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Table of contents:

Centres of excellence - academia and their master programmes

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NUCLEAR EDUCATION AND TRAINING - NESTET 2013
Madrid 17-21, November 2013
A0014

EDUCATING NUCLEAR ENGINEERS BY NUCLEAR SCIENCE AND TECHNOLOGY MASTER AT UPM

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1. Introduction

One of the main objectives of the Master on Nuclear Science and Technology implemented in the *Department of Nuclear Engineering* (DIN) is the training for the development of methodologies of simulation, design and advanced analysis necessary in research and in professional work in the nuclear field, for Fission Reactors and Nuclear Fusion, including fuel cycle and safety aspects. The programme also includes other basic disciplinary contents such as Quantum Mechanics and Atomic & Nuclear Physics, Non-Energy uses of Radiation Sources and Nanotechnology

The experience gained in the last years by our Department in the development of *Codes for design and advanced analysis in Reactor Physics* has been included in the programme, with the understanding of the current computational methodologies/codes from the nuclear data processing, then the lattice and core calculations codes, the 3D Core Physics simulations at static and dynamic conditions, and finally the power plant simulators. A large experience in Plasma Physics and Advance Materials under development and irradiation, including Reactor Systems, for Nuclear Fusion, is also in the program that includes multiscale simulation and availability to have access to experimental facilities for the students.

Our Department was provided in 2008 with the *Interactive Graphical Simulator* of the PWR nuclear power plant “José Cabrera”. The simulator is a state-of-the-art full-scope real-time simulator, that was used for training and qualification of the plant operators. Very illustrative screens show all the plant systems, and allow to act directly on the system components. Alarm control panels, similar to the ones existing in the control room of a nuclear power plant, are also available to alert users to potential equipment problems or unusual conditions. The Simulator plays an important role for education and training of our students, providing an attractive virtual space that allows to improve the understanding of the whole plant components and its safety systems, because of that the *Consejo de Seguridad Nuclear* grant each course several fellowships for training of students in this installation. Recently his TRACPWR software has been adapted to the new hardware base on PC's with Windows. The SGI is now a more friendly tool, and easier to use by the students.

The Department participate in the international Sustainable Nuclear Fission Technology Platform (SNF-TP), and the European Nuclear Energy Network (ENEN), with the possibility for our students to obtain the “*European Master of Science in Nuclear Engineering”.* Participation in Erasmus-Mundus in Nuclear Fusion Science and Technology and a new Program of Erasmus Curricula in Plasma Physics and Fusion Technology is also an additional experience and attractive aspect for Master’s students.

Also there are several agreements with foreign universities and privates companies in the nuclear field, being some of them cooperative partners in the European research projects throught the Euratom 7th Framework Programme, in which the Department is involved. Our Doctoral students may take advantage of that, doing the PhD research work in the projects, also the Department support the invitation of relevant foreign professors to teach advanced seminars to our students.

2.Master on Nuclear Science and Technology

The present Master/Doctorate in Nuclear Science and Technology programme implemented in the Department of Nuclear Engineering of the Universidad Politécnica de Madrid (NED-UPM) has the excellence qualification by the Spanish Ministry of Education. One of the main objectives of this programme is the training for the development of methodologies of simulation, design and advanced analysis, including experimental tools, necessary in research and in professional work in the nuclear field. This is, Fission and Fusion Reactors, including fuel cycle, waste management and safety aspects, and also non-energy uses of nuclear physics and technologies. The programme includes other basic disciplinary contents such as Quantum Mechanics and Atomic & Nuclear Physics, Non-Energy uses of Radiation Sources (such as Lasers and Accelerators) as well as, Nanotechnology.

In this context, based on the experience gained through research, significant efforts have been done to improve the following subjects in the curricula: Nuclear Power Plants (NPP), Nuclear Technology, Nuclear Safety, Nuclear Reactor Design, Radiation Sources for Diagnosis, Medical, Industrial Application, and Quantum Mechanics Applications such as nanoscience and Nanotechnology.

But more realistic studies are also required to complete the education & training objectives in the "Nuclear Safety" and "Nuclear Power Plants" programmes. For this purpose, we use a full scope Interactive Graphical Simulator (IGS) running in real-time, which was donated by the Spanish José Cabrera NPP, after its operation ceased in 2006. The simulator was used during the commercial exploitation of the plant for training of the main control room personnel, technical support engineers, and for operations management. It was commissioned on NED-UPM in 2008.

On the experimental side, NED-UPM has a neutron measurements laboratory with a calibration bench, and presently a new facility based on sputtering techniques is being commissioned in order to support training and research on development and testing of new high radiation-resistant materials.

3. Codes for design and advanced analysis in Nuclear Engineering.

The experience gained in the last years by NED-UPM in the development of Codes for design and advanced analysis in Reactor Physics has been included in the Master Programme, with the understanding of the current computational methodologies/codes from the nuclear data processing, the lattice and core calculations codes, the 3D Core Physics simulations at static and dynamic conditions, and finally the power plant simulators.

A large experience in Plasma Physics and Advanced Materials development, characterization and testing under irradiation, together with Reactor Systems for Nuclear Fusion, is also incorporated in the Programme. This includes the development of codes for High Energy Density Matter studies, which is key for inertial fusion energy (both Radiation Hydrodynamics and Atomic Physics), but also original codes in atomic quantum and classical dynamics and defects diffusion for Materials Research in a scheme of multiscale simulation, with new developments in Fluid dynamics and Basic Physics for Liquid Metals behaviour, important in new generation of Fission and Fusion Reactors, and accessibility to experimental facilities for the students.

The "Nuclear Reactor Design" programme has been focused on the understanding of the computational codes for nuclear reactor design, starting with the nuclear data processing codes, the core calculations codes, and finally the plant simulators codes (JANIS, NJOY, WIMSD, ORIGEN/ACAB, MCNP, COBAYA/SIMULA, COBRA, SIMTRAN, RELAP).

Some of these codes have been developed in our NED-UPM for many years including the generation of the necessary cross-section libraries for accurate use of the codes. First, visualizing with JANIS code, and checking nuclear data from Evaluated Nuclear Data Files (ENDF), with ENDF Utility Codes. Different lattice codes have been developed to solve the neutron transport equation to model pin-cells and clusters taking part of the SEANAP system developed by NED-UPM for NPP design. Deterministic computational methods are complemented with Monte Carlo calculations. Students are introduced in this methodology and several examples for shielding and criticality systems are simulated with MCNP4.

For activation and burn-up calculations ACAB and ORIGEN2.2 codes are used. ACAB code (partially developed by NED-UPM) is designed to perform activation and transmutation calculations for nuclear applications. ACAB is used to simulate realistic operational scenarios of very different nuclear systems: inertial fusion, magnetic fusion, accelerator driven systems, and fission reactors.

Neutronic calculations for core design in 2D and 3D are introduced with COBAYA and SIMULA codes, respectively. These codes also are part of SEANAP system. For core design and operational monitoring we use our SIMTRAN code, SIMTRAN is a 3D-PWR core dynamics code, under development and validation for 20 years. It was developed as a single code merge, with data sharing through the 3D neutron-kinetics nodal code (SIMULA) and the multichannel, with cross flows, thermal-hydraulics code COBRA IIIC/MIT2. COBAYA3 is also now integrated in the NURESIM European platform for best-estimate reactors simulation.

For Multiscale Simulation of Materials, a significant number of developments have been performed with original development or co-development of Molecular Dynamics codes such as MDCASK, and Kinetic MonteCarlo (modified BIGMAC). In general, the full scale is covered from First Principles (SIESTA, VASP), Molecular Dynamics (MDCASK and LAMMPS), Defects Diffusion by MonteCarlo, Dislocation Dynamics, and Structural Codes such as ANSYS, but also with a large modification and adaptation to our problems of free codes such as CODEASTER.

Fluid dynamics problems in nuclear facilities (both reactors or research in New Sources) is covered by implementing and using popular CFD codes such as ANSYS-FLUENT or STAR-CD, extensively modified in some cases for specific problems. In particular, a large modification includes new data generated by using Quantum and Classical Molecular Dynamics, to study liquid metals such as LiPb or others, and get responses to problems of heat transport, corrosion or phase transition. Safety aspects for new Nuclear Systems are considered by using a special version of the MELCOR code for liquid metals, which is being implemented. Also in the safety area, and for fusion reactors, the diffusion and transport of tritium inventory has been originally implemented with new data in codes such as TMAP in order to estimate the final T inventory.

A key aspect developed is the computational coupling of those codes; from the 3D CAD/CAM description of the system to be studied, the particle transport, the heat deposition and particle irradiation, the generation of the basic numbers of material damage and activation, the fluid dynamics of the heat extraction (coolant), the tritium breeding in case of fusion, and the thermo-mechanical effects up to the Power Plant Thermodynamics cycle.

Atmospheric dispersion of radioactive elements in case of accidents are modelled with available codes but also with some new including new chemistry and physics such as Tritium analysis. A new battery of data has been included for components different of HTO, HT and organic bound tritium (OBT), with new models in NORMTRI, UFOTRI and the weather ECMWF/FLEXPART dispersion model, to incorporate the sequential chain of elements after deposition and through the organic systems with evaluation to the environment.

4. Facilities

4.1 Interactive Graphical Simulator

NED-UPM was provided in 2008 with the *Interactive Graphical Simulator* of the PWR nuclear power plant “José Cabrera”, whose operation ceased definitively in 2006. The simulator is a state-of-the-art full-scope real-time simulator, which was used for training and qualification of the plant operators. The Simulator plays an important role for education and training of our students, providing an attractive virtual space that allows to improve the understanding of the whole plant components and its safety systems. The *Consejo de Seguridad Nuclear* grants each course several fellowships for training of students in this installation.

The Interactive Graphical Simulator is a full scope PWR nuclear Power plant engineering simulator that is especially useful for didactic purposes, as it is an interactive tool that allows the student to complete the teaching-learning methodology in nuclear science and technology as is recommended in the new engineering studies adapted to the Bologna rules. This simulator attracts, motivates and retains students within the nuclear science, and improves the quality of training, making students more active in their own learning and replacing simple memorization of the complex processes involved in the operation of a nuclear power plant by a more meaningful learning, involving interactive and team working experience.

The simulator provides the plant responses using TRAC as the software package. Very illustrative screens display all the plant systems, and allow to act directly on the system components. Alarm control panels, similar to the ones existing in the control room of a nuclear power plant, are also available to alert users to potential equipment problems or unusual conditions. The components and systems of the whole power plant are simulated, this includes the nuclear reactor, the pressurized vessel, the primary and secondary loops, the turbine, the condenser, the fluids systems, the instrumentation and control components, and the electrical systems, as well as the emergency systems that are automatic started when needed.

