COMPETENCE BUILDING ACTIONS FOR ALFRED INFRASTRUCTURE

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Abstract

The ALFRED infrastructure consisting in the Lead Fast Reactor (LFR) technology demonstrator (ALFRED), six experimental facilities and a coordination hub is envisaged to be constructed in Romania, on Mioveni nuclear platform. The implementation of ALFRED demonstrator in Romania introduces a set of responsibilities both in terms of adequate preparatory activities and in ensuring the full range of competencies associated with LFR technology. In the PRO ALFRED project, coordinated by RATEN ICN in the frame of the national RDI Programme, important steps were performed to develop methods for competences building aiming to respond to the ALFRED infrastructure requirements, as well as to implement specific training actions. A dedicated work package addressed various actions divided in two implementation stages. The paper presents the main activities targeting the achieving of WP's objective, together with the most important outcomes.

Keywords: *ALFRED infrastructure, educational program, competences, training, human resources*

Introduction

A world-class research infrastructure is planned to be built in Romania, on the Mioveni nuclear platform, in the frame of the Advanced Lead Fast Reactor European Demonstrator (ALFRED) implementation. ALFRED infrastructure consists in ALFRED demonstrator itself, six experimental facilities (ATHENA, HELENA2, ELF, ChemLab, HandsOn, Meltin'Pot), and the coordination hub.

ALFRED, a 125 MW(e) pool type reactor, aims to develop the demonstrator of Lead Fast Reactor (LFR) Generation IV (Gen IV) technology. The project is coordinated by the Fostering ALFRED Construction (FALCON) consortium, created in December 2013 for ALFRED implementation in Romania. ANSALDO Nucleare, ENEA and RATEN ICN carry out relevant activities in nuclear fields and represent the founding members of the consortium.

The experimental facilities are dedicated to support activities for testing and qualifying materials & components, for validation and verification of numerical tools and methodologies, to address ALFRED demonstrator safety and licensing key aspects, and also to identify valuable solutions for the LFR technology open issues.

ATHENA is designed for testing at large scale the main components and systems of the demonstrator and to qualify them in representative conditions.

ChemLab is focused on the heavy liquid metals chemistry and materials science, supporting the design and qualification of the coolant chemistry and control system.

ELF is a pool facility designed for endurance experiments, to characterize the components and systems in the real conditions of the reactors and to assess the operational performances [1].

HELENA2 is a loop facility, able to operate both in natural and forced conditions, for testing at large to full scale the core elements and their characterization from the thermal-hydraulic point of view.

Meltin'Pot is a devoted severe accidents investigation facility (fuel-cladding-coolant interaction, transport of radionuclides, deposition), for supporting the design of accident management provisions, and for validation of the related software tools.

HandsON is designed for testing and qualifications of systems and procedures for the core elements handling from the reactor to the containment and vice versa [1].

The Hub is planned to support the scientific management, to integrate the cooperation for a better use of the experimental infrastructure, and also to manage the open access option. A Lead School will be hosted in Hub for young researchers, technicians and students training and also for dissemination purposes.

The implementation of ALFRED demonstrator in Romania introduces a set of responsibilities both in terms of adequate preparatory activities (such as the development of experimental basis, the development and validation of computational tools), and also in ensuring the full range of competencies associated with the LFR technology.

Important steps were conducted in the PRO ALFRED project (September 2019 - November 2020), coordinated by RATEN ICN in the frame of the national RDI Programme. One of its specific objectives was to develop methods for building the needed competences related to the ALFRED infrastructure requirements as well as to implement specific training actions.

PRO ALFRED Project, an important step towards an increased Romanian participation in the ALFRED infrastructure implementation

PRO ALFRED project - Activities for the Preparation of the ALFRED Research Infrastructure Development in Romania, was devoted to strengthen the Romanian RDI capability in the nuclear field, with focus on Gen IV systems development, and on the LFR technology in particular. The cooperation at the national level between research, education, industry and business environment was also envisaged [2].

