CITON'S PARTICIPATION IN THE DEVELOPMENT AND IMPLEMENTATION OF SMR IN ROMANIA - A VERSATILE SOLUTION FOR CLEAN ENERGY PRODUCTION

PARTICIPAREA CITON LA DEZVOLTAREA ȘI IMPLEMENTAREA REACTARELOR SMR ÎN ROMANIA - O SOLUȚIE VERSATILĂ PENTRU O PRODUCERE CURATĂ DE ENERGIE ELECTRICĂ

Gabriela FLORESCU[1], Rodica NICOLAE[2], Andreea IVAN[3], Iulian Pavel NIȚĂ[4]

Abstract: *The paper reflects some key aspects related to CITON activities and contribution to building the understanding of a new technology like innovative SMRs and LFR type reactors with SMR attributes which is very important to produce the real communication between designers and authorities and decision makers in Romania. Alongside other organizations and companies within the Romanian nuclear energy sector, CITON has the mission of meeting the necessary requirements in the context of deployment of safe, secure, clean and cost-effective new build like SMR by reinvigorating the existing capacity and support the development of a strong long-term national nuclear support infrastructure sustainable and in line with national and international R&D initiatives.*

Keywords: SMR, clean energy, gen IV reactors, ALFRED, LFR

Rezumat: *Lucrarea reflectă câteva aspecte cheie legate de activitățile CITON și contribuția la construirea înțelegerii unei noi tehnologii, cum ar fi reactoarele inovatoare de tip SMR și LFR cu caracteristici SMR, ceea ce este foarte important pentru a produce o comunicare reală între proiectanți și*

[1] Eng., CITON head of safety and environmental department, Romania, e-mail: florescug@router.citon.ro,
[2] Eng., CITON head of civil engineering department, e-mail: bigum@router.citon.ro
[3] Eng., CITON nuclear engineer at system and process department, Romania, e-mail: ivana@router.citon.ro
[4] PhD eng., CITON system analyst at system and process department, Romania, e-mail: nitai@router.citon.ro

autorități și factorii de decizie din România. Alături de alte organizații și companii din sectorul energetic nuclear românesc, CITON are misiunea de a îndeplini cerințele necesare în contextul implementării unei noi construcții sigure, sigure, curate și economice, precum SMR, prin revigorarea capacității existente și sprijinirea dezvoltării unei o infrastructură națională de sprijin nuclear pe termen lung, durabilă și în conformitate cu inițiativele naționale și internaționale de cercetare și dezvoltare.

Cuvinte cheie: SMR, energie curată, reactoare de gen IV, ALFRED, LFR

1. Introduction

CITON (Centre of Technology and Engineering for Nuclear Projects) is part of the State-Owned Company Technologies for Nuclear Energy (RATEN) which is a strategic legal entity in Romania coordinating research and development (R&D) activities in the nuclear energy field. RATEN maintains and develops the scientific and technologic support for the national nuclear energy program [1]. CITON's main activity is dedicated to Design and Engineering services for Nuclear Projects and to R&D studies associated with the implementation of the National Nuclear Program [2]. CITON as a full-service engineering company can assist the customers within all phases of projects implementation including EPC (Engineering, Procurement, and Construction development support) interconnection. The institute's personnel (engineers (nuclear, mechanical, electrical, chemical, civil, etc.), chemists, physicists) has a broad experience and expertise in the field of the design and engineering for NPPs' and other nuclear/radiologic facilities.

RATEN CITON performs R&D studies and technical analyses to promote and implement new and innovative concepts of advanced reactors in Romania. Together with ICN (Institute for Nuclear Research) [3], the other subsidiary of RATEN, CITON is running the national nuclear R&D program to preserve and develop the competencies required for the entire nuclear fuel cycle. Both organizations provide support and guidance for governmental agencies and decisions makers. Complex projects (new built) Generation IV technologies, SMR etc. are included.

2. CITON main activities in the field

R&D studies for the development and implementation of SMR NPP and ALFRED reactor in Romania

Taking into account the energy priorities at national and European level, the international agreements, conventions and treaties to which Romania is part, for peaceful use of nuclear energy, RATEN CITON mission aims to consolidate and develop scientific and technological support for the National Nuclear Energy Program. Among them we mention: scientific and technological support for the construction of new nuclear power plants and addressing the topic of innovative Small Modular Reactors (SMR) for different types of technologies (SMR-LFR, water cooled SMRs, etc.).