The simulator provides the real plant responses during normal operation, and simulates several maneuvers, a series of malfunctions, and operational transients, and it also allows the training in emergency operation procedures. With the simulation of these situations the student is trained in the plant behavior, and in the nuclear and thermohydraulics phenomenology in the nuclear reactor and in the components of the whole plant.

Standard operational situations to run by the students are: Normal operation in nominal power; Nuclear power variations and turbine demand follow; Plant start-up from Cold-Zero-Power to Full-Power; and Plant down from Full-Power to Cold-Zero-Power, and evolution during the Zero-Power period.

For the simulation of hypothetical accidents, best-estimate and realistic codes are used. The evolution is run in real time, and the students take conscience of the time and the risk of these potential situations, and the high reliability needed in order to limit the global risk. The accidental and complex situations run by the students are: Loss of coolant accident (LOCA), Steam generator tubes leakage or rupture, stop of the main pump rotor, transients with failure of the protection system and the reactor scram, Pressurizer fault, Main steam line break (MSLB) in/out the Containment building, Anticipated Transients without Scram (ATWS), etc.

4.2 Neutron dosimetry laboratory

The neutron measurements laboratory of NED-UPM has two neutron sources (^{241}Am-Be with 77 and 111 GBq), a cylindrical water cask (0,9m diameter) for irradiation with thermalized neutron, and a precision bench for irradiations in air by means of a fully automated pneumatic device for storage, transport and positioning of the source and measuring instruments. The installation has a Bonner spheres spectrometer with a small ^{6}LiI(Eu) scintillation detector, four shadow cones (made of iron and polyethylene) and a Berthold LB6411 ambient dosimeter.

By using detailed Monte Carlo methods with MCNP code, several studies have been carried out to characterize the neutron fields in the laboratory in a set of reference points when the ^{241}Am-Be source is situated in irradiation position 3 m over the floor and 4.5 m far from the nearest walls. It The ambient dose equivalent obtained by calculations has been also compared with that obtained from the spectrometric measurements and directly with the dosimeter measurements.

4.3 Experimental sputtering set-up for coating deposition.

The research company Nano4Energy is specialized on development, design and commissioning setups for sputtering deposition. In particular, this company develops coating solutions by using High Impulse Magnetron Sputtering (HIPIMS), DC and RF sputtering techniques. The company is commissioning a pre-industrial process at NED-UPM for the development of sputtering deposition of thin film for different purpose (photovoltaic cells, optical coatings, plasma facing components…).

That installation will be used with adequate modifications for diagnosis and irradiation of advanced materials in the same conditions that those at the first wall of the chamber of Laser Fusion Reactors. A similar facility already used at the Spanish Research Council CSIC will be now upgraded for higher voltage and stronger conditions. The installation will also be used for research activities for the Programme students. Moreover, because of the versatility of the facility and the experience in coating deposition of NED-UPM members, this setup is also intended to be used for the deposition of nanostructured-based materials (high radiation resistant).

4.4 Internet Reactor Laboratory

With the assistance and support of the IAEA, five reactors experiments on Reactor Physics will be incorporate in the Master curricula. These experiments will be follow online by the students through videoconference, with a connection with the control room of the ISIS experimental pool reactor in CEA- Saclay.

This five sessions will include:

Lab 1: Fuel loading
Lab 2: Approach to criticality; Reactor start up; Reactivity effect around criticality
Lab 3: Reactivity effect of devices (cylinders and box) placed in the core; Rod calibration curve; Global worth by the rod drop technique
Lab 4: Role of precursors; Temperature effect; Operating range of each detection system and associated OLC
Lab 5: Detection system in pulsed mode; Detection system in current mode; Neutron flux measurements with a micro fission chamber – Cartography

Theses sessions has special interest to understand the Reactor Physics concepts, and will be part of our advanced seminar program.

They will provide to the students, after the theoretical classes on Nuclear Technology, and before the Interactive Graphical Simulator sessions, this last installation is useful to understand the whole plant components, and the safety systems behavior.

5. International Masters Programs

NED-UPM is involved in several international programs:

- European Master of Science in Nuclear Engineering
- Erasmus-Mundus Nuclear Fusion Science and Technology
- Erasmus Curricula in Plasma Physics and Fusion Technology (PLAPA, New program)

Our University is involved and participates in several Education and Training Platforms, at national level is part of the CEIDEN technological Platform, at European level in the Sustainable Nuclear Energy Technology Platform (SNE-TP), and the European Nuclear Education Network (ENEN) association, both promoted by the European Commission. We also participate in the National Platform for Fusion Technology, and in the recently started National Ministerial Programme INDUCIENCIA that aims to join industry with universities and research institutions; in both cases the participation is not only for research and development, but also with intensive subprograms for education and training.

Also the University has participated in programs of the World Nuclear University (WNU), and the Frederic Joliot & Otto Hahn Summer School (UE).

6. Research Activities

NED-UPM has agreements with several foreign universities and companies in the nuclear field, being some of them cooperative partners in European research projects. Our Doctoral students may take advantage of that, doing the PhD research work in the projects, also NED-UPM supports the invitation of relevant foreign professors to teach advanced seminars to our students. New Programmes are also established with Institutions in Chile, Argentina, Japan and China.

The different research areas carried out in NED-UPM cover the main topics in Nuclear Engineering field, supported by the National Research Programs, the Nuclear Safety Council, the National Radioactive Waste Management Company ENRESA, the nuclear power plants, or international organizations as EURATOM, STFC RAL in the UK, CEA in France, CERN, LLNL and LANL in USA, Japanese Science and Technology through Bilateral Agreement (ILE Osaka and Graduate Photonic Institute).

- Fission Reactor Physics
  - SEANAP System for PWR reactor cores design and analysis with original methodology.
  - PWR operation surveillance.
  - Nuclear data needs, processing and development of tools
  - Burnup credit criticality safety
  - Sensitivity and uncertainty analysis for nuclear criticality safety and burnup calculations

- Nuclear Safety
  - Analysis of Severe Accidents in LWR
  - Integrated Safety Assessment and Probabilistic Safety Assessment for NPP

- Radiological protection
  - Dosimetry and neutron metrology
  - Environmental, radiological and economic impact of nuclear energy
  - Decision support systems for Nuclear Emergencies and post-accident management

- Nuclear Fusion
  - Development of computational models for target physics in Inertial Confinement Fusion
  - Design and analysis of experiments under the EU support, for X-ray lasers and for ICF.
  - Fusion reactors study and design (both engineering/experimental and Power Plants)
  - Development of computational models for the analysis of activation and material damage by irradiation.
  - Experiments in the area of Materials Irradiation and NanoMaterials development in collaboration with other research centers

- Fluid Dynamics
  - Development of a 2D fluid dynamic model with radiation transport using advanced techniques.
  - Development of new algorithms for considering in the state-of-art codes for engineering design new data bank and modifications to incorporate new fluids, key in new reactors.

- Materials
  - Development of New Advanced Materials with new nanostructures to support very high irradiation of Ions, X-rays, Gammas and Neutrons. Structural and Functional materials such as optical lenses using both Multiscale Modeling and Experiments.
  - Damage in nuclear reactors vessels
  - Separation and Transmutation of radioactive waste.

- New Sources of Radiation (by Lasers and Accelerators)
  - Design of New Facilities for very advanced Irradiation in extreme high fluxes of Particles and Radiation and potentially new methods for Medical and Industrial Applications, and Material and Biological Diagnosis.
  - Laser Generated Ions, Positron and Neutrons
  - Spallation Sources

7. Conclusions

The Master on Nuclear Science and Technology implemented in the *Department of Nuclear Engineering* (DIN) train students for the development of methodologies of simulation, design and advanced analysis necessary in research and in professional work in the nuclear field, for Fission Reactors and Nuclear Fusion, including fuel cycle and safety aspects.

The students are able to use the current computational methodologies/codes for nuclear engineering that covers a difficult gap between nuclear reactor theory and simulations. For students, the understanding in a comprehensive way of these codes is an important value in simulation, design and advanced analysis both in the research activities and in the professional work.

Also they are able to use the Interactive Graphical Simulator that has been proven to be an optimal tool to transfer the knowledge of the physical phenomena that are involved in the nuclear power plants, from the nuclear reactor to the whole set of systems and equipment on a nuclear power plant. As well as the new Internet reactor laboratory has interest to understand the Reactor Physics concepts.

The experimental set-ups for neutron research and for coating fabrication offer new opportunities for training and research activities. All of them are relevant tools for motivation of the students, and to complete the theoretical lessons. They also follow the tendency recommended for the European Space for higher Education (Bologna) adapted studies, help to increase the hands-on work of the student, and allows them to experience the work inside a team, in practical and real installations.

MASTER IN NUCLEAR ENGINEERING AND APPLICATIONS (MINA): A KNOWLEDGE MANAGEMENT TOOL OF THE SPANISH NUCLEAR INDUSTRY

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ABSTRACT

Knowledge Management in nuclear industry is indispensable to ensure excellence in pe rformance and safety of nuclear installations. The Master on Nuclear Engineering and Applications (MINA) is a Spanish education venture which foundations and evolution have meant an adaptation to the European Education system and to the domestic and international changes occurred in the nuclear environment. This paper summarizes the most relevant aspects of such transformation, its motivation and the final outcome. Finally, it discusses the potential benefit of a closer collaboration among the existing nati onal education ventures in the frame of Nuclear Engineering.

1. Introduction

Obtaining the necessary knowledge for the right people, at the time, manner and appropriate place, was defined by Ackermans et al. [1] as Knowledge Management (KM). Its ultimate goal is to ensure the closest approach between the speed of learning and the market exchange rate. To do this, it is essential to create an environment for sharing the acquired knowledge and its application, thus preventing recurrent learning processes that would make any system inefficient. The prominence achieved by the KM over the last decade has been led largely by the huge transformation of the information and communication technologies (ICT). These have involved radical structural changes in key aspects , such as: access to information, its immediacy and the new structures and sorting capabilities.

The importance of the knowledge management becomes even greater in the nuclear industry [2]. There is a di rect relationship between the KM and the s afety of the facilities . Design, licensing, construction, operation, maintenance and even d ismantling activities must be risk-informed and based on knowledge. The abilities to make correct decisions and perform the necessary actions require achieve and preserve know ledge and experience [3]. Therefore, the KM in the nuclear industry has to respond to a clear challenge: providing human resources and training base necessary to successfully work in the applications arising from nuclear technology, either for energy produ ction or for other uses demanded by society as medical, industrial, agricultural, etc.. For this, there are three fundamental pillars:

- Education and training initiatives. Their approach and interconnection are critical for their success. Exchange fore between nuclear teaching professionals and the mutual recognition of educational initiatives, are key tools for building a robust and efficient formative tissue.

- Storage and structuring of scientific and technical heritage from the development of existing nuclear programs. Databases set up to gather and preserve information in an ordered, easy to interpret, and open access way, is instrumental too.

