# Approach for ALFRED licensing in Romania

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**Abstract**

After official notification to the Romanian National Commission for Nuclear Activities Control, CNCAN, about the intention to build the Advanced Lead-cooled Fast Reactor European Demonstrator (ALFRED) at the Mioveni nuclear platform, the Fostering ALFRED Construction (FALCON) international consortium – leading the project – and CNCAN agreed to initiate a formal pre-licensing phase. This was jointly deemed opportune because of the innovative nature of the LFR technology, to prepare the subsequent licensing on sound and comprehensive bases. The idea of a formal pre-licensing was also inspired by international recommendations, which pointed out early dialogues with safety authorities as effective ways of smoothing the licensing of advanced reactors, by contributing to raising a mutual awareness of the implications introduced by novel technologies. Aiming at preparing an effective licensing framework for ALFRED, the pre-licensing phase foresees three main activities: i) to establish the normative framework, defining the actual licensing rules and metrics to use by assessing the applicability of the existing norms, guides, codes and standards, including international ones; ii) to preliminary validate the reactor design, by issuance of a “letter of comfort” by CNCAN which provides the designer with the confidence that no show-stopper is identified and that the envisaged safety approach fits with the regulator’s expectations; iii) to jointly agree on a “Safety Demonstration Programme” providing the experimental evidence required to justify the safety claims of the proposed design on those areas not covered by the established normative framework. These complementary building blocks will permit both FALCON and CNCAN to base the ALFRED licensing on a mutual understanding of the reference normative to engineer the design and build the demonstrator, and of the reference criteria to assess and prove the safety performance of the system. The paper details the ALFRED pre-licensing approach, also providing an overview of the achievements on each streamline.

## INTRODUCTION

Since the launch of the Generation IV International Forum (GIF) in 2001, the vision for revolutionary nuclear energy systems gained more and more international momentum. The number of projects targeting one of the six candidate technologies is steadily increasing, and involving more and more countries on the global scenes. In this context, Lead-cooled Fast Reactors (LFRs) are continuously attracting attention, stirring up growing interest on the perspectives for superior economic and safety performances while securing the highest sustainability standards of the closed fuel cycle. LFRs are however relatively new concepts: besides some past experience on submarine propulsion, which is classified because of the military application, the underlying technology requires a demonstration phase propaedeutic to the successive commercial deployment. Under this propelling need demonstration projects were initiated worldwide, the BREST-OD-300 being the most relevant of which, emerging as the first LFR – and Generation-IV system as well – that has achieved construction licensing by the Russian nuclear regulator Rostechnadzor[[1]](#footnote-2).

In the European context, the need for an LFR demonstrator originated in 2009, with the launch of the “LEADER” project [1] within the Euratom 7th Framework Programme. Among the objectives of the LEADER project, the most relevant was the development of the design of a European LFR technology demonstration reactor, which resulted in drawing the first configuration for the Advanced LFR European Demonstrator (ALFRED) [2]. At the conclusion of the LEADER project, the initiative to continue with the development of the design and technology of the demonstrator was taken by Ansaldo Nucleare, ENEA and RATEN ICN, who jointly decided to establish the Fostering ALFRED Construction (FALCON) international consortium in 2013. The three founding members were successively joined by a number of European organizations from industry, research and academia, all acknowledging the strategic value of the project and sharing the vision for a leading role of Europe in the nuclear energy technologies for the future.

After extensive efforts on research and development of the LFR technology, which allowed to substantiate the technical choices supporting the design of ALFRED, RATEN ICN – as representative organization in Romania, the candidate country for hosting the demonstrator – officially notified the national nuclear regulatory authority CNCAN (National Commission for Nuclear Activities Control) about the intention to build and operate the ALFRED LFR demonstrator at the Mioveni nuclear platform, thereby initiating regular interactions between FALCON and CNCAN.