One of the strategic objectives mentioned in the RATEN R&D Strategy 2015-2025, rev.1 [4], is the development of research activities for Generation IV reactors, with a focus on SMRs and Lead-cooled Fast Reactors (LFR).

CITON specific activities for R&D studies in regards to the development and implementation of modular reactors (SMR) address the following:

- Assimilation of methodologies specific to innovative SMR technologies developed worldwide;
- Support design studies, technological engineering and siting of SMR type reactors;
- Analysis of technological systems, equipment, electrical systems and automation;
- Summary analysis of the worldwide evolution of advanced nuclear reactors.

Some of the first R&D studies performed by CITON related to Small Modular Reactors were elaborated with the aim to evaluate the present international status of SMRs context and the identification of sustainable solutions for Romania in the field of nuclear safety and security.

Concerning the water cooled SMRs, a special interest was manifested through these R&D studies, for the integral pressurized water reactors (iPWRs) technology with all primary components located inside the reactor vessel because of their unique inherent safety features, lower initial capital investment, and siting flexibility for locations unable to accommodate more traditional larger NPPs. Because of their ability to

replace or repower aging fossil fuel plants, or to provide an option for complementing existing industrial processes or power plants with an energy source that does not emit greenhouse gases, studies were performed on siting of a SMR NPP on an already existing old coal-fired plant site which provided electricity in the national grid, district heating and also process steam for an industrial facility.

Keeping in mind our national strategy, via these R&D studies, CITON is proposing to replace the demonstrated power need at existing grid locations (which are using older small coal-fired plants) with cleaner electrical power from SMRs while fully using the rest of the installed infrastructure of cooling water, transmission lines, and trained operators/maintenance staffs. Certain SMR projects were selected due to their match to the existing site particularities, the steps on site preparation activities were analyzed, and also all the criteria for selection and assessment of the proposed NPP site were addressed in these studies. The coal-fired plant site chosen for replacement had different facilities and services already available at the site, thus facilitating a much simpler implementation process for the new SMR, like connections to the national electricity grid and district heating system, site access by road and railways, availability of the cooling water, telecommunications facilities and also access to public services, such as a fire brigade, medical care, and others like potable water, housing for construction workers, services reliability (power, gas, equipment and materials, etc.).

The advantages conferred by the selection of SMR technologies to replace the existing coal-fired power plant are given by: reduced capital requirements per reactor unit for simpler financing strategies, shorter construction program and simpler project management, suitable for district heating and, easier siting and matching with the requirements of the electrical grid and the output of the system for process heat. In addition, we will obtain a friendly environmental area by removing the highly polluting factors and also the energy system in the area will be upgraded. This solution of replacing retiring power plants while providing affordable, emission-free, and carbon-free energy by implementing SMRs was found very attractive.

To provide further support, guidance and capacity building on the future implementation of SMR nuclear power plant in Romania, is under development a study regarding the applicable standards and regulations for

the nuclear safety of these types of technologies. The purpose of this study is to identify the standards, regulations and methodologies from the national legislation and international regulatory framework, applicable to the development of a set of procedures and/or instructions specific to the safety analysis and supporting documentation for the demonstration of the nuclear safety of SMR type installations. At the same time, the selection criteria regarding these types of technologies will be presented.

After ALFRED reactor (Advanced Lead Fast Reactor European Demonstrator) will have gained enough operational experience it will be considered a prototype for competitive SMRs based on LFR technology. In order to become a commercially viable product for SMRs like applications, the demonstrator will first serve as an intermediate step to address licensing challenges and absence of nuclear operational experience. The project will implement a staged approach to qualify the technical options for safe and competitive operation of a commercial fleet of SMR NPPs with LFR technology.

Specific activities for the implementation of ALFRED demonstrator in Romania are studies conducted with the purpose of capacity development for the provision of permanent on-site technical consultancy/assistance for engineering works and quality assurance for the future implementation of ALFRED project in Romania. Also are carried out studies on the anticipated evolution in long-term operation of LFR structure materials and for the development of an in-situ monitoring methodology. Another subject addressed in R&D studies is the roadmap for ALFRED licensing process in Romania thus providing support through site characterization and compliance with the requirements established by the regulatory body in Romania. National, European and international licensing frameworks are analyzed in these studies in order to identify the procedural steps, the needed documents, the expected level of details, and also the competences to be involved in this project. A special attention is paid on the Romanian national context related to ALFRED licensing so that all the steps for ALFRED licensing process will be identified and discussed, on the basis of the requirements of the regulatory body in Romania.