- Mobility of students and professionals. The existence of the education and training international initiatives allows that students from countries with nuclear plans, under development, have the opportunity to learn from the experience in countries with consolidated programs. Furthermore, globalization has meant the growth of professionals in areas that even absent in their home country, are being developed beyond the borders.

The current development of ICT has undoubtedly led to innovative methodologies that enable and enhance each of these pillars.

The Master in Nuclear Engineering and Applications (MINA), title of the Autonomous University of Madrid (UAM), organized and managed jointly with CIEMAT, set one of the national nuclear education initiatives [4]. After five editions with nearly a hundred students in total, MINA is more aware than ever of its role in the KM of the Spanish nuclear sector. This article provides a reflection on the consistency of its approach with the fundamental objectives of the KM and it describes the major changes made along the years to continuously update it in a consistent way with the national and international nuclear sector.

2. Sectorial integration

The Master in Nuclear Engineering and Applications (MINA) was conceived with the ultimate goal of forming nuclear professionals. Therefore, every effort has been to introduce into the job market, graduates capable of performing the activities that the Spanish nuclear sector develops inside and outside our borders. To do this, it was imperative, from the beginning, to maintain a close cooperation with the industry in the many aspects of this master.

There are several elements that illustrate the sectorial integration of MINA:

- Professional profile. The subjects were set from the needs expressed by nuclear companies and institutions in the country, who also participated in articulating the detailed programs. A description of the classification procedure of the subjects (priority, fundamental and complementary subjects) and content development was detailed by Herranz et al. [4].

- Teacher involvement. MINA combines the teaching of the scientific basis for nuclear technology with its application in industry and engineering. The first is provided by teachers and researchers of high reputation. The application, which is more than 50% of teaching time, is largely responsible for industry professionals. This balance allows students to approach the experience of the industry, without neglecting the grounds on which it is based.

- Project management. The dimension of proposal and management of end of master projects has reached averaged values above 80% (Figure 1). These projects usually deal on the on-going activities in industry, companies and institutions, a fact that underscores their interest in them. Not least, these projects allow direct contact of student and industry.

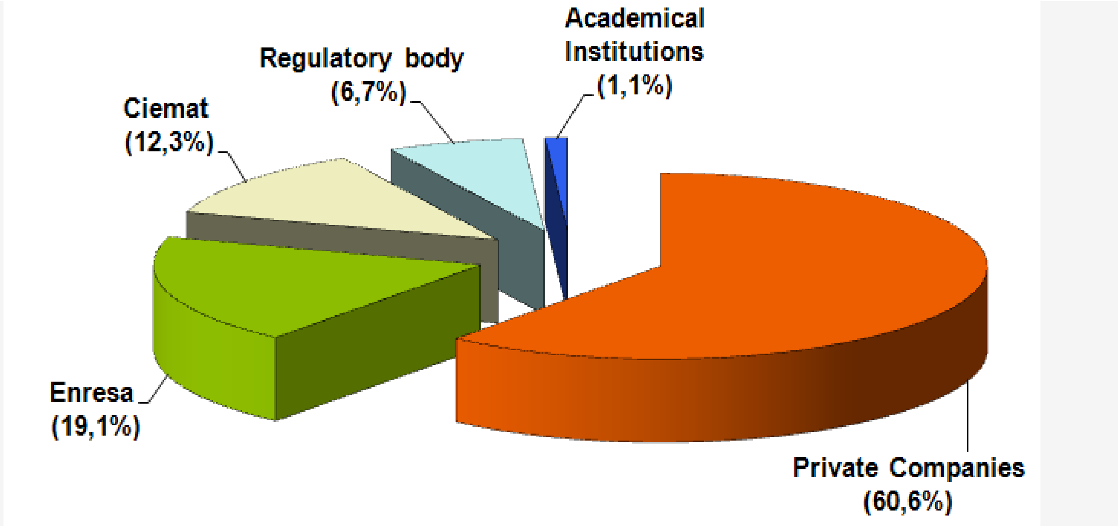

Fig 1. Management of end of master projects

- Access to facilities and events. The students of MINA have access to different facilities during the master; examples are Juzbado nuclear fuel factory, CN Almaraz, the Cabril radioactive waste store for low and intermediate radioactive level, CN Jose Cabrera and others. Also, the Spanish Nuclear Society opens its doors in the Operating Experience Annual Conference for students of master's and postgraduate courses related to nuclear technology, including MINA.

- Financial support. The nuc lear sector contributes to the economic viability of MINA through various mechanisms, such as grants for registration or financial assistance for the project development (Figure 2).

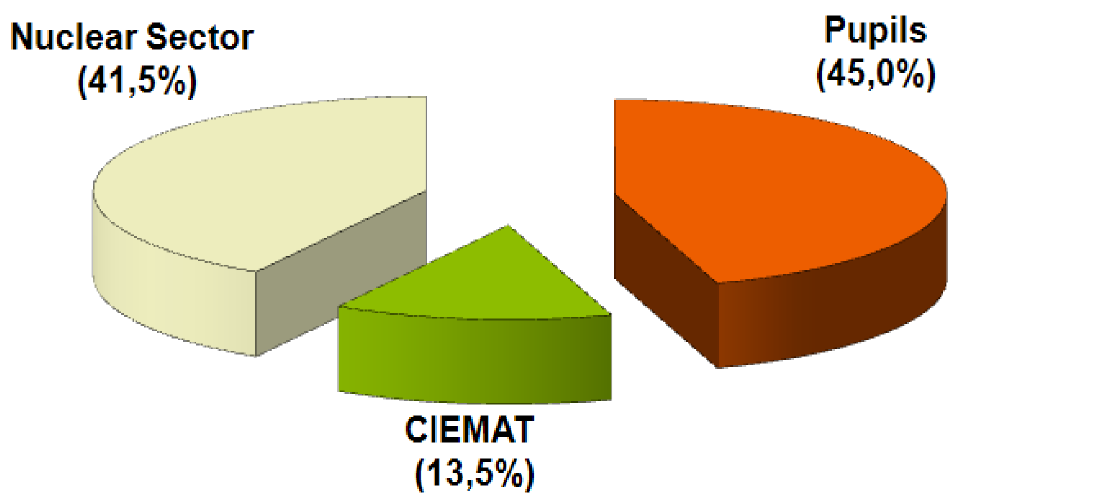

Fig 2. MINA cost coverage

From the beginning , MINA has maintained a constant contact with the Nuclear Fission Energy R & D Technology Platform (CEIDEN). Currently, one of the MINA team members is fully integrated into the education and training committee of the platform. Moreover, MINA distributes the students´ dossiers who have passed all the l evel tests into the industry and institutions.

In short , MINA acts as a vector of the experience accumulated by the industry to a new generation of professionals and it is able to assimilate them through the fundamental knowledge acquired.

3. Temporal progression

All the instruments of the any KM system have to be linked to a continuous assessment, aimed at optimizing its efficiency and adapting to changes in their environment. Thereby, MINA established a quality assurance system based on the analysis of: individual surveys of subjects, general surveys of the Master, self-assessments at the end of each academic year and, finally, a regular review of the nuclear sector development. Surveys are completed by students, the access is via Internet and are anonymous. The last two items are responsibility of the MINA team and the main difference between them is the temporal scope . Following the analysis of all of them MINA has undergone transformations that, according to their origin, can be divided into academic and sectorial.

3.1 Academic evolution

The academic evolution refers to those changes introduced for two fundamental purposes: accommodate MINA to the European Higher Education Area (Bologna Process) and provide students the achieving th e maximum performance. Numerous changes have been implemented in this framework; just to mention some of the most representatives:

- Modular structure. Subjects have been grouped into eight modules, each one of 150 hours, of which at least 50% correspond to the individual student work. Each module is equivalent to six ECTS (European Credit Transfer System). A final module of 12 ECTS is devoted to develop the end master project (Figure 3).

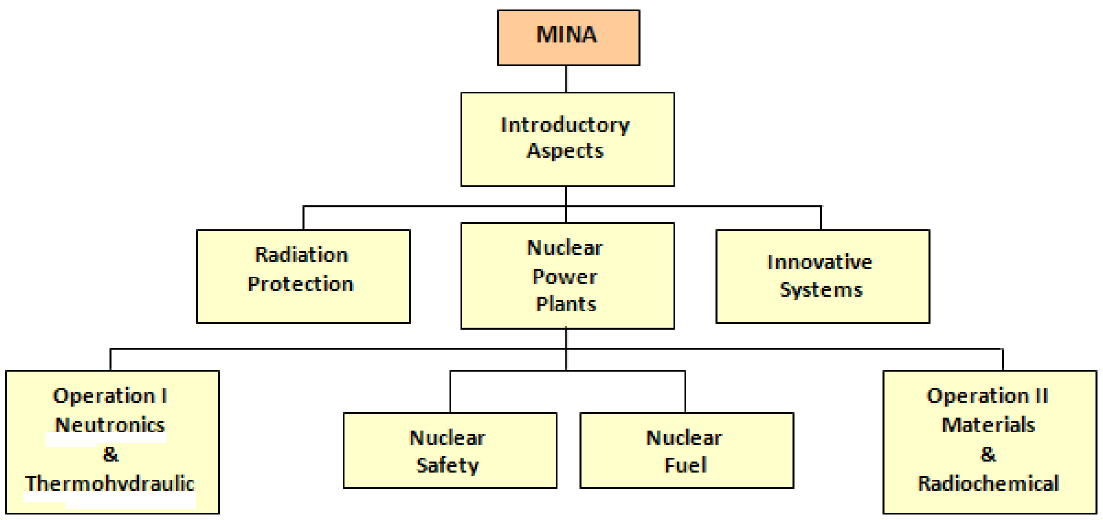

Fig 3. Modular structure of MINA

The introductory aspects give way to three thematic lin es: radiation protection, nuclear power plants and innovative systems. From the second one a broad spectrum of fundamental disciplines structured into four modules is covered: neutronics and thermohydraulics, nuclear safety, nuclear fuel, and materials and radiochemistry. As shown schematically in Figure 4, the project shows the learning outcomes acquired through the modules and it means the closest approximation of students to the reality of industry and institutions.

