Teaching Fast Reactors within the frame of European Union Projects.

Ch. Latgé[1], A.Vasile[2], K. Mikityuk[3], R. Garbil[4]

1) *CEA Nuclear Energy division, Nuclear Technology Department Cadarache, 13108 Saint-Paul lez Durance Cedex, France Christian.latge@cea.fr*
2) *CEA Nuclear Energy division, Reactor Studies Department Cadarache, 13108 Saint-Paul lez Durance Cedex, France Alfredo.vasile@cea.fr*
3) *Paul Scherrer Institute, Nuclear Energy and Safety Division Villigen 5232, Switzerland Konstantin.mikityuk@psi.ch*
4) *DG Research and Innovation Euratom Fission European Commission, Rue de La Loi 175 Brussels, Belgium Roger.GARBIL@ec.europa.eu*

INTRODUCTION

Close to ENEN (European Nuclear Education Network) activities, European Union develops, through some coordinated projects, the framework for a joint education & training strategy and a communication & dissemination plan for ESNII (European Sustainable Nuclear Industrial Initiative) within the frame of SNETP (Sustainable Nuclear Energy Technology Platform).

ESNII ACTIVITIES:

A coordinated education & training strategy is key to support the future development of FNRs. It is based on the identification of tracks to enhance existing infrastructures dedicated to Education & Training, on the development and/or application of modern pedagogical tools and on Educational Seminars dedicated to students and young researchers and engineers, involved in Fast Reactors programs. These Seminars also allow sharing knowledge within the European Fast Neutron Reactors community, between confirmed researchers and students, and between the ESNII (European Sustainable Nuclear Industrial Initiative) systems, ie Sodium Fast Reactors, Lead Fast Reactors and Gas Fast Reactors with the aim to identify synergies and commonalities.

Educational activities during ESNII+ project

This activity was carried out during 13 events, 9 workshops, 2 Summer Schools, and 2 biennial Conferences throughout the 4 years of the ESNII+ project, from 2013 to 2017.
The 9 educational seminars were dedicated to the following topics:

1- Fuel properties & Fuel transient tests,
2- Core neutronic safety issues,
3- Instrumentation for Fast Neutron Reactors,
4- Thermal-hydraulics and thermo-mechanical issues for Safety,
5- Mitigation of seismic risks,
6- Coolant physico-chemistry and dosimetry; quality control strategy,
7- Safety Assessment of Fast Neutrons Reactors,
8- Severe accidents in Fast Neutron Reactors,
9- Sitting and Licensing of Fast Neutron Reactors,

These events allowed 519 attendees from European universities, public research centres and private companies to participate to the activities including 175 student's participations during these various events.

Close to these educational activities, surveys of Masters programs in Nuclear Engineering, courses of relevance for ESNII systems and Non-academic training schemes were carried out and analyzed for the present survey. Following these surveys, several suggestions were done:

- To improve the definition of learning objectives, with regards basic knowledge, skills and competences to be acquired and learning activities constructively aligned with learning objectives
- to establish a second year in one or several of the existing European nuclear engineering masters programs dedicated to ESNII system competence building.
- to promote centers of excellence for hands on training on experimental, operational and maintenance techniques, ie Sodium School in France or to create new one's ie Gas school in Czech Republic, Magnetohydrodynamics School in University of Latvia or Heavy Liquid Metal school.
- to promote more intensively the continuous feedback between students, teacher and peers with aim to facilitatee the learning process...

The following educational methodologies were also investigated and discussed, within the frame of a Working Group involving European Universities ie KTH (Sweden), UPM (Spain), Unipi (Italy),UL (Latvia), INSTN (France)….

- CDIO (Conceive, Design, Implement & Operate) approach (www.cdio.org). This approach focuses on providing students with functional skills that are of direct value for addressing the complex problems they will encounter in industry [Crawley 2014],
- Active and experimental learning, using practical work using facilities, instruments, tools and other equipment, integrated into learning activities. Facilities where such learning activities can be carried out were listed, and recommendations for new facilities was given, if some educational tools were missing.

Educational activities during ESFR-SMART project

Within the frame of a more recent EU project, ESFR-SMART (European Sodium Fast Reactor Safety Measures Assessment and Research Tools), dedicated to SFR's, from 2017 to 2022, other methodologies, applied to other nuclear applications, are currently listed and analysed:

- Student's active learning using "flipped" classrooms, implemented in Chalmer's University (Sweden), where lectures and materials usually presented in class are instead made available to the students on the web and before class. During class, wrap-up sessions, quizzes, practical exercises… more focused on the student needs, promoting increased interactions between students and teachers.
- Training on experimental reactors, via Internet ie ISIS reactor in CEA-INSTN (National Institute for Nuclear Science and Technology (INSTN)
- VERT® – innovative Virtual Environment Radiotherapy Training (delivery of medical exposures to a virtual patient, (INSTN)
- E-Learning Courses, based on MOOCS (Massive Open Online Course) ie in INSTN about particles, nuclear energy. Up to now, in Europe no existing MOOCs focused on Generation-IV Reactors
- The simulators, as SIRENA at CEA: a tool for two needs: student's studies (transient situations...), training of operators.
- "role play" activity based on Project-Based-Learning (PBL) methodology, used in UPM (Madrid)
- External lectures by leading figures from the nuclear industry, choice of optional/elective courses, long research projects and dissertation implemented in Cambridge University…

ESFR-SMART partners on the following topics currently organize seven events among them a Summer School and six educational Seminars on the following topics:

1- Sodium facilities design and safe operation,
2- Instrumentation for safety,
3- Liquid metal thermal hydraulics and fuel safety,
4- Deterministic modelling of nuclear systems,
5- Magneto-hydrodynamics in liquid metal systems,
6- Prevention, management and mitigation of Severe Accidents

CONCLUSION

Through this not exhaustive review of Education & Training activities done through EU projects dedicated to Generation IV systems, the following items can be underlined:

- These projects contribute to the improvement of Educational initiatives and above all to the development of skills and competence of the Young Generation, who designs and will operate these Generation IV systems,
- These projects strengthen and link together new networks, in particular, the network of the European students studying the Generation IV systems, the network of EU Universities and the Network of Experimental platforms,
- These projects contributes also strongly to the Public acceptability of these systems.

Acknowledgments: The authors thanks warmly all the contributors to these Educational activities, within the frame of H2020 ESNII+ and ESFR-SMART projects. The research leading to these results has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 754501.