## Early interactions

The joint leadership of the FALCON members introduces an element of novelty in the ALFRED project, in that information regarding elements related to licensing aspects, such as the design or supporting research, may come from any of the consortium members without distinction. The first consequence, object of the early interactions between FALCON and CNCAN, was the need to establish procedures for the formal communication of information. RATEN ICN, as national representative organization, was appointed the role of official point of contact on behalf of the whole FALCON consortium. The established procedures, flowing down to the other consortium members, required adaption of internal ones for compliance.

Even though, in a spirit of full collaboration and synergy, the three founding members are significantly involved in all the activities encompassed in the ALFRED project, leading roles are assigned to them on the most relevant areas. The appointment of leadership reflects the related competences and background, and the scope of the activities performed in each area: Ansaldo Nucleare, ENEA and RATEN ICN are thus the leading organizations to what concerns reactor design, R&D and licensing/siting aspects, respectively.

Related to the scope of activities performed by each FALCON member, due certification of the respective quality management systems was requested by CNCAN. The norms enforced by CNCAN foresee different specific requirements for all kind of activities, and notably for design [3], for R&D [4] and for software development and use [5], all building differentially on general norms for the authorization of quality management systems related to activities in the nuclear domain [6].

Another main element of initial discussion was related to the degree of novelty of the LFR technology. CNCAN has a sizeable experience in licensing CANDU reactors, specifically, Units 1 and 2 of the Cernavoda nuclear power plant, but no experience in licensing an un-certified design, as it is the case of advanced reactors. Because of the differences inherent to the proposed technology and associated with the ALFRED design, it was agreed the delivery of thematic lectures by the founding members of FALCON, for CNCAN experts to familiarize with the relevant aspects that will form the technical bulk of the licensing application. This transfer of information was performed initially under an extensive seminar umbrella, covering technology aspects in general, specific issues with a direct impact on design choices, and an overview of the ALFRED reactor design. Besides the explicit relevance of the seminar per se, it was the first chance for young professionals enrolled by CNCAN specifically to work on the specifics of the ALFRED project. Following the initial seminar, a plan for regular exchanges was agreed, in the form of topical discussions anticipated by the transmission of technical documentation on the selected topics. The focus of each exchange is chosen on the basis of the outcomes of the previous exchanges, of the resulting discussions, and of the topics that enter the internal review by CNCAN.

The last key point discussed during the early interaction stages, was related to the establishment of an *ad hoc* approach for the licensing of the demonstrator. Coherently with the innovative nature of the technology, and with the recognized gaps in the normative framework in support of licensing, a formal *pre-licensing* stage was agreed between CNCAN and FALCON, in anticipation to the formal application for the issuance of construction permit. This approach was acknowledged as beneficial by both parties, to consolidate a reciprocal understanding of the needs and specificities related to licensing a reactor based on an innovative technology while building consensus on the normative framework to fill the abovementioned gaps.

## Current status: Pre-Licensing

The ALFRED project is currently in its pre-licensing stage, established with the purpose of facilitating the formal licensing application stage that will follow. Considering the needs for the subsequent licensing to execute, three main activities were initiated, and are currently ongoing.

### Establishment of the reference normative framework

As acknowledged in more and more contexts, the current normative frameworks established in all countries operating a nuclear power programme, are basically focused on water-cooled reactor technologies, reflecting the actual need of licensing such systems for their exploitation. This is also the case of Romania, where a complete normative framework is in place, that copes with the existing national power programme, standing on the use of CANDU reactors.

Sparse exceptions however exist, which were developed in the past to cope with the needs associated to the research programmes on non-water reactor technologies (e.g., sodium-cooled fast reactors or high-temperature gas-cooled reactors). Most of these specific regulations are not in force anymore, due on one hand to the research programmes that were discontinued, and on the other to the continuous advancement of the base regulations for water-cooled reactors, that was enlarging the gap between the two parts. Indeed, even if targeting different technologies and designs, all the different norms and requirements developed within the same normative framework shared the same inspiring principles and protection objectives, which in facts remains the main value of those past exercises.