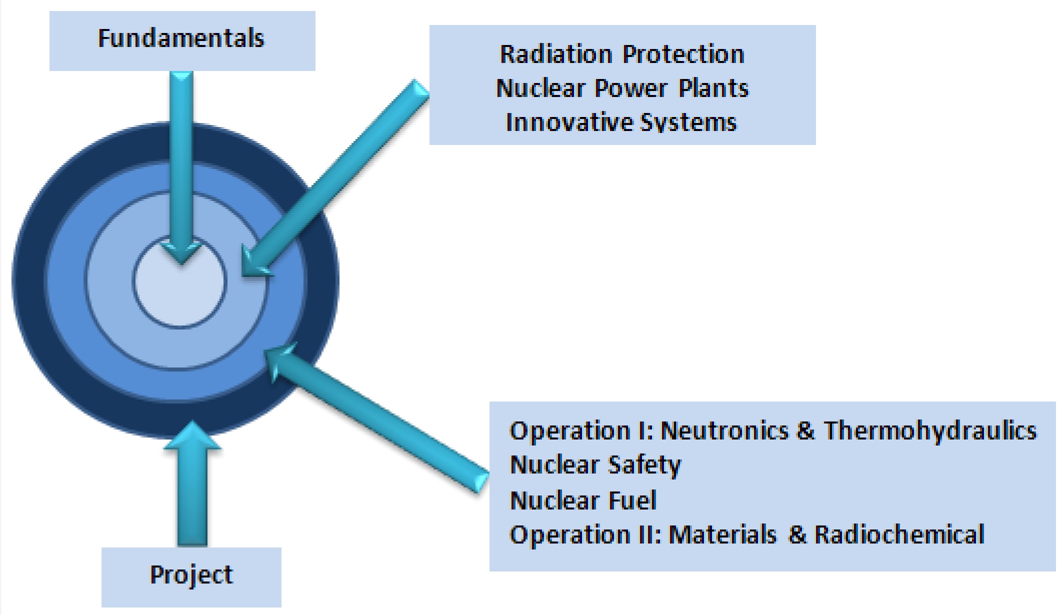

Fig 4. Conceptual scheme of the integration modules-project in MINA

- Emphasizing the practical aspects. Throughout the five performed editions of MINA some training elements, such as practical sessions, problem-solving sessions and assignments, have increased in nu mber and importance . In this sense, special mention deserves the inclusion of two sessions in the Tecnatom PWR and BWR simulators.

- Workshops. In the pursuit of know-how, learning spaces have been set in MINA where students have direct contact with analytical tools of interest in the nuclear sector. Currently there are four on-going workshops: MCNP (neutronics) FRAPCON-3 (nuclear fuel), Trace (thermohydraulics) and Melcor (severe accident).

- Reduction and restructuring of school hours. Since the first editi on of MINA the number of class hours has decreased more than 20%, and this fact, together with the continuous time setting, allows students to have more time for assimilation through the study, development of exercises and / or preparation of other academic activities.

- Weighting the pressure of evaluations . Without limiting the level of demand , assessment processes are optimized . On the one hand, it has fostered among teachers that the elaboration of technical reports and the resolution of practical activities be considered as complementary when assessing students, without implying the renounce of a test in those subjects whose contents are determined as essential. On the other, the number of exam s has decreased due to the realization of joint tests in subj ects included in related fields, or by the use of alternative means of examination, in subjects with less than 10 teaching hours. However, in those cases where the failure is higher than 25% in testing, the obtainment of the master's degree will mean to pa ss these subjects by mean of a revalidation exercise at the end of the master.

To these and other more minor changes (such as progressive adaptation of the contents in subjects such as neutronics or thermohydraulics), the signature of a number of educational cooperation agreements with the majority of companies and institutions involved in MINA has to be added . This has facilitated the integration of students in companies and institutions during the master project.

Finally, the intensive and extensive use that MINA makes of computing resources, through the specific space created for the master in the CIEMAT Virtual Classroom (Figure 5) have to be emphasized. There, students can access all the contents of the master and their programming, in addition to exchange and discussion forums. In individual cases, no physical presence level tests have been made through the network.

Fig 5. Web gate of the MINA 2012 -2013 edition

3.2 Sectorial evolution

Since 2008 several significant events have occurred in the nuclear environment, both domestically and internationally. MINA has maintained attention to them and has been adapted according to developments in the sector.

Beyond the necessary adaptation of MINA, one of the main objectives of the analysis made, was to assess the need for MINA as a tool within the nuclear KM in Spain. Among the main motivations of the origin of MINA, was the called nuclear renaissance. Following the slowdown in the world's nuclear plans, seemed legitimate, therefore rethink its meaning in the present context. The conclusion was clear: MINA initiative remains as a nuclear professional training relevant and capable.

The extraordinary dynamism and broad spectrum of nuclear technology makes that professionals of the sector in Spain ply their trade in remote locations such as Brazil, China and Korea, and not so far away as the United Kingdom; some MINA students, in fact, have found employment in companies based in France or Germany. Furthermore, the absence of construction activities of new Spanish nuclear power plants does not prevent to create needs in other areas such as design, construction and operation of other facilities (such as the Centralized Temporary Storage, CTS), or dismantling itself (as might be the case of Garoña NPP). As if these reasons were not enough, the generational change is a fact that is occurring in Spain and requires replace those people who have been protagonists of the national nuclear program until now by new experts that can absorb their experience and keep their good work. This fact is indisputable in a country with more than 7000 MW in operation, that in 2012 were responsible for almost 21% of total electricity production in Spain, and whose operation is to continue at the highest levels of security for decades.

Finally, it is noteworthy that, despite the economic crisis, the average number of students in each MINA edition that has been incorporated into the institutions or companies, is around 60%. This fact is an additional indicator of the validity of the mast er for the labour market.

The context analysis also allowed the identification of significant events with potential impact on MINA. Below the facts and particular impacts on the master are extracted:

- The final decision on the location and commissioning o f the Centralized Temporary Storage. The review of the contents of subjects as fuel cycle, nuclear fuel and radioactive waste indicated that the imparted knowledge is adapted to the capabilities that could be sued for the construction and operation of the CTS. Moreover, the fuel workshop will allow that students deepen even more into the evolution of the fuel during dry storage.

- The Fukushima-Daiichi accident. Subjects as Nuclear Safety and Environmental Impact have adapted their contents. The first empha sized, among others, the external events, the fuel storage pools, the filtered containment venting, the stress tests, and in general, everything related to severe accidents; in particular in the severe accident workshop, students will simulate the sequence s of TMI -2 and Fukushima -Daiichi accidents. In the subject of Environmental Impact, monographic sessions exist about Fukushima, and the inclusion in the contents of the recovery techniques of soil and water, as well as organizing a new workshop on atmospheric dispersion of radioactivity are promoted . The chapters on boiling water reactors in the subject of Nuclear Power Plants, or the fuel cooling pools in the Fuel Cycle, have been reinforced.

- The nuclear rethinking. One of the immediate consequences of Fu kushima has been the loss of the so -called nuclear renaissance, at least for some time. In the new situation takes even more strongly the possibility of plants life extension, even up to 80 years [5]. The teachers of Nuclear Materials subject are currently contemplating the possibility to accommodate the contents to explicitly include the NPP life extension. Also expected further underline the highlighted role of Asian and emerging countries in the nuclear development, within the subject of Generic Aspects of the Nuclear Energy. To these two changes must be added the introduction of the modular reactors within the subject of Fission Innovative Systems in future editions. Unlike the first two, this change has no connection with the accident in Japan in March 2011.

- The end of operation in the Garoña NPP. The dismantling of nuclear facilities is a MINA specific subject. The recent events around Garoña could highlight its importance and perhaps to promote some changes in the contents currently taught. Also, it will be possible to include the visit to Garoña in the visit plan that the students usually perform every year to some Spanish nuclear facilities.

The changes described in the preceding paragraphs have been the result of the analysis made by the managemen t and coordination team of MINA to adapt the Master to the current nuclear context. Although some changes have been occurring gradually, as the directly derived in Nuclear Safety subject after Fukushima accident, others have been proposed from the teachers of the affected subjects and will be a reality in the next edition of MINA.

4. Final considerations

Knowledge management in the nuclear sector is essential to ensure a safe and optimum operation of facilities. The Master in Nuclear Engineering and Applicat ions (MINA), has managed to become a vehicle of knowledge and experience by incorporating the nuclear sector in the design and implementation of the Master. As result, around 60% of MINA students are presently working as young professionals in nuclear industry and institutions.

MINA is a consolidated and mature project. However, it evolves to achieve a better adaptation to academia and industry environments. As a result, MINA is an education initiative well framed in the European Area of Education and which contents are updated and articulated through educational tools that promote learning and training of future professionals.

MINA coexists in Spain with two other education initiatives specifically addressing nuclear engineering. Each of the three masters has own characteristics that distinguish one from the others. In spite of it, it would be desirable that, without any harm to their individual identities, a stable framework to find synergies, creating feedbacks and achieving mutual academic recognition, was established. Far from weakening, this cooperation would enhance the nuclear option over other training options, optimizing teaching resources (such as Radioactive Waste Course, taught by the Autonomous University of Madrid, the Polytechnic University of Madrid and CIEMAT) and, possibly, it would result in a more homogeneous and attractive profile to the nuclear sector. The education and training platform, implemented within CEIDEN could be the appropriate environment to forge such collaboration.

5. References

[1] Akkermans H., Speel P-H., Ratcliffe A., 1999. “Problem, Opportunity and Feasibility Analysis for Knowledge Management –An Industrial Case Study”, 12th Workshop on Knowledge Acquisition, Modelling and Management, Alberta (Canada), 16-21 October 1999.

[2] IAEA, 2012. “Knowledge Management for Nuclear Research and Development Organizations”, IAEA-TECDOC-1675, ISBN 978-92-0-125510-5, 2012.

[3] IAEA, 2011. “Comparative Analysis methods and Tools for Nuclear Knowledge Preservation”, Nuclear Energy Series, NG-T-6.7 STI/PUB/1494, ISBN 978-92-0-113610-7, 2011.

[4] Herranz L. E., García-Cuesta J.C., Falcón S., Marco M., Couchoud M., 2008. “MINA 2008: Una aproximación renovada al máster de la ingeniería nuclear y sus aplicaciones en España”, Nuclear España, Mayo 2008.

[5] OECD-NEA, 2012. “Challenges in the Long-Term Operation of Nuclear Power Plants”, NEA/ CNRA/R(2012)5, ISBN 978-92-64-99187-3.

MASTER IN NUCLEAR ENGINEERING IN BARCELONA: ALIGNING UNIVERSITY, UTILITY AND SOCIETY AIMS

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ABSTRACT

The Master in Nuclear Engineering from BarcelonaTECH has started its third edition. The degree, completely taught in English, aims to produce competent nuclear engineers for the nuclear industry. Endesa participated actively in the definition of the syllabus. The Master's 90 credits are divided in required subjects (46.5), elective subjects (13.5), internship (15), and Master's Diploma Thesis (15). The subjects include activities based on active learning and team work: this way, evaluation system becomes an integral and inseparable part of the learning process. About one half of the classes have been delivered by lecturers external to BarcelonaTECH. Besides ENDESA, other companies (ANAV, AREVA, ENRESA, ENSA, ENUSA, Nuclenor, Tecnatom, Westinghouse) are collaborating in the Master with different degrees of involvement. CIEMAT (a major Spanish research centre) and the Spanish Regulatory Body (Consejo de Seguridad Nuclear, CSN) are participating in the Master, as well. In general, students are satisfied with the Master, which fulfils the expectations of the Industry and which, by producing professionals committed to safety culture, makes a significant contribution to society.