Engineers in CITON are also conducting studies related to the control room architecture, electrical and C&I systems of ALFRED reactor for the assimilation of new concepts regarding design and operation requirements for these systems. They are also studying the possibilities of

locating the main constructions and structures related to the ALFRED reactor as well as their water supply and provide technical solutions for the NPP siting. Other systems related to ALFRED reactor addressed in different R&D studies developed by CITON are sizing and location of the main equipment and components of the condenser cooling system, regenerative circuit and feedwater system in the secondary system.

Design and engineering contracts for the development and implementation of SMR NPP and ALFRED reactor in Romania

Feasibility studies for the construction of experimental facilities supporting LFR technology in Romania

In the nuclear energy sector, current Romanian energy strategy [5] (project under public consultation) favours the construction of Cernavoda U3-4 and also water-cooled SMRs and ALFRED demonstrator (SMR design) are being considered for the building of new nuclear capacities in the future. In this regards, one of the main funded projects by the Ministry of Research and Innovation in Romania, is the implementation of ALFRED reactor - a LFR technology demonstrator. Because this reactor has SMR oriented features being the prototype of a lead cooled SMR, this section of the paper presents CITON activities in regards to the steps taken for the ALFRED implementation in Romania.

For the LFR technology development, the demonstration stage envisages the implementation of ALFRED reactor in order to demonstrate the technical and economic viability of the LFR concept. In a previous stage of ALFRED execution is necessary the realization of a research infrastructure for testing, verifying, validation and demonstration of the knowledge of the associate phenomena and also for the qualification of the materials, components and equipment to support the final design and licensing of the ALFRED reactor.

The preparation of feasibility studies for the experimental facilities of this research infrastructure was contracted. The technical and economic documentation included written and drawn parts and it was prepared in accordance with the Romanian legislation. The feasibility studies were elaborated based on the concept systems developed by ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development in Italy), which together with Ansaldo Nucleare and RATEN ICN are the main coordinators of FALCON (Fostering ALFRED

Construction) international consortium [6]. The organization prepared two feasibility studies: the first one for ATHENA - the largest pool facility in the world, for large-scale components testing in representative conditions for LFR technology and ChemLab, a broad-scope laboratory on the chemistry of HLMs and materials science, and the second one for ELF – a pool facility for long-term experiments, to characterize the components and systems in LFR installations and HELENA-2, a loop facility for full-scale testing and complete thermal hydraulic characterization of fuel and absorber assemblies.

The contract for the implementation of the first project, ATHENA facility and ChemLab (funded under the Competitiveness Operational Program, in the Major Research Infrastructures field, Call 488/1/1) was signed in July 2020 with project finalization in December 2023, and at the moment is ongoing separated public bids for buildings and facilities.

For the elaboration of the feasibility studies for these experimental facilities, the following activities were engaged:

- Conceptual design for buildings and structures serving the facilities and laboratories;
- Conceptual design for HVAC system, compressed air system, technical gases system, demineralized water supply system, water supply and fire protection system and lifting and handling equipment;
- Conceptual design for C&I components, electrical power systems and low current installations;
- Premises related to the environmental impact assessment;
- Project implementation schedule;
- Cost benefits analysis and evaluation of the main technical and economic indicators of the investment.

Recently, CITON was contracted by Sargent&Lundy to develop a Site Selection Study for Societatea Nationala Nuclearelectrica (SNN) who was awarded a non-refundable grant of USD 1.28 million by the US Trade and Development Agency (USTDA) for use in the identification of potential sites in Romania to host Small Modular Reactors [7]. The USTDA is an independent federal government agency focused on connecting US companies with export opportunities in emerging markets. A draft intergovernmental agreement was signed in October 2020 between the USA and Romania on cooperation to expand and modernize Romania's nuclear power program [8]. In addition to the construction and refurbishment

projects at Cernavoda, the agreement calls for cooperation in areas such as regulation, exchanges between research laboratories and universities, staff training, as well as research and development. It also provides for cooperation in the development of SMR in Romania.