Financed through the National RDI programme (PNCDI III) by the Romanian Ministry of Education and Research, the project was launched in September 2019 and was coordinated by *State Owned Company Technology for Nuclear Energy* (RATEN) over 15 months.

The partnership established to achieve the project objectives, brought together nuclear research, power economics research and two universities (the main suppliers of technical personnel for the nuclear field in Romania): RATEN ICN Pitesti and Center of Technology and Engineering for Nuclear Projects - RATEN CITON, Bucharest (both RATEN's branches), University of Pitesti (UPIT), University *Politechnica* from Bucharest (UPB), National Institute for Nuclear Physics and Engineering - Horia Hulubei, Bucharest (IFIN HH) and Institute for Economic Prognosis, Bucharest (IPE).

PRO ALFRED project was structured in 7 work packages (WPs) which addressed the priority aspects of the project's action plan [2], namely:

- Preparing technical documentation for research, development, testing, demonstration supporting infrastructure: HELENA2, ELF, Meltin'Pot, HandsON, hub (WP1);
- Preliminary elements and studies for the ALFRED demonstrator licensing (WP2);
- Developing the national research capacity for the ALFRED infrastructure implementation (WP3);
- Planning the ALFRED infrastructure scientific management (WP4);
- Developing competence building strategy for ALFRED infrastructure implementation and operation (WP5);
- Technical-economic evaluations of the LFR technology from the future national energy market perspective (WP 6);
- Promoting ALFRED infrastructure for a sound national and international support (WP7).

The PRO ALFRED project structure is presented in Fig.1.

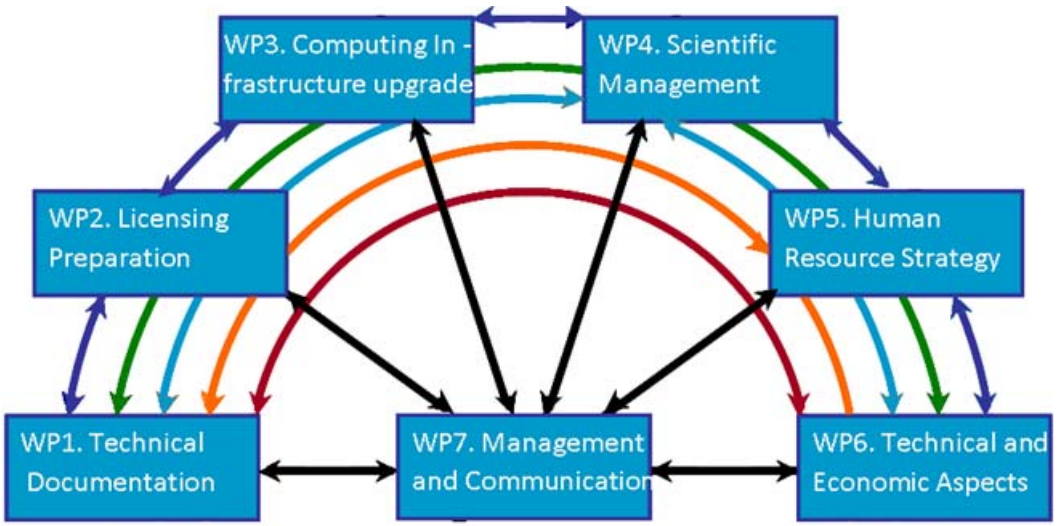


Fig. 1. PRO ALFRED project structure [2]

PRO ALFRED aimed to prepare Romania's contribution to ALFRED infrastructure implementation, through the development of technical documentation, definition of strategic elements on scientific management, ensuring human resources and promoting infrastructure, achieving the needed elements for demonstrator's authorization, as well as through technical-economic evaluations needed in support of the ALFRED demonstrator as a major project. During the project, the following outcomes were generated [3], as follows:

- Vision elements for experimental installations and their siting, conceptual projects for HELENA2, ELF and hub, feasibility study for HELENA2 and ELF;
- Elements for ALFRED authorization: list of codes and standards applicable to demonstrator implementation, reference site characterization studies, preliminary radioactive waste management and decommissioning plans, planning of the pre-operational program for monitoring the radioactivity of the environment for the site;