1. Introduction

In an international context in which World electricity demand grows rapidly, an important part of the new installed capacity worldwide will be made of renewable technologies and nuclear plants.

After Fukushima Daichi accident in March 2011 some European Union countries have made the decision of renouncing to nuclear energy, but other countries maintain a strong position in favour of this form of energy. Globalization of the economy and the increasing presence of European companies in international projects contribute noticeably to a growing need for hiring qualified professionals by companies around the world.

Endesa, which holds a large share (47%) of the Spanish nuclear capacity, is aware of these needs and it is interested in preparing professionals for the nuclear sector in Spain.

In Barcelona, Nuclear Engineering education has a history of more than forty years, always linked to the School of Industrial Engineering of Barcelona (ETSEIB) of the Universitat Politècnica de Catalunya (BarcelonaTECH).

In 2010, approach between Endesa's professionals and BarcelonaTECH teaching staff started with the aim of defining the syllabus of a future Master in Nuclear Engineering. Endesa would contribute to the Master with its knowledge and operating experience in the nuclear field, BarcelonaTECH would provide its expertise in training engineers (among them nuclear engineers) for the society. After several iterations the program was defined and was submitted to the National Agency for Quality Assessment and Accreditation of Spain (ANECA) for verification.

In March 2011, Antoni Giró, BarcelonaTECH's president, and Andrea Brentan, the Chief Executive Officer of Endesa, signed a Memorandum of Understanding by which the Master was brought to live. The first edition started in October 2011. Since September 2013 the third edition is underway.

The master has the sponsorship of Endesa and the collaboration of most of the Spanish nuclear industries. The Spanish Nuclear Safety Council (CSN), the regulatory body, has been involved in the Master from the beginning and has collaborated actively in the development of the two editions of the Master done so far. Researchers from CIEMAT (the Spanish research centre for energy and environment) have participated as teachers in the Master as well.

Part of the academic offer of the Master in Nuclear Engineering from BarcelonaTECH [1] is offered as well in the framework of the European Master in Innovation in Nuclear Energy (EMINE) [2], launched in 2011 by KIC Innoenergy (European Institute of Innovation and Technology [3]). EMINE students can choose between BarcelonaTECH and KTH (Sweden) to get their first 60 ECTS credit points and then move to Grenoble INP or to ParisTech (France) to get other 60 credits (including internship and project). Electricité de France, AREVA, Vattenfall and Endesa are industrial partners of KIC.

2. Participant institutions

Endesa [4], the largest nuclear plant operator in Spain and the main private sponsor of the master, aims to use talent to help the company face its most important scientific and technological challenges for its business in the future. Seven years ago Endesa launched the Endesa Energy School, another step in Endesa's pledge to manage its human and intellectual capital and focus on treating the Company's intangible assets.

BarcelonaTECH [5] is a public higher education and research institution that specialises in architecture, sciences and engineering. The University is strongly committed to providing high quality technical education to timely attend the educational needs of traditional and emerging productive sectors. It is the leading Spanish university in terms of number of international students in master's and doctorate, and is the European university more involved in Erasmus Mundus (13 masters and 7 doctoral programs).

BarcelonaTECH has 23 different schools and faculties in 8 Catalan cities involved in teaching, research, development and technology transfer. One of these centres is the School of Industrial Engineering of Barcelona (ETSEIB) [6] which combines both a longstanding tradition (it was established in 1851) with a spirit of renewal and continuous improvement that have made it one of the best engineering schools in Spain and an internationally renowned educational centre. The School maintains strong ties with the local industrial, financial and social sectors and can boast significant international presence and recognition. Research and technology transfer have helped the ETSEIB to foster a strong presence and involvement in industry.

The Department of Physics and Nuclear Engineering (DFEN) [7], and specifically its Nuclear Engineering Section, is in charge of the education in Nuclear Engineering, always linked to the School of Industrial Engineering of Barcelona (ETSEIB). Together with the Institute of Energy Technologies (INTE), the DFEN offers a Doctorate Programme in Nuclear and Ionizing Radiation Engineering.

The Institute of Energy Technologies (INTE) [8] is one of the ten research institutes of BarcelonaTECH. It develops research activities in different fields: energy studies, ionising radiation, the physics and technology of detectors and particle accelerators.

Besides Endesa, other companies are collaborating in the Master with different degrees of involvement. The list of companies includes: ANAV [9] (the operator of Ascó-1, Ascó-2 and Vandellòs-2 power plants, all of them PWR, in the vicinity of Barcelona), Nuclenor (a company participated by Endesa that operates a BWR plant in Santa Maria de Garoña), ENUSA [10] (publicly traded Spanish company for design, manufacture and supply of fuel), ENRESA [11] (public company in charge of the safe management, storage and disposal of the radioactive wastes produced in Spain), ENSA [12] (state owned company specialized in the manufacturing of heavy equipment), TECNATOM [13] (advanced engineering), IDOM (engineering company), Initec-Westinghouse and AREVA. These companies facilitate that their professionals participate in the Master, open internship positions, and/or offer guided visits to their facilities.

CIEMAT (a public Spanish research centre) [14] is participating in the Master, as well, mainly in the area of structural materials for nuclear plants and material degradation, but as well in other topics related with the activities of the centre.

Last but not least, the Master benefits from the collaboration of the Spanish Regulatory Body (Consejo de Seguridad Nuclear, CSN [15]), which contributes with lectures and offers grants to the students through the Argos Chair in Nuclear Safety (in the ETSEIB) sponsored by the CSN.

3. Aims and objectives

The Master in Nuclear Engineering from BarcelonaTECH aims to train competent nuclear engineers ready to assume managerial positions within the nuclear industry or research institutes in the nuclear field. It offers a high quality education for a strategic energy sector, needed of professionals able to work rigorously, accordingly to the Safety Culture and imbued of a high sense of responsibility.

The Master is oriented towards the preparation of qualified professionals, therefore the participation and opinion of the nuclear industry has been essential in the definition of the curriculum and syllabus. In this sense, the collaboration with Endesa has been a fundamental piece of the Master's definition.

Other important strength of the master is the long-standing collaboration existing between the CSN (the regulatory authority in Spain) and BarcelonaTECH concerning nuclear safety. Since safety issues are of utmost importance in the exercise of the profession, this collaboration is deemed essential for the Nuclear Engineering education.

The connection of DFEN professors with engineers of the nuclear plants (active or retired) has contributed as well to the aim of forming well prepared professionals. After years of cooperation in research and technology transfer, and having a large part of the engineers in ANAV been educated at the School of Industrial Engineering of Barcelona, the personal links are strong. Senior engineers (former ANAV employees), with years of experience, have helped both to the development and teaching of part of the syllabus.

The courses are taught entirely in English with a dual aim; first, they can be taken by foreign students and, second, Spanish students will be fully prepared to participate in international projects.

The degree has been designed to help students:

- Achieve a deep understanding of the theoretical and practical fundamentals of nuclear engineering and the technology associated with power production via nuclear fission chain reactions.
- Have both a clear and broad vision of the energy transformation chain of nuclear fuel into its final useable form, from uranium mining to the management of used nuclear fuel.
- Learn the lifecycle of the different installations, from the initial construction to the decommissioning of a nuclear facility.
- Have a deep understanding of regulation and nuclear safety.
- Develop a strategic view of the sector and the ability to comprehend problems and to make decisions.

Students will acquire the competences needed to manage projects that are run within a company: material supply logistics, plant safety and technical management.

Nuclear industry is highly internationalized; with companies from different countries involved in the same project. The presence of students from different countries together with teaching methodologies based on team work, project based learning, etc. allow students to acquire the competences needed to work in a highly demanding field

It is worth mentioning that, since this Master allows the access PhD degree studies, it will contribute to the formation not only of professionals but as well of qualified personnel able to exert research and teaching tasks.

4. Master's programme and methodology

The Master in Nuclear Engineering form BarcelonaTECH is fully adapted to the European Higher Education Area (EHEA) standards, each credit implying 25 h of student work. The Master's duration is 90 credits (European Credit Transfer System, ECTS). The syllabus is organized in required subjects (providing the necessary multidisciplinary training), elective subjects (which students can use to complement their training in different areas of interest), an obligatory internship (in the industry or in a research and development centre), and finally a Master's Diploma Thesis, preferably in conjunction with the internship. Table 1 gives an overview of the distribution of the credits.

TYPE OF SUBJECT	CREDITS
Required	46.5
Elective	13.5
Internship	15
Master's Diploma Thesis	15
TOTAL	90

Table 1: Type of subject and distribution of credits.

The curriculum is organized on the basis of "subject areas". A subject area is understood as the set of content and training activities aimed at the achievement of certain competences that can be conceived in an integrated manner. Table 2 shows the required subject areas and the credits planned for each of them.

Required Subject Areas	Credits
1. Fundamentals of Nuclear Engineering and Radiological Protection	9
2. Nuclear Power Plants	15
3. Fuel Cycle and Environmental Impact	6
4. Regulations and Safety	6
5. Management of NPPs	10.5
Total	**46.5**

Table 2: Credits allocated for the different required subject areas.

The contents of the different subject areas can be summarized as follows:

- Fundamentals of Nuclear Engineering and Radiological Protection: this bloc includes contents in the areas of Nuclear Physics, Detection and Measurement of Radiation and Radiological Protection
- Nuclear Power Plants: the main systems, components and materials of the nuclear and conventional islands of a nuclear power plant are described, with special focus on PWRs. Includes contents in the areas of Reactor Physics and Thermal-hydraulics.
- Fuel Cycle and Environmental Impact: description and justification of the different stages of the nuclear fuel cycle; quantification of the principal source terms of the environmental impact of a nuclear facility and potential doses.
- Regulations and Safety: Spanish regulatory framework; basic principles of nuclear safety and technologies and procedures developed to meet them.
- Management of Nuclear Power Plants: this module includes the operation and maintenance of a nuclear plant, along with design and construction procedures for new plants, the evaluation of costs and the life management.
- Elective Block
  Every year a series of optional courses are offered. Students select 3 of them. During the academic year 2012-2013 the following elective subjects were offered:
  - Fusion technology
  - Instrumentation
  - Non-destructive testing methods
  - Monte-Carlo methods for radiation transport calculation
  - Core design
  - Seminars on management and safety.
- Internship: students are placed in real work situations in companies and thus will work with experts in the field who can offer them both their knowledge and experience. It should enable the development of high-level competences.
- Master’s Diploma Thesis This work should be a synthesis of skills acquired. It will be directed to the assessment of the competences associated to this master’s degree.

All the subjects include a large fraction of active learning and team work. An important part of the learning process takes place in a Project Based Learning framework: students, grouped in small teams of 3 or 4 persons, develop two transversal course projects (one per semester) involving all the required subjects of the semester.