There will be services provided which are required in connection with the delivery of technical assistance for a preliminary assessment of new potential SMR-compatible nuclear sites in Romania. The purpose of the overall project is to identify a short list of possible sites in Romania that could accommodate a SMR NPP and to assess the suitability of selected SMR technologies. Specialists involved in the development of the Site Selection Study for SNN, have large experience in siting of nuclear facilities, such as nuclear power plants and radioactive waste repositories.

The study will be based exclusively on publicly available information and specialized literature. Data collection, their analysis and interpretation, as well as establishing general / specific site selection criteria, represent the most consistent part of the scope of work. For this task the guidance of "IAEA Safety Standard SSG-35 - Site Survey and Site Selection for Nuclear lnstallations" July 2015 [9], will be applied. The technical documentation for siting must clarify the impact on the environment and other human activities in the area for both normal operation and potential exposures. The process of site selection and assessment is a lengthy and extensive activity requiring the engagement of a number of disciplines. The major areas considered in the selection and assessment process are: health, safety and security, environmental, engineering and cost and socio-economic. Also, for this project, it will be developed a roadmap for the licensing process of the selected sites for SMR construction. The roadmap shall account for the particularities of the potential sites.

3. Concluding remarks

CITON is actively engaged in supporting technological upgrading and advances in the nuclear power technology through the preparation of R&D studies associated with the implementation of National Nuclear Program. In regards to the world’s increasing high interest in the development of Small Modular Reactors, some studies were prepared regarding the concept and design of advanced Nuclear Power Plants with Small Modular Reactors to gain experience related to the benefits offered by

these types of NPPs with a capacity of less than 300 MWe over the conventional bigger nuclear sites. These studies took into consideration all type of SMRs, water cooled reactors, high temperature gas cooled reactors (HTGR), and also fast nuclear reactors especially lead cooled fast reactors (LFRs) because of the future implementation of ALFRED demonstration lead-cooled reactor in Romania.

The paper reflects some key aspects related to CITON activities and contribution to building the understanding of a new technology like innovative SMRs and LFR type reactors with SMR attributes which is very important to produce the real communication between designers and authorities and decision makers in Romania. Alongside other organizations and companies within the Romanian nuclear energy sector, CITON has the mission of meeting the necessary requirements in the context of deployment of safe, secure, clean and cost effective new build like SMR by reinvigorating the existing capacity and support the development of a strong long-term national nuclear support infrastructure sustainable and in line with national and international R&D initiatives.

4. Conclusions

According to the 2020 Romanian Energy Strategy Project, the employment of Small Modular Reactors might be beneficial to increase energy capacities without CO_2 emissions and sources of hydrogen production, after 2035. Romania is suitable for the implementation of a SMR in the near future due to the availability of a support infrastructure necessary for the assurance of national participation in the project deployment (e.g. technical and scientifical support organizations, regulatory authority and various companies in the local industry capable of project management, constructing, operating, maintaining and regulating the different project activities) developed during the last five decades of ongoing national nuclear energy program.

R E F E R E N C E S

[1] *https://www.raten.ro/*
[2] *http://www.citon.ro/*
[3] *https://www.nuclear.ro/*

[4] *RATEN – Regia Autonomă Tehnologii Pentru Energia Nucleară*, Strategia de dezvoltare RATEN pentru perioada 2015-2025, Revizie 1, (2021). *https://www.raten.ro/documente/Strategia_RATEN_2015-2025_Rev1.pdf.*
[5] *Ministerul Economiei, Energiei i Mediului de Afaceri,* Strategia energetică a României 2020-2030, cu perspectiva anului 2050, Proiect (2020).
[6] *http://www.alfred-reactor.eu/index.php/falcon-2/*
[7] *https://world-nuclear-news.org/Articles/US-grant-for-Romanian-SMR-siting-assessment*
[8] *https://world-nuclear-news.org*/Articles/Romania-and-USA-agree-to-cooperate-in-nuclear-proj
[9] *International Atomic Energy Agency*, Site Survey and Site Selection for Nuclear Installations, IAEA Safety Standards Series No. SSG-35, IAEA, Vienna (2015)