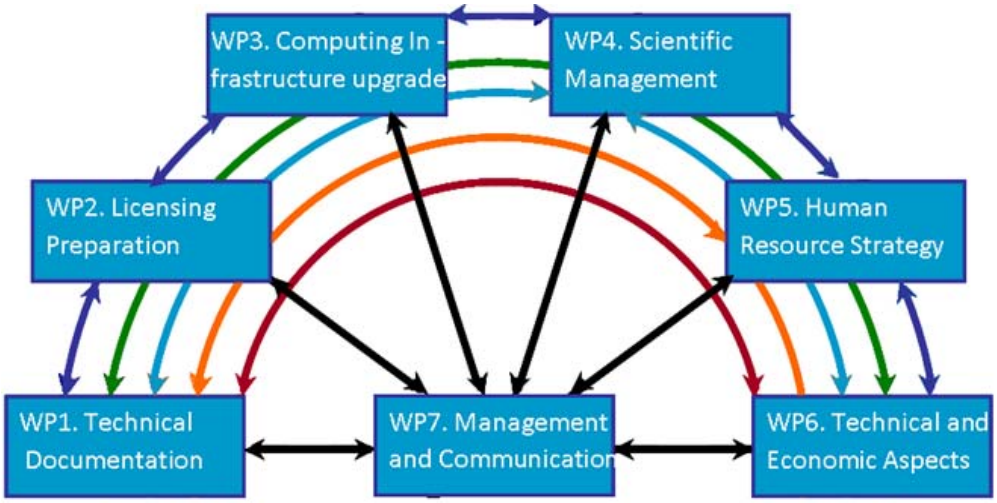


Fig.1. PRO ALFRED Project Structure

Among the WPs, WP2 aimed to support realization of the elements necessary for the ALFRED authorization process preparation, its activities being performed in two stages:
• Stage 1 – definition of the vision elements on the validation process and requirements for LFR technology-specific development;
• Stage 2 – elaboration of technical documentation, studies, strategies and other actions to prepare the authorization process.
To support the authorization process of the ALFRED demonstrator, some necessary elements of the process were elaborated, analysed and/or performed:

- elaboration of the document containing the proposed vision for licensing the demonstrator project;
- applicability of codes and standards for the ALFRED demonstrator;
- preparatory site studies on: area demography, meteorology, pre-operational monitoring of radioactivity at the level of the whole ICN platform;
- radioactive and/or hazardous waste generation assessment throughout ALFRED lifecycle;
- preliminary concept of the initial decommissioning plan of the ALFRED reactor.

Analysis of the applicability of codes and standards for the project

To license ALFRED, a ″Licensing Basis Document″ needs to be developed at the beginning of the process, as the reference basis for the whole process of licensing. This document will be based on Romanian regulations, supplemented, wherever necessary, by other international norms, industrial standards and codes, together with quality standards. The designer is expected to provide a list of the applicable codes and standards intended to be used as a basis for the design, procurement and construction.

Traditionally, the nuclear design codes and standards are the accepted basis for the design verification of technical solutions in any nuclear facility, but the innovative coolants and candidate materials are not thoroughly covered by the existing nuclear design standards and require dedicate efforts, therefore, a list of original and amended nuclear codes and standards is necessary. In this regard, under PRO ALFRED WP2 umbrella, the existing nuclear codes and standards were analysed, in terms of their applicability to innovative reactor projects.

The existing industry codes and standards for the design and the technical details of the reactor and support systems constitute the starting point of the analysis, to elaborate and agree on the list of standards and norms applicable to the ALFRED demonstrator project.

To catalogue the useful codes and standards, a hierarchical structure was developed, containing several levels to include the codes and standards, depending on their flexibility regarding the requirements [4]. The following categories were considered:
- Compulsory (Level I);
- Necessary (Levels II to IV);
- Recommended (Level V).

The performed analysis addresses the 3 levels corresponding to the ″necessary″ codes and standards, where some of which may require ″interpretation" before being applied by the designer. The recommended codes will be defined during the in-depth detailed design activity.

For each standard considered in the analysis, a preliminary assessment of its applicability to the ALFRED project was performed [4]. A consistent subset of applicable codes and standards selected by the designer for the ALFRED systems, structures and components will be extracted from the list resulting from the analysis, to be included in the ALFRED Licensing Basis Document.

Support the safety demonstration

All design activities, as well as the subsequent verification analyses, make large use of computation, through dedicated codes that, to different extents, have been identified, adapted and validated for their specific use applied to LFRs. In particular, all those codes whose results are used in filing the Safety Analysis Report (SAR) which substantiates the ALFRED licensing, will have to be qualified by CNCAN, which means that a validation dossier will have to be prepared by FALCON partners and provided to CNCAN for approval.