- Upgrading the computational infrastructure by developing the needed concepts for processes and associated phenomena modelling, as well as by acquiring, analysing, processing and storing specific data for knowledge capitalization;
- Elaboration of strategy document on ensuring the long-term sustainability of the ALFRED infrastructure, the quality manual for experimental campaigns, ALFRED infrastructure scientific management, as well as the RDI agenda for LFR technology in Romania;
- Educational program tailored to respond in a timely manner to the needed competence building, required for implementation and operation of the ALFRED infrastructure, training and mobility plans, human resources strategy;
- Preliminary studies on investigation of the economic, social and technical-scientific impact of the ALFRED infrastructure at local, regional and national level;
- Elaboration of the ALFRED White Book, communication strategy and promotion of the ALFRED infrastructure.

These valuable results were obtained, beside the project partners contributions, with the support of ENEA and ANSALDO Nucleare, as members of FALCON Consortium, which provided technical assistance in relevant activities of PRO ALFRED project.

Activities and important outcomes for ALFRED infrastructure competence building

To develop a competence building strategy for ALFRED infrastructure implementation and operation, two objectives were proposed: (1) to prepare training activities, in order to ensure human resources (HR) needs for ALFRED infrastructure, (2) to elaborate the Human Resources Strategy.

To achieve them, a number of actions have been foreseen, being divided in two implementation stages: end of November 2019 for mapping the Romanian universities potentially participating in the competence building process and identification of the HR needs for ALFRED infrastructure, and middle of November 2020 for the following actions [4]:
- Proposal of optimal measures to implement an attractive and efficient education and training (E&T) process;
- Elaboration of new curricula and reconfiguration of the existing one;
- Implementation methodology;
- Development of training and mobility plans;
- Elaboration of HR strategy for ALFRED infrastructure.

The project implementation has produced important outcomes, which are discussed in the following.

Mapping the Romanian universities potentially participating in the competence building process

An analysis of the educational programs conducted by the main suppliers for the personnel carrying out activities in nuclear field in Romania was performed, mainly based on UPB and UPIT partners. Currently, a number of six universities are involved in the competence building process, as follows: University Politechnica from Bucharest (UPB), University of Pitesti (UPIT), University of Bucharest, Babes-Bolyai University of Cluj, Constantin Brancusi University of Targu Jiu, and Ovidius University of Constanta.

UPB and UPIT, as the main supplier of technical personnel for the nuclear field, offer bachelor's degree, master's degree and doctorate degree in the key domains of the nuclear energy. Each year, around 40 students graduate Power Engineering and Nuclear Technologies (bachelor's degree at UPB through the Faculty of Power Engineering, and at UPIT through the Faculty of Sciences, Physical Education and Informatics), 25 obtain a master degree in Nuclear Engineering specialization from UPB and other 15 in Materials and Nuclear Technologies specialization offered by UPIT.

The mapping of Romanian universities shown that the UPB and UPIT educational programs are focused on the current generation of thermal reactors (CANDU, PWR) and on TRIGA research rector operated by RATEN ICN. In the light of opportunities offered by the ALFRED infrastructure, the curricula from UPB and UPIT was extended, by including specific courses on the Gen IV nuclear reactors in general (UPB), and on LFR technology in particular (UPIT). Therefore, UPIT introduced in both bachelor's and master's degree programs, courses focused on the ALFRED reactor, and UPB introduced in the master's program, courses which include specific elements on Gen IV nuclear reactors.

It has to be noted that UPIT and UPB are members of Partnership Agreement in the field of Research and Education for Advanced Nuclear Systems (CESINA). This agreement, signed in 2017, to strengthen the Romanian collaboration between the key players in the E&T and RDI fields, is coordinated by RATEN ICN, having the aim of providing the national support for ALFRED implementation in Romania and establishing a general framework to support this project.