Considering the typical hierarchical structure of the elements defining a normative framework, sketched in general terms in Fig. 1, also reflecting the structure of the IAEA’s Safety Standards, inspiring principles (reflected in the law) are established along with binding targets to shape the overall normative context; these are then implemented in the form of mandatory requirements, usually accompanied by guidelines which clarify their relationship with the principles and the underlying rationales to strengthen their application; finally, codes and standards are endorsed to provide all elements for the practical application to the specific design. The principles are of so high-level to be generally technology neutral. While the rationales behind the requirements are derived from the principles, these are generally technology neutral as well, even though the requirements are generally formulated in a specific form for the target technology.



Fig. 1. Typical hierarchical structure of the elements defining a normative framework.

Due to the innovative nature of the LFR technology, and looking to the Romanian case, a gap is identified, concerning the extension of the existing normative framework to address the specific needs associated with the deployment of LFR systems. To this regard, however, a degree of flexibility exists: since the technologies implemented in Romania are not indigenous, the normative framework is mostly focused on the elements of highest level, such as norms, requirements and guidelines. The other, lower-level elements meant for specific aspects of the design of a nuclear system, i.e., the nuclear design codes and standards, are integrated through the endorsement of those established in the international landscape, and with no prejudice among the several available. Since the most of the distinguishing technological elements appear at such lower levels, seen the other way around this means that most of the current normative framework can be applied to the ALFRED case.

The actual gap, in Romania, is therefore not dissimilar from the one that could be identified in other countries where the realization of systems based on an innovative reactor technology is considered. To this regard, synergies can be sought with the initiatives that are being performed internationally: among these, are here worth mentioning the efforts done within the Generation-IV International Forum (GIF), for the translation of the IAEA’s Safety Standards to the LFR case, starting with the safety requirements for the design of an NPP, the SSR-s/1 [7] to proceed then to the descending guidelines, or the initiative, recently launched by the IAEA for the development of a technology neutral framework, where again the IAEA’s Safety Standards represent the reference starting point.

Also descending from the founding basis of the Romanian framework, it is already a praxis for the licensing applicants to issue, at first, a so called “Licensing Basis Document” (LBD) where all the references that establish the specific framework for the subsequent licensing process are identified, notably including the list of codes and standards that are proposed to apply for the evaluation of the proposed design. More specifically, the LBD is organized in sections covering:

* regulatory documents (e.g., CNCAN norms, WENRA regulatory policy statements, etc.) that form the normative reference for the licensing;
* codes and standards, that provide references for practical use in the design, manufacturing, etc.;
* safety design requirements (as reported in any of the above documents), that fix the specific requirements established for ALFRED along with the guidance on implementing them;
* safety analysis requirements, which particularly establish the events that, according to a systematic review of the design, must be taken into account under the two main categories of Design Basis Conditions (DBC) and Design Extension Conditions (DEC).

The need for reviewing the existing reference framework is also in line with the general practice, for which all elements descending from the top-level principles can be modified, if the rationales and proposals are exhaustively justified. Being a living document, the LBD represents an integral part of the licensing application and evaluation, subject to multiple iterations for integration or modification of the list upon request.

All the current activities dealing with the need for establishing a reference, complete normative framework to be used in the ALFRED licensing process, are indeed focused on the preparation of the LBD.

The first elements being discussed for inclusion in the ALFRED LBD deal with complementing the Romanian requirements and associated guidelines with additional references, adding elements possibly more specifically oriented to the specificities of the LFR technology (such as the LFR Safety Design Criteria, developed by the GIF as technology-specific translation of the IAEA’s SSR-2/1). In parallel with this discussion, an investigation is being performed on all codes and standards available in the international context, so as to select a list – the most exhaustive as possible – to be proposed and discussed with CNCAN as starting point.