The list of subjects and their distribution in semesters is detailed in Table 3. Subject credits aren’t coincident with subject area credits because course projects are treated as transversal subjects encompassing different subject areas. Figure 1 shows the temporal sequence of the curriculum.

Subjects	Credits
First Semester	
Fundamentals of Nuclear Engineering and Radiological Protection	8
Reactor Physics and Thermal-Hydraulics	7.5
Systems, Components and Materials	6
Fuel Cycle and Environmental Impact	5.5
Course Project 1	3
Second Semester	
Regulations and Safety	5
Management of Nuclear Power Plants	8.5
Elective subjects	3 x 4.5
Course Project 2	3

Table 3: Credits allocated for the different required subject areas.

The evaluation system is an integral and inseparable part of the process of learning. The assessment instruments or activities are integrated into the planning of learning activities, are appropriate to the level of complexity of the learning outcome, are diverse and frequent, and are intended to have immediate feedback.

To achieve meaningful learning, students have to apply their knowledge to realistic situations, in contexts close to the workplace, facing problems whose solution requires making decisions.. So, for each subject the dedication of the student (25 hours per credit, 40% contact, 60% autonomous) is planned based on activities using varied teaching methods, coherent with the learning objectives and in line with the evaluation mechanisms so as to achieve high quality learning outcomes.

The courses combine theoretical and practice-based activities (demonstration classes, self-guided studies, use of calculation codes and laboratory) with guided visits to different nuclear installations. The project-based learning ("learning by doing") greatly facilitates the acquisition of generic competences and motivates future engineers by enabling them to apply the knowledge they acquire to solve realistic problems.

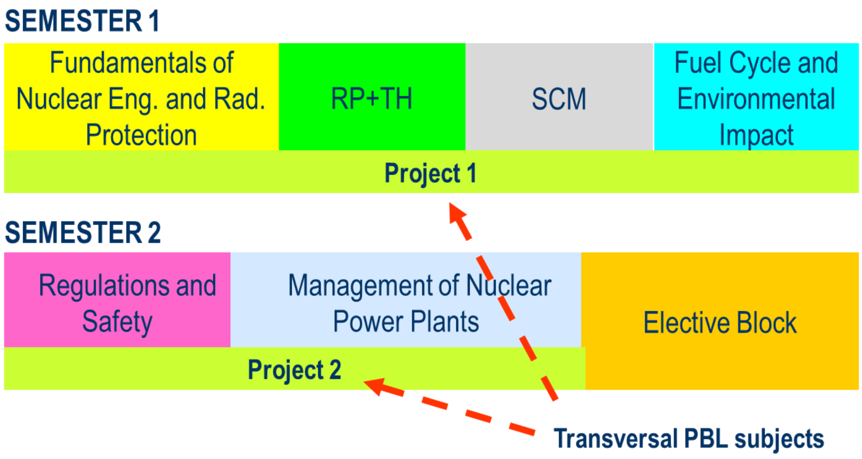

Figure 1: Distribution of the curriculum in semesters.

As mentioned in the previous section, one of the goals of the master is to facilitate the students' transition from university to industry. The internship is part of this strategy, but it is not the only one. About one half of the classes are delivered by lecturers external to BarcelonaTECH (half of them from the industry); this participation is more relevant in subjects like "Management of Nuclear Power Plants" and "Regulations and Safety". In the first two editions of the Master, the list of lecturers has included professionals and researchers from: ANAV, AREVA, Endesa, ENRESA, ENSA, ENUSA, IDOM, Nuclenor, Tecnatom and Westinghouse (all of them from the industry side), the regulatory body (CSN), CIEMAT, F4E, the Spanish National Fusion Laboratory, JRC Petten, Penn State University, Pisa University, Madrid Polytechnic University etc. In total, some seventy people have participated as lecturers in the Master.

Another important activity regarding the adaptation of students to the industry is the participation in a seminar that every year organizes the Spanish Nuclear Society in Madrid. In this seminar the Directors of the Spanish NPP expose their operating experiences during the previous year. This seminar represents the students' immersion in the real industrial world. Endesa sponsors the simultaneous translation to English. Within the Master, this seminar is programmed as an activity of the subject Management of Nuclear Power Plants.

Finally, guided visits to industrial facilities contribute as well to the students' approach to industrial reality. Visits include and one of the power plants near Barcelona, the ENUSA's fuel factory in Juzbado, Tecnatom's headquarters in Madrid, ITER site in Cadarache, three days of practices at the full scope simulator of Tecnatom in Vandellòs and the factory of ENSA in Santander.

5. Balance of the first and second editions

In its first edition 15 students followed the masters and, in general, finished their studies with good academic records.

Eight of these students, of different origins, arrived at BarcelonaTECH through the EMINE program with scholarship awarded by KIC Innoenergy. These students followed, in equal number, the second year of the EMINE in ParisTech and Grenoble INP. The other seven students were Spanish. One of them incorporated into the second year of EMINE. According to the available information, all the students of the first edition (2011/2012) have completed internships at European reference institutions such as CERN, CEA, PSI (Paul Scherrer Institut) in Switzerland, Pisa University (GRNSPG), KIT or the NPL al United Kingdom, and at companies such as AREVA, ANAV and Westinghouse.

Students of the first edition have got their degrees between May and September 2013. Presently they are in remunerated pre-doctoral positions (~15%), seeking for a PhD student position (~ 35%) or looking for a job (~10%); some have obtained a job in the nuclear industry or institutions of the nuclear sector (~20%): Westinghouse, Electricité de France, IAEA; data are missing for the others (~20%).

During the first year valuable information was gathered by means of surveys, personal interviews and meetings with groups of students, which allowed detecting improvement opportunities.

The following important aspects were detected:

- The feedback resulting from the assessment of planned activities not always arrived to the students in time. This probably made their learning process more difficult.
- In some subjects, the students' evaluation system was not clear enough beforehand.

- In some subjects, the workload was not evenly distributed during the semester. It was concentrated towards the end of the term.
- In general, lecturers external to the University should receive an academic orientation regarding the clarity of objectives assessment methods, etc.
- A greater coordination was necessary among the teachers responsible of the different subjects regarding the overall workload distribution and the exams scheduling.

A great deal of the students' suggestions were taken into account immediately and implemented on the go during the first edition of the master. All of them have been introduced in the second edition (2012-2013).

Seventeen students participated in the second edition, thirteen of them of diverse origin came through the EMINE programme, the other four were Spanish. Although in the second edition academic results have been also good in general, not all the students validated all the credits.

EMINE students are now in Paris or Grenoble to take their second year of courses. Spanish students are now in internships at ANAV, BarcelonaTECH (linked to the DFEN PhD program), IDOM and ENDESA.

In general, the students that have followed the first two editions of the Master are satisfied. Students identified, among the most satisfactory activities, the guided visits to industrial facilities.

The students of the two first editions come from worldwide: India (9 students), Ethiopia (2 students), United States, Argentina, France, Italy, Bangladesh, Lebanon, Egypt, Indonesia, China, and Republic of Mauritius. This master is particularly attractive for those students coming from countries with plans to build new nuclear power plants, since the subject "Management of Nuclear Power Plants" covers the most important keypoints of the life of a nuclear power plant, from the beginning of the process till its dismantling.

6. Conclusions

The Master in Nuclear Engineering from BarcelonaTECH has started its third edition. It is foreseen that within few years the demand of highly skilled nuclear engineers will increase. The degree, born from the synergies of different institutions at the Universitat Politècnica de Catalunya (BarcelonaTECH) and Endesa, aims to produce these competent professionals,

The Master's 90 credits (each credit implies 25 hour of student's work) are divided in required subjects (46.5), elective subjects (13.5), internship in a company or research centre (15), and Master's Diploma Thesis (15). The subjects include activities based on active learning and team work. Evaluation system is an integral and inseparable part of the learning process. The Master in Nuclear Engineering is completely taught in English.

The following strengths are identified:

- The focus of the curriculum and syllabus
- The external participation in its definition
- The learning methodology
- The experience of BarceloneTECH in the field of Nuclear Engineering education
- The implication of the Spanish nuclear industry in the Master, that provides an applied approach.
- The implication of the regulatory body
- The high fraction of sessions lectured by external experts.
- The practical visits to sites and installations of interest.

In general, students are satisfied with the Master, which fulfils the expectations of the Industry and which, by producing professionals committed to safety culture, makes a significant contribution to society.

Finally, all the companies and institutions implied in the Master have expressed their intention to keep collaborating in it, specially Endesa, in its clear pursuit of training professionals.

7. References

[1] http://nuclearengineering.masters.upc.edu/
[2] http://www.kic-innoenergy.com/emine/home/
[3] http://eit.europa.eu/
[4] http://www.endesa.com/en/Home
[5] http://www.upc.edu/
[6] http://www.etseib.upc.edu/
[7] http://dfen.upc.edu/
[8] http://inte.upc.edu/
[9] http://www.anav.es/
[10] http://www.enusa.es/
[11] http://www.enresa.es/
[12] http://www.ensa.es/
[13] http://www.tecnatom.es/
[14] http://www.ciemat.es/
[15] http://www.csn.es/

EUROPEAN MASTER IN INNOVATION IN NUCLEAR ENERGY (EMINE), THIRD EDITION ON PROGRESS.

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1. Introduction

The 3th Edition of European Master in Innovation in Nuclear Energy (EMINE) in the frame work of the European Institute of Innovation and Technology –KIC InnoEnergy is on progress.

The experience achieved with master EMINE is presented.

MSc EMINE helps tomorrow's nuclear engineers take up the challenges that the nuclear energy industry faces in terms of safety, social acceptability and waste management. By offering outstanding technical training and addressing the economic, social and political issues of nuclear energy, the programme broadens the scope of traditional nuclear education**.**

2. Programme Description

As a significant contributor to energy supply security and diversity, the nuclear industry is a key component of EU energy policy. For example, the price of nuclear electricity is competitive and predictable, and carbon emissions are low and comparable with the best renewable. Nuclear energy is also a potential low-carbon substitute for fossil-fuel-based combined heat and power production.

MSc EMINE will help provide the industry, which already employs around 400,000 people in Europe, with the highly-qualified engineers required to meet the ambitious nuclear expansion plans that many countries are now drawing up. Its students receive the high-level technical education they need to master the engineering complexities of nuclear power generation, as well as business training related to innovation issues and energy management.

The programme thus helps students integrate the technical aspects of the nuclear industry with key political, economic and social issues.

3. Industrial Partners

The uniqueness of EMINE lies in the involvement of its industrial partners. Four major players of nuclear energy, AREVA, EDF, ENDESA and Vattenfall take active part in the master.

The CEA is also actively involved in EMINE, bringing thus its expertise as one of the most important research centres in Nuclear energy in Europe.

Figure 1: EMINE Industrial and Academic partners.