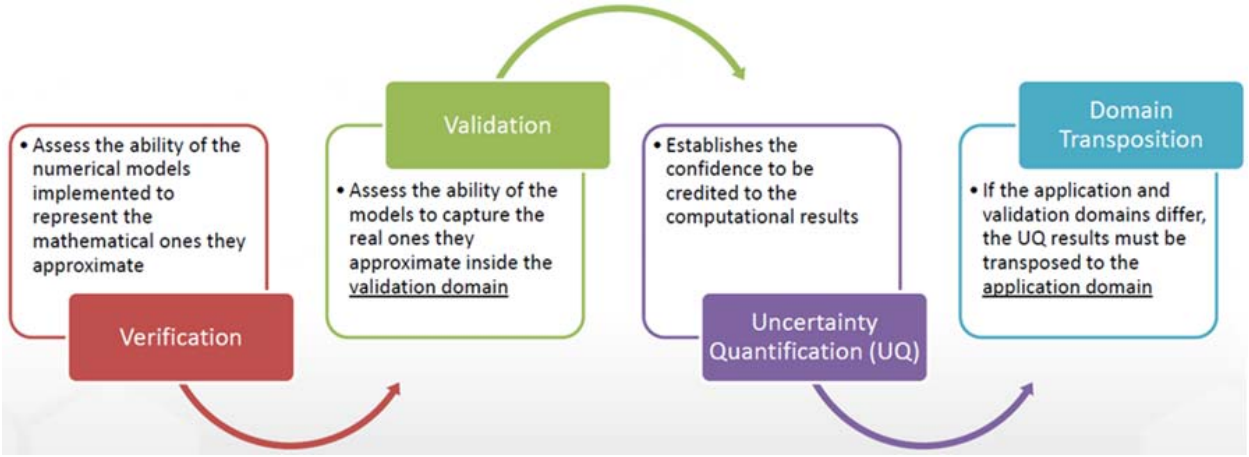


Fig. 2. Computer codes validation steps [4]

An investigation regarding the computer codes available that may be applicable to the LFR domain was performed. For each macro-system and specific scientific field applicable to LFRs, the available computer codes were analysed, discussing their maturity for use in the authorization application [4].

Preliminary studies for the characterization of the site

When applying for a license for the construction and operation of an innovative nuclear installation, the applicant must meet the regulatory requirements taking into account the novelty, complexity and the risks represented by the proposed activity.

Sustained efforts were made to characterize the reference site for ALFRED, Mioveni platform, from meteorological and demographic points of view. The meteorological characterization included data analysis on climate, temperature, precipitation regime and severe atmospheric phenomena, using two sets of data (one set of data communicated by the National Meteorological Administration, registered at the Pitesti meteorological station and a second set of data from the ICN weather tower) [5].

In parallel, having in mind the constructive and functional features of the ALFRED demonstrator, as well as the establishment of the RATEN ICN platform as a reference location, the necessary elements for planning and initiating a pre-operational radioactivity monitoring program of the environment were identified [5].

These were analysed differently in relation to the possible location of the demonstrator (considering the reference location and an alternative one), indicating the requirements for expanding the existing monitoring program (at the reference location), or for initiating instead a radioactivity monitoring program from the beginning (at the alternative site).

Monitoring the environment radioactivity serves in preparation of some components of the Preliminary Safety Report and Environmental Impact Report, essential elements for obtaining the construction and operation authorization.

Preliminary studies on the generated waste and the decommissioning process

According to the requirements of the European regulations in force, the ALFRED reactor project must take into consideration, from the design stage, both waste management process and decommissioning process.

The activities related to radioactive waste management were dedicated to identification of the types of radioactive waste generated both from the ALFRED demonstrator operation and decommissioning. At the same time, the critical requirements on the research activities useful to be carried out for development of methods and technologies necessary for the management of those radioactive wastes have been established [6]. The categories of radioactive waste generated from the operation of the ALFRED demonstrator, specifically for the category of low and medium active waste generated from current operating activities, as well as the radioactive waste generated from the reprocessing of spent nuclear fuel, were described.

Based on the radioactive waste management experience of RATEN ICN, the challenges were identified, and some requirements for development of methods and technologies necessary for characterization, treatment and conditioning, for final storage of radioactive waste generated from the ALFRED demonstrator operation and decommissioning were proposed [6].

A first version of the initial decommissioning plan for the ALFRED nuclear installation was elaborated [7]. This initial decommissioning plan will be completed with the data resulting from finalization of the design phase. The initial plan will be sent to CNCAN, along with the application for the construction authorization.

At least once every 5 years the initial decommissioning plan will be completed with new data and registered information in the integrated management system, being from that moment, ″The updated decommissioning plan of the ALFRED demonstrator″ [7].

Conclusions

ALFRED licensing process will be performed in 2 main stages:

- a pre-licensing phase, including the preparatory activities to facilitate the effective licensing phases;
- licensing phases for design validation, siting, construction, commissioning, and operation.

The preparatory efforts were focused on drawing the elements of the licensing framework.

PRO ALFRED project brought major contributions to the preparatory activities.

A preliminary assessment of the reactor project will give a better picture of the compliance with regulatory requirements and will identify the challenges to obtain the license, if any.

At the end of the pre-licensing phase, it is foreseen the issuance of a ″Letter of Comfort″ by the regulatory body. The statement will confirm that no major safety concerns are anticipated from the ALFRED conceptual design, and that nothing is foreseen to impair the following licensing phases, provided the safety demonstration program is successfully executed.

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