Identification of the HR needs for ALFRED infrastructure

The human resource is considered as a key factor for the success of ALFRED implementation in Romania, taking into account the complexity of the infrastructure, the scientific activities and experimental campaigns which will be performed, and the loss of young people interest to embrace a career in nuclear field.

The investigation of HR needs was performed for the ALFRED infrastructure RDI activities, operation and realization of the dedicated activities in the experimental facilities and hub, as well as for the safe operation of the ALFRED demonstrator. Around 600 jobs (with higher and secondary education) were accounted for these purposes. For each job, the required specializations and minimal competencies were established [6].

Regarding the RDI activities, the specializations and minimum competencies were established for the following domains: reactor physics, thermal-hydraulics, nuclear safety, lead and cover gas chemistry, materials, instrumentation and control, fuel, spent fuel and waste management, radiation protection, decommissioning and scientific management.

Since all of the needed jobs will involve detailed activities, each domain was divided into dedicated sub-domains.

The estimation of the jobs needed for the operation and carrying out the experimental activities in the six support facilities was performed starting from the RDI priorities and experimental campaigns. A number of 63 jobs (people with higher and secondary education) were accounted. To cover the hub's intended activities, a need for 8 positions was identified. For the successful operation of the demonstrator, the jobs were divided in four groups: operation itself, administrative activities, technical support, and maintenance activities.

Proposal of optimal measures to implement an attractive and efficient E&T process

An analysis of the existing curricula at UPB and UPIT was performed in this activity in order to understand how the current educational program covers the minimal competences required by the ALFRED infrastructure. The focus was on the contents of courses and laboratory activities for three specializations: Environmental Engineering – EE (a bachelor program in UPIT), Materials and Nuclear Technologies – MNT (a master program in UPIT), and Nuclear Engineering – NE (a master program in UPB). The analysis involved the competences required for the experimental support facilities, the coordination hub and for the ALFRED demonstrator, in order to identify the useful elements and those which are missing in the existing educational offer - skills required by the employer relationship.

The analysis was performed using an expert judgment evaluation type, the final result being the average of the scores offered by the individual analysis performed by two RATEN ICN experts, who provided essential arguments for awarding the score (1 to 5) to each competence. At the end of the analysis, the totally uncovered competencies (score 1), slightly covered competences (score 2), those partially covered competences (score 3), the acceptable covered competences (score 4) and the fully covered competences (score 5), for the accomplishment of the targeted activities were identified [7].

The capacity of the educational programs in competencies building for the research activities in the LFR technology field was also assessed. The evaluation took into account the elements resulting from the practical experience of RATEN ICN to integrate graduates of these universities in the current research activities directly, or by completing a training/integration internship. Following the evaluation, additional measures were recommended to guide students towards research and development activities.

Another important result was the proposal of some measures (on short and long term) to reduce/fill the gap between the existing educational offer of UPIT and UPB, and defined requirements for ALFRED infrastructure. The measures refer to: the introduction in current curriculum of new information or disciplines on LFR technology, the revision of existing disciplines and/or the introduction of new disciplines in current curriculum, training based on academic education received in universities and focused on LFR technology, creating a new specialization by setting up a master program dedicated on LFR technology, correlating research activities in the six experimental facilities with doctoral programs. Methods and tools both for short- and long-term measures were also proposed [7].

Elaboration of new curricula and reconfiguration of the existing one

A questionnaire was developed with the aim to identify the needs for covering the requested competences, to ensure that HR will carry out specific activities in ALFRED infrastructure. After the questionnaire application by the RATEN ICN specialists, the critical competences, totally uncovered by the contents of courses and laboratory targeted for the specializations analysed in the previous activity, were identified.

The challenge of providing highly qualified HR for undertaking the activities within the ALFRED infrastructure, led to the revision of the existing curricula from UPIT and UPB bachelor's and master's specializations, as well as the proposal of new courses to ensure the necessary skills in performing dedicated activities to the standards imposed by the investment specificity. New curricular supports, namely ″Instrumentation and control in nuclear systems″ and ″Introduction to nuclear safety analysis for the ALFRED demonstrator″ were developed by UPIT and UPB.