4. Programme content

The two-year (120 ECTS) MSc EMINE programme teaches students about energy management issues and gives them in-depth knowledge of the nuclear industry. The first year is spent learning the fundamentals of nuclear engineering plus safety and radiation protection as well as the design and management of power plants, all mandatory for any nuclear engineer, at either of the following locations:

- Royal Institute of Technology (KTH), Stockholm, Sweden
- Technical University of Catalonia (UPC), Barcelona, Spain

MSc EMINE also includes mandatory international mobility among recognized universities in Europe. A second year is spent at either of the following:

- Grenoble Institute of Technology (Grenoble INP), France
- ParisTech, France

Grenoble INP offers specialization in Materials Science for Nuclear Energy with two options: Fuel or Components.

At ParisTech, five options are available:

- Nuclear Reactor Physics and Engineering
- Nuclear Plant Design
- Operations

- Fuel Cycle
- Decommissioning and Waste Management

At the end of the first year, students from both UPC and KTH gather at a summer school at Grenoble Ecole de Management (Grenoble, France) to discuss and dissect innovation issues in energy markets in general and nuclear in particular.

During their second specialization year, students have the opportunity to gain a closer insight into innovation issues through a live case study where they apply a methodological 'learning-by-doing' approach in projects coached by KIC InnoEnergy. After completing their second year, students perform a master thesis at an industrial group or research laboratory.

As a result of this approach, MSc EMINE students gain a deep knowledge of what innovation is all about and acquire the soft skills very much appreciated by employers e.g. creating problem-solving solutions or developing fresh initiatives.

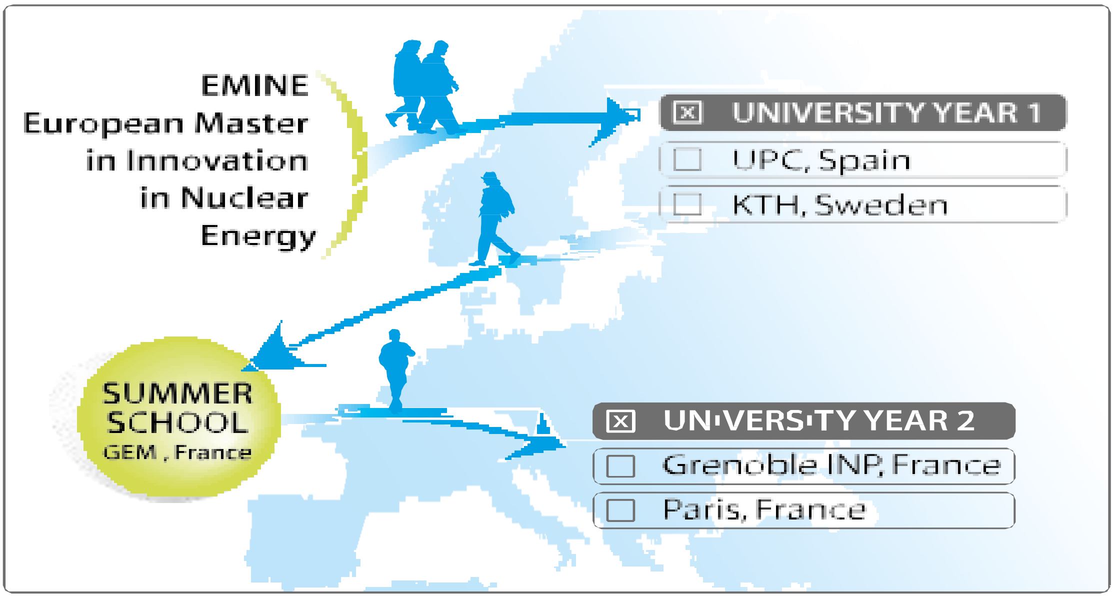

Figure 1: EMINE track programme.

Furthermore, the involvement of leading actors from the European nuclear industry helps EMINE's students benefit from professional conferences and lectures as well as in-house training at key research centres.

5. Career opportunities

The EMINE programme leads to a comprehensive understanding of the stakes of the nuclear business. It opens a path towards a wide range of positions in the industry, from design and construction, to operation and maintenance, decommissioning and waste management.

As MSc EMINE engineers are trained in soft skills, they are also able to evolve in management positions. In addition to a career in industry, EMINE students can also pursue a research career leading to a PhD degree.

6. Requirements

Applicants must have completed a Bachelor of Science or Bachelor of Engineering or equivalent degree that provides a solid background in electrical engineering and/or Physics and/or Chemistry and/or Mechanics and/or Materials Science.

7. Conditional acceptance

Students in their final year of undergraduate education may also apply and if qualified, receive a conditional offer. If you have not completed your studies, please include a written statement from the degree administration office (or equivalent department), confirming that you are enrolled on the final year of your education and giving your expected completion date. If you receive a conditional offer, you should present your degree certificate to the InnoEnergy Admissions Office before your admission in a specific programme can be formalized. The InnoEnergy Admission Office will forward this to your programme, and appointed Year 1 university, such that your admission can be completed.

8. English proficiency

All the progamme is in English.

All applicants must provide proof of their English language proficiency, which is most commonly established through an internationally recognized test such as TOEFL, IELTS or University of Cambridge/ University of

Oxford Certificates.

9. Funding details

KIC InnoEnergy grants scholarships to selected students. Scholarships include a monthly allowance during the 24 months of the training, as well as travel and installation costs in the case of non-European students. Students awarded a scholarship will have their tuition fees covered.

10. Accreditation

On completion of the EMINE programme, a Master of Science degree will be awarded from the universities where studies were performed during year one and year two, i.e. a double-degree. A diploma from KIC InnoEnergy related to innovation and entrepreneurship will also be presented.

11. Students:

The students in the tree first editions are from:

France, Spain, USA, India, Lebanon, Argentina, China, Egypt, Indonesia, Italy, Mauritius, Ethiopia, Bangladesh. Montenegro, Germany, Poland.

Figure 3: EMINE students in several activities.
For more information:
http://www.kic-innoenergy.com/emine/home/

THE "DECOMMISSIONING AND WASTE MANAGEMENT SUMMER SCHOOL" AT THE JOINT RESEARCH CENTRE IN ISPRA, ITALY

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ABSTRACT

The Joint Research Centre of Ispra, one of the research sites belonging to the European Commission, Directorate General JRC, was created in the late '50s, in order to support European research related to the civil use of nuclear energy, focussing on safety, safeguards and security aspects. It currently hosts a number of nuclear facilities, some of which are maintained in operation, while others were shutdown in past years or are currently being decommissioned. The Ispra site hosts almost 2500 workers, among which around 400 internal and external workers, operate daily in radiologically designated areas, performing activities related to decommissioning, nuclear waste management, nuclear security research and radioisotope production.

The JRC-ISPRA has been the organiser for many years of the ESARDA courses on nuclear safeguards and non-proliferation, which enjoys academic recognition through the ENEN. The Nuclear Security unit also provides a large set of training courses to nuclear safeguards inspectors and to border security personnel. At the local site level, a radiation protection training programme (based on classical conference teaching and OTJ training) was launched in 2009 by the Radiation Protection Sector of the Nuclear Decommissioning Unit, covering general and specific training on radiological risks and on JRC-ISPRA facilities, and more general conferences are offered on radioactivity and radiation for visitors, schools and the public visiting the site during "open days".

A specific need has emerged in recent years for education and training (E&T) in the field of decommissioning and radioactive waste management (D&WM) field: according to international institutions, it will become increasingly necessary, in the future, to address this need, also taking into account the global reduction in the number of competent persons in the nuclear workforce.

The E&T need in decommissioning and radioactive waste management has been recognized and addressed *via* a specific training action: the "*Summer School on Decommissioning and Waste Management*", a joint initiative of the University of Milano, the IAEA , the Joint Research Centre of Ispra and the Italian Society for Radiation Protection (AIRP)**.**
The School targets both internal JRC professionals, who already daily operate in the field of D&WM, and external students/professionals. During the Summer School, site visits and hands-on training take place in the JRC-ISPRA waste management facilities, which provides a unique opportunity for students and professionals to become familiar and gain experience in the field by receiving both theoretical lectures and direct practical application. Moreover, lecturers from many European companies and institutions present state of the art of specific developments in characterisation, clearance procedures, decontamination, dismantling, waste storage, etc. The paper will describe the history, content and organisation of the D&WM Summer School.

1. Introduction

A joint education and training initiative between the IAEA, the Joint Research Centre of the European Commission, the University of Milano and the Italian Radiation Protection Society (AIRP) was started in 2009: the "**Summer School on Nuclear Decommissioning and Radioactive Waste Management**". This event contributed, during its five editions, to the training of more than 300 professionals in D&WM from more than 100 Institutions/Companies.

After two initial years in which the Summer School (DSS) was held in the University of Milano buildings, with a single-day visit to the Joint Research Centre in Ispra (JRC-ISPRA), since 2011 the DSS has been entirely held in the JRC-ISPRA site, profiting both from its nuclear facilities in the process of decommissioning, and of the availability of various radiological facilities for radioactive waste management and for demonstration purposes.

Although the training format chosen (frontal lessons + visits and demonstrations) has proved to be very successful throughout the five initial years, also confirmed by participants' feedback, an evolution of the DSS is foreseen in the next years. It will in the future also involve the development of a real case-study, and a more active participation of the attendees in the preparation of safety case for decommissioning and waste management as the collection of arguments that contribute to demonstrate the safety of facilities and activities.

With this new format, The Organising Committee foresees that the DSS will more effectively help students and young professionals in the field of decommissioning and radioactive waste management (D&WM) (the attendee target group) to actively develop their personal skills and competences.

2. Emergence of D&WM training needs

D&WM is an important emerging subject for the nuclear industry, and will become more and more important during the next years, also considering the ageing of existing nuclear power plants and of radiological installations, and the projected gradual reduction in use of nuclear power in some countries.

According to the NEA [1] "i*n some countries, such as the United Kingdom - in recent years, the decommissioning sector has formed the largest part of the civil nuclear workforce*".

However, D&WM has only since recent years been covered in some university courses, and only recently some specific modules have been made available in masters programmes.

An important training need in this field does in fact exist, according to some evaluations [1], and will even increase in the coming years with the emerging D&WM market, which adds to the well-known European and world-wide concern over competent workforce reduction, caused by departures to pension of many experienced persons [2, 3, 4, 5].

The availability of the DSS, an event open without any fee or limitation in the number of participants, is addressing some of these concerns, and following recommendations of the international nuclear E&T market, as reported by the NEA [1]:

- (Recommendation 4) *Access to research facilities suitable for education and training purposes should be widened and international co-ordination for such uses should be enhanced. Efforts should be made by governments to financially support existing infrastructure*
- (Recommendation 6) *Research facilities should work with industry and academia to create opportunities for more effective use of research facilities so as to enhance education and training*

The European Commission JRC-ISPRA, recognizing the necessity of a proper evaluation of training needs in D&WM, intends to organize a technical seminar, aimed at identifying stakeholders in the field, and at collecting the views of professionals and universities and requests and suggestions.