In all this process, a preliminary evaluation is being performed to assess the applicability of all the identified references to the ALFRED case, taking into account the technology and design spaces in which the provisions sought for ALFRED have been developed and selected. While some items are found to be applicable or not applicable, with no intermediate shade, for many others the driving principles and specific formulations are such, that interpretation, or justified modifications, could be sufficient to turn such items cross-technology applicable. At the same time, another important selection criterion is based on the overall coherency of the so forming framework: since the evaluated elements come from different sources, it must be ensured that those selected do not create improper mixtures, thereby avoiding inconsistencies in the resulting framework.

### Preliminary validation of the reactor design

In parallel with the assessment of the reference normative framework, a preliminary evaluation of the ALFRED design is being pursued, as part of the pre-licensing activities agreed between FALCON and CNCAN. This preliminary evaluation has a twofold purpose.

First of all, it targets informing CNCAN about all the provisions that are included in the proposed design baseline, which are presented associating each to the driving rationales for the choice of the reference option and for the specific design implemented. Through this, CNCAN will familiarize with aspects related to the practical implementation of the underlying technology, complementing the general information that is being delivered by FALCON through the series of thematic seminars. CNCAN will thus evaluate the proposed solutions, for their coherence and appropriateness with the technology-specific aspects, in terms of addressing the challenges and exploiting the advantages introduced by the use of Lead as coolant.

The second main purpose of the evaluation is the familiarization, by CNCAN, with the specific provisions that will form the lines of protection and defence of the design that is being considered. CNCAN will therefore evaluate the compliance of the proposed solutions with the general principles underpinning safety (e.g., multiple barriers, diversity and redundancy, etc.) and security, notably from the perspective of a subsequent licensing in Romania, as well as their adequateness in terms of anticipated performances. During the evaluation, besides any request for additional information, comments or recommendations could be issued by CNCAN, that might eventually lead to a revision of the proposed configuration and, eventually, to a new design baseline.

At the conclusion of the evaluation process, a “letter of comfort” will be issued by CNCAN relative to the finally agreed design, which will provide both the designer and the regulator with the confidence that no show-stopper is identified, and that the envisaged safety and security approaches and their actual implementation fit with the expectations of the regulator, so to ease the subsequent actual licensing process.

### Joint agreement on a specific “Safety Demonstration Programme”

The conclusions of both the establishment of the reference normative framework and of the preliminary evaluation of the design will provide complementary information for an essential piece of the subsequent licensing. The evaluation of the design will highlight all those solutions that have a central role in the proposed safety approach, and which therefore will be classified of higher importance to the implementation of safety. For those solutions, therefore, reliance on established codes and standards will be central to licensing. At the same time, the technical and technological review associated with design evaluation will bring to light the shortcomings of the international codes and standards that are identified in the establishment of the normative framework.

The gaps emerging from these comparative analyses will be collected and discussed to point out the missing elements that, complementing or substituting the existing codes and standards, would form a complete reference to design ALFRED, and even more to justify its design in front of CNCAN for its licensing approval. For all those missing elements, a set of experimental evidences will be compiled, by providing which the emerged gaps could be closed. All these new, specific experimental needs will be used to draft a specific “Safety Demonstration Programme” (SDP), agreed between FALCON and CNCAN, that will pair with the already existing research, development and qualification programme developed by FALCON. All the results deriving from the SDP will finally be added to the licensing application, so that the safety assessment report, with the results of the SDP in appendix, will form a complete dossier which provides an exhaustive justification of the safety case for ALFRED.

## Conclusions

The continuous advancement in the design of advanced reactors has raised the need for an upgrade of regulatory frameworks so to align to the specificities of the involved technologies. Since the complete development of a new, consistent framework tailored to a specific technology may take long to set, a practice becoming more and more common is to anticipate the formal licensing process with a pre-licensing phase from which both the regulator and the applicant can take profits through a mutual understanding of how to translate specific safety and regulatory needs – that are not new – to a novel context. This is also the case for the ALFRED project and the reference regulations in Romania.

A series of preliminary actions has been started by FALCON, as promoter and developer of the ALFRED project, and CNCAN, the nuclear regulatory authority in Romania, progressively addressing the identified gaps and drafting the plan to overcome them.