Due to the specificity of the infrastructure, an orientation towards experimental activities is mandatory. Thus, new experimental platforms for the Nuclear Materials discipline from UPIT Materials and Nuclear Technologies master program were also developed in the project frame.

The analysis performed by applying the questionnaire to identify the training needs, led also to the updating of the UPIT and UPB disciplines, by introducing new contents for the following disciplines [8]:

- Radioactive waste treatment, Materials and nuclear technologies, Nuclear power plant systems, and Advanced nuclear power plants; ALFRED reactor; testing facilities, in frame of the Power Engineering and Nuclear Technologies (bachelor's program at UPIT);
- Nuclear safety for Environmental Engineering (bachelor's program at UPIT);
- Environmental protection systems for nuclear power plants, Nuclear Materials, and Radioactive waste management, in frame of the Materials and Nuclear Technologies (a master program at UPIT);
- Advanced nuclear power plants systems, Nuclear materials for advanced reactors and Fast reactors in frame of the Nuclear Engineering (a master program at UPB).

Implementation methodology: pilot course and train the trainers course

Within this activity, training actions for the trainers were initiated. A two weeks online course was organized by UPIT involving experienced lecturers. Implementation was carried out on a group of experts from RATEN ICN with significant theoretical knowledge and work experience in LFR technology, and the ability to build those skills, necessary for increasing the performance in the knowledge transfer process.

The first week was dedicated to the aspects of pedagogy and communications of adults, effective communication methods and institutional communication. In the second week, methodology, didactics and evaluation techniques were addressed [9].

For building the specific skills needed in the field of nuclear safety in LFR technology, with focus on LFR safety analyses, a pilot course ″Introduction in nuclear safety analysis for the ALFRED demonstrator″ was developed by UPB. It was organized also online, one week duration, and was implemented for a group of 15 persons from RATEN ICN. The course structure covered the following topics:

- ALFRED overview (2 hours);
- ALFRED demonstrator. Nuclear safety aspects (2 hours);
- Kinetics of fast reactors (4 hours);
- Thermal-hydraulics of fast reactors (6 hours);
- Deterministic safety analyses. Dedicated computer codes (4 hours).

This course will complete the existing ″Fast reactors″ course from the *Nuclear Engineering* Master's program of UPB, and can be used by RATEN ICN in the training program for the new employees who, even if they have a basic academic training in the field of nuclear engineering, are not enough familiar with the specific problems of fast reactors [9].

Development of training and mobility plans

In the frame of this activity, training and mobility /training plans were elaborated and partially implemented, for the following target groups: students, new employees in RATEN ICN, researchers from RATEN ICN oriented towards the scientific program of the infrastructure, and trainers. All are going to bring important contributions in assuring the needed workforce for ALFRED infrastructure. For each training plan, the objective, the recommended duration, the resources and means used, plan's content, and evaluation methods were proposed. These plans represent a graduated approach for the detailed elaboration of effective training programs, based on the accumulation of the most practical elements regarding the characteristics of the people who will follow the training activities, as well as the increasing of RATEN ICN capabilities [10].

Students' competencies, possible future employees at RATEN ICN, can be built through their integration in activities that will be undertaken within the research support infrastructure, as well as the demonstrator. Students can complete training courses on the nuclear platform at Mioveni and/or in universities or research centers from Europe and worldwide, equipped with laboratories, experimental facilities and simulation systems able to develop the LFR technology.

Training plans for new employees, who will work in experimental facilities support, represent the initial plans. Given the relatively distant time horizon for demonstrator operation (2035-2036), plans for training of future operators in the ALFRED control room and those for maintenance personnel, were defined only at level of general elements, to be detailed later.

The training and mobility plan for RATEN ICN researchers was developed with technical consultancy support (ENEA and ANSALDO). Its implementation was carried out on a group of 10 young researchers. The list of attendees was defined following the application of selection criteria, established by the host organization (ENEA). In the first stage, lasted 2 weeks, the researches were trained by lecturers in virtual classrooms.