Moreover, as the DSS can be considered part of the "vocational training pipeline", efforts are underway to validate and accredit its E&T value, via formal university procedures.

In this sense, the DSS Organising Committee is well aware of the recommendations of the European Council and of the European Parliament ([6], [7]) and of the work being done at the level of ECVET for the preparation of an ECVET-oriented taxonomy of nuclear jobs [8], also considering D&WM jobs, and is actively participating in its development.

3. Training facilities and education and training experience at the JRC-ISPRA

The European Commission JRC-ISPRA is a Directorate-General of the Commission, providing independent scientific and technological support for EU policy-making. The JRC-ISPRA site was founded in 1958, after signature of the EURATOM Treaty of Rome, in order to foster research on nuclear applications and technologies: its mission and roles evolved throughout the years and presently nuclear research is only a limited part of its various activities.

The JRC-ISPRA site is the third largest Commission site after Brussels and Luxembourg. It covers an area of 167 hectares and has 36 km of roads and 6 km of perimeter fencing. There are around 250 buildings hosting some 1 800 site staff plus typically 500 staff of external companies and up to 200 daily visitors. The JRC-ISPRA hosts nuclear facilities awaiting decommissioning (two research reactors, three hot cells laboratories, a radioactive liquids treatment station, etc.), facilities already in the decommissioning process (a radiochemistry laboratory, old deposits for radioactive waste, etc.), waste management facilities in operation (a solid waste characterization, treatment and management station, a new radioactive liquids treatment station, a new interim storage facility, RW characterisation facilities, two decontamination facilities, etc.), and research facilities which are in operation (the Cyclotron Laboratory, the Performance Laboratory (PERLA), the PUNITA, EUSecTRA and ITRAP Laboratories, etc.).

Since 1999, with the adoption of the "*Nuclear Decommissioning and Waste Management Programme*" -a process which will span over a few decades-, JRC-ISPRA is committed to progressively reducing its nuclear liabilities, releasing from regulatory control all classified areas which were accommodated nuclear activities in the past, and eventually assigning them to conventional research activities, without any radiological constraints.

JRC-ISPRA accounts for more than 20 classified zones for radiation protection purposes, and the number of occupationally exposed workers operating in JRC-ISPRA is around 180 internal staff and around 180-200 external staff (depending on specific projects), employed by 25-30 specialised external companies.

A long experience in E&T exists since many years at the JRC-ISPRA: this is linked to the original mission of the JRC-ISPRA, to disseminate knowledge on nuclear topics and harmonize nuclear culture in Europe, but was enormously developed throughout the years, especially in the fields of nuclear safeguards, nuclear materials' management, and nuclear security [9], e.g. the ESARDA workshops.

From a local point of view, some E&T experience also exists in the field of radiation protection, partly due to obligations regarding continuous training to internal and external occupationally exposed workers in the field. In 2009 a new training course catalogue was been established featuring around 40 courses, which are continuously given to occupationally exposed workers throughout the year, alternatively in Italian and in English, and are regrouped in a one-week session once per year [10].

The JRC-ISPRA site is therefore an excellent environment for E&T given the possibility to offer to students both training experience and modern infrastructures for event management and frontal lessons; and the possibility to actively visit site works and laboratories in which decommissioning and radioactive waste management operations are undertaken on a daily basis.

Moreover, many training activities, including the DSS, fall under the dedicated nuclear training and education programmes in the frame of the European Nuclear Safety and Security School (**EN3S**) of JRC's Institute for Transuranium Elements.

4. The original concept of the "Summer School" and the organizing Institutions

The first edition of the DSS was a concept developed by some professionals of D&WM and of the radiation protection fields, who agreed to start that event based on their perception of a specific training need.

The original concept of the DSS, which has been basically conserved up the most recent editions, was to combine frontal lessons with practical demonstrations.

It was originally a three-days event whose sessions were mostly addressed to radioactive waste management and also presented an overview on European experience and a visit to some RWM facilities in JRC-ISPRA.

The sessions in the three-days first edition (DSS2009) were:

1. Radioactive waste and risk associated
2. Principles in waste management
3. European Experiences
4. Practice in waste management and research
5. Visit to the JRC-ISPRA Decommissioning project

The Organisations sharing the first DSS2009 were: the **University of Milano** (Marie-Claire CANTONE), the **IAEA** (Phil METCALF), and the **JRC-ISPRA** (Celso OSIMANI): Marie-Claire and Celso also represented, and in fact involved, the Italian Radiation Protection Society (**AIRP**).

The second edition, DSS2010, featured three sessions, and spanned over four days:

1. Radioactive waste and risk associated
2. Radiation protection and policy issues
3. Principles and experience in decommissioning and waste management

It comprised a more detailed visit to the facilities at JRC-ISPRA, allowing students to appreciate the complex infrastructure needed for waste characterisation and treatment.

In 2011, the 3rd edition of the DSS was entirely held at the JRC-ISPRA: its duration was maintained to four days, but the number of sessions and topics available were significantly increased. The change in the DSS's format addressed more operational aspects in D&WM, as recalled in the title of the DSS itself, which was modified from the original "*Criteria and approaches for radioactive waste management and nuclear decommissioning* " to: "*Operational issues in radioactive waste management and nuclear decommissioning*".

Sessions available in DSS2011 were:

1. Initial characterization, dismantling and demolition
2. Stakeholders' Involvement
3. Hands-on Visit to JRC-ISPRA's WM Facilities
4. Seminar: Final Radiological Survey
5. Operational Decommissioning Experience in Europe
6. Radiation Protection
7. Waste Management


Figure 1, Pictures from DSS2011 JRC-ISPRA visits

For the first time a demonstration in the waste management facilities allowed students not only to follow explanations of measurement techniques but to perform themselves some basic, *a priori* selected, operations on the JRC-ISPRA installations.

Moreover, recognizing the opportunity to focus every year on a more specific subject, a half-day seminar on the issues regarding "*Final radiological survey*" after decommissioning was proposed to the attendees.

In 2011, it was considered that the DSS format had reached a good level of maturity, and was replicated in 2012 and 2013 with minor changes in a more consolidated form.

5. The consolidated format of the "Summer School"

In 2012 and 2013 the DSS spanned over five days offering in both editions six topical sessions:

1. SESSION 1 – Involvement with society and stakeholders
2. SESSION 2 – Radiological characterization and facility release; regulatory issues
3. SESSION 3 - Hands-on visit to JRC-ISPRA WM facilities
4. SESSION 4 - Radiation protection
5. SESSION 5 - Operational decommissioning experience in Europe
6. SESSION 6 - Waste management

Every session was preceded by an opening lecture offering more insight in its specific field.

For DSS2013 additional Laboratory visits were foreseen: not only to the JRC-ISPRA waste management facilities, as in previous editions, but also on specific facilities belonging to the Institute for Transuranium Elements (ITU) i.e. the PUNITA Laboratory (detection of small amounts of nuclear materials and characterization); to the 3D Laser Laboratory (reconstruction of images and detection of change); and an introduction to the use of the NUCLEONICA software in D&WM with interactive exercises jointly developed online by the lecturer and the participants.

6. Participation and feedback to the "Summer School"

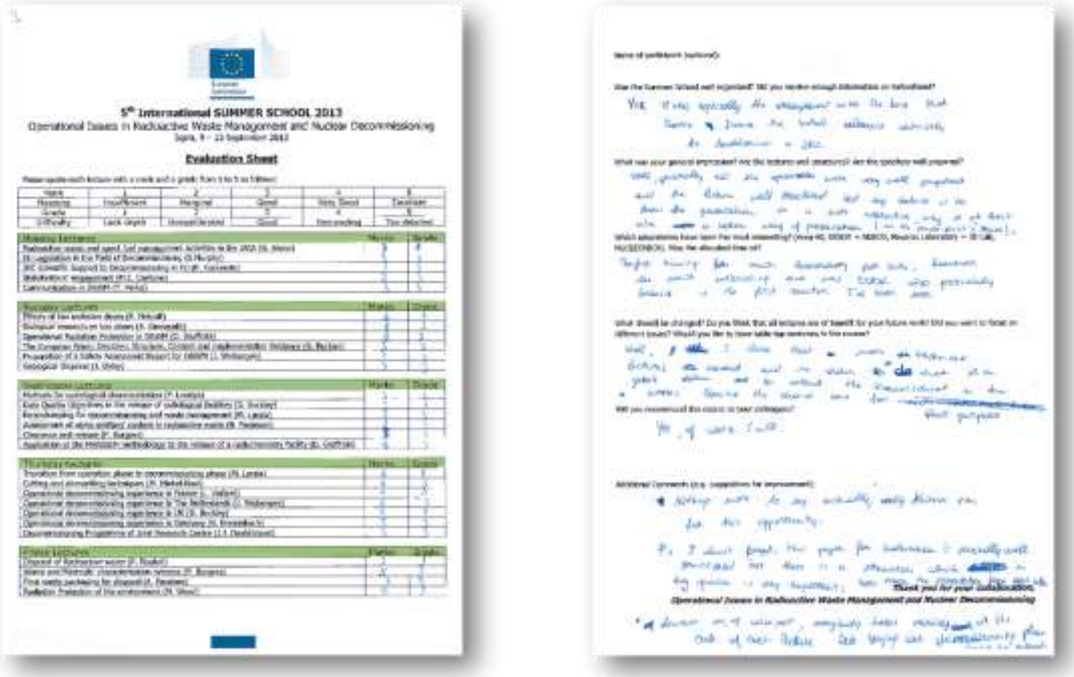
Participation to the DSS events has always been very rewarding for the Organizing Committee: number of attendees, in fact, were:

- 2009 edition: limited to 30 participants, 30 registrations
- 2010 edition: limited to 30 participants, 30 registrations
- 2011 edition: limited to 100 participants, 100 registrations
- 2012 edition: limited to 100 participants, 87 registrations
- 2013 edition: limited to 100 participants, 71 registrations

An important number of institutions/companies were sending representatives to the DSS: 12 for the 2009 edition, 16 for 2010,, 51 for 2011, 34 for 2012 and 25 for 2013.

The DSS lecturers came from 14 different institutions/companies in 2009, from 13 in 2010, 16 in 2011, 19 in 2012 and in 2013.

According to the evaluation sheets distributed and collected feedback from participants was very positive encouraging further developments of the DSS in the same directions. In previous editions they helped to focus possible improvements and additions to the programme, namely on economic aspects and on informatics applications/demonstrations.


5th International SUMMER SCHOOL 2013

Operational Issues in Radioactive Waste Management and Nuclear Decommissioning

Evaluation Sheet

Figure 2, Examples of evaluations sheets

The following picture shows the average appreciation mark (on a range 1 (low) to 5 (maximum) for different DSS2013 lectures: it is interesting and a positive information that the appreciation of attendees rises as the DSS is unfolding.