Propaedeutic to any subsequent step, the novelty introduced by the multi-organizational involvement in FALCON was addressed, to establish formal reference roles among the members in front of CNCAN, the communication protocol among all organizations and the needs for certification of the quality management systems that reflect the different scope of activities performed by each. In parallel, a knowledge transfer was initiated to the benefit of CNCAN, so that any discussion might stand on common bases of understanding.

Upon these bases, the pre-licensing process was then started, dealing with practical elements required to prepare the formal licensing application. Within the pre-licensing phase, three actions are addressing the main gaps so to come to an agreed procedure: i) the definition of a normative framework through the compilation of a “Licensing Basis Document”, where elements collected and judged appropriate from the international context are included to complement the existing norms (mostly based on the experience gathered on the water-cooled reactor technology); ii) the evaluation of the proposed reactor design, particularly to assess its compliance and that of the underlying safety approach with regulator’s expectation, so to arrive to issuance of a “letter of comfort” representing the absence of show-stoppers for ALFRED licensing; and iii) the compilation of a “Safety Demonstration Programme”, stating the experimental evidences that are requested to complement the residual gaps in the existing normative references selected in the Licensing Basis Document so that all specific elements of the ALFRED design can find due justification for supporting the licensing application.

The current plans for addressing all actions propaedeutic to the licensing of ALFRED foresee the finalization of the Licensing Basis Document in time for the preliminary validation of the ALFRED design to move to a formal level during year 2023. The conclusion of this preliminary design validation will be accompanied by the elaboration of the Safety Demonstration Programme, whose availability by 2025 would be in line with the overall project schedule.

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References

1. DE BRUYN, D. et al., “Main achievements of the FP7-LEADER collaborative project of the European Commission regarding the design of a Lead-cooled Fast Reactor”, International Congress on Advances in Nuclear Power Plants ICAPP 2013 (Proc. Int. Conf., Jeju Island, 2013).
2. FROGHERI, M. et al., “The Lead Fast Reactor: demonstrator (ALFRED) and ELFR design”, Fast Reactors and Related Fuel Cycles: Safe Technologies and Sustainable Scenarios FR13 (Proc. Int. Conf., Paris, 2013), IAEA, Vienna (2015), Paper CN199-024.
3. COMISIA NAŢIONALĂ PENTRU CONTROLUL ACTIVITĂŢILOR NUCLEARE, Norme privind cerinţele specifice pentru sistemele de management al calităţii aplicate la proiectarea instalaţiilor nucleare (NMC-05), Order of CNCAN President no. 69/30.05.2003, CNCAN, Bucharest (2003).
4. COMISIA NAŢIONALĂ PENTRU CONTROLUL ACTIVITĂŢILOR NUCLEARE, Norme privind cerinţele specifice pentru sistemele de management al calităţii aplicate activităţilor de cercetare – dezvoltare în domeniul nuclear (NMC-04), Order of CNCAN President no. 68/30.05.2003, CNCAN, Bucharest (2003).
5. COMISIA NAŢIONALĂ PENTRU CONTROLUL ACTIVITĂŢILOR NUCLEARE, Norme privind cerinţele specifice pentru sistemele de management al calităţii aplicate la producerea şi utilizarea softurilor pentru cercetare, proiectare, analize şi calcule destinate instalaţiilor nucleare (NMC-12), Order of CNCAN President no. 76/30.05.2003, CNCAN, Bucharest (2003).
6. COMISIA NAŢIONALĂ PENTRU CONTROLUL ACTIVITĂŢILOR NUCLEARE, Norme privind autorizarea sistemelor de management al calităţii aplicate la realizarea, funcţionarea şi dezafectarea instalaţiilor nucleare (NMC-01), Order of CNCAN President no. 65/30.05.2003, CNCAN, Bucharest (2003).
7. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, Safety Standards Series, Specific Safety Requirements No. SSR-2/1 (Rev. 1), IAEA, Vienna (2016).
1. http://www.gosnadzor.ru/news/64/3502/ [↑](#footnote-ref-2)