The thematic of the training plan addressed relevant topics for LFR development, as follows: LFR material studies and coolant physical –chemistry, thermal-hydraulics, components validation, safety experimental studies, instrumentation, and numerical tools.

The situation created by COVID pandemic crisis has blocked the travel to ENEA Brasimone Center, initially planned. Thereby, for the second stage (lasted 3 weeks), the initially planned training was replaced with three very useful seminars. In the second stage, the young researches worked in 4 small teams, on very specific subjects. The results were assessed based on the elaboration of 4 thesis works, under assistance of the Italian mentors. At the end of the second stage, each team presented the thesis in front of the Evaluation Committee. For evaluation, each work and people received a score based on specific criteria. Certificates attesting the training on LFR technology attendance and the final grade were issued [11].

Elaboration of HR strategy for ALFRED infrastructure

The human resources strategy was based on the strengths, weaknesses, opportunities and threats (SWOT) analysis and offered an overview on the ensuring of human resources for the ALFRED infrastructure. The synthesis of strengths, weaknesses, opportunities and threats was presented. From methodological point of view, the SWOT analysis was performed on the basis of brainstorming and expert analysis, with participation of the RATEN ICN experts.

Understanding the future potential employees' expectations and the existing job offers on the national workforce market represent important aspects, which RATEN ICN takes into account in its human resources policy. The major attractive element is given by the opportunity of a professional career, in a complex and advanced technical infrastructure, such as ALFRED infrastructure. Regarding the evolution of the workforce market, an analysis was presented, including the expectations of potential employees on the future jobs.

Besides establishing of the general and specific objectives of the human resources strategy, the appropriate methods for staff recruiting for the ALFRED infrastructure and the methods for its retention were identified. The evaluation of the most common methods for staff recruitment was performed by the ENEA and Ansaldo Nucleare based on desk research investigation. The recruitment process for 3 European research infrastructures (European Spallation Source, Extreme Light Infrastructure and International Thermonuclear Experimental Reactor) was analysed. A comparison was also performed, taking into account the recruitment method used in the Électricité de France.

Based on 4 specific criteria (dissemination in the Gen IV scientific community, relevant applications for high quality and high specialized candidates, cost-effectiveness in terms of time required for the recruitment and costs, and staff retention capacity) the best method selection for the ALFRED infrastructure staff recruitment was concluded as the announcements for vacancies [12].

The short-term recommended measures to provide the human resources for ALFRED infrastructure, the needed resources, as well as the Action Plan for the HR Strategy implementation, completed the broad efforts to cover all aspects connected with the strategy to ensure the skilled personnel for the future infrastructure [13].

Conclusions

The activities and related outcomes obtained in the PRO ALFRED project will contribute to the competences building process implementation, needed for ALFRED infrastructure operation and performing of dedicated RDI activities.

Tailoring the national educational program to ensure the full spectrum of competences requested for ALFRED infrastructure, the training and mobility plans development and implementation, as well as elaboration of human resources strategy, are the most important outcomes resulted from the activities of the competence building dedicated work package in PRO ALFRED project.

The updated courses for bachelor's and master's programs at UPB and UPIT are already implemented in the curricula and could respond in a due time to the requested competence building process for the implementation and operation of the ALFRED infrastructure.

The implementation in RATEN ICN of the training and mobility plan developed by FALCON partners was considered a success, the knowledge and experience acquired by young researchers being able to contribute to shortening the design and licensing phases of ALFRED demonstrator. This experience will be continued, with the support of the ENEA Brasimone Center.

Human resources strategy includes elements for a strategic approach, in terms of identifying and preparing effective measures for recruitment, hiring, professional integration and retention of high qualified staff in RATEN ICN, as well as their implementation. The strategy aims to ensure increase of the workforce competence and stimulation of the interests in accordance with motivational perceptions and identified resources, targeting the real needs of ALFRED infrastructure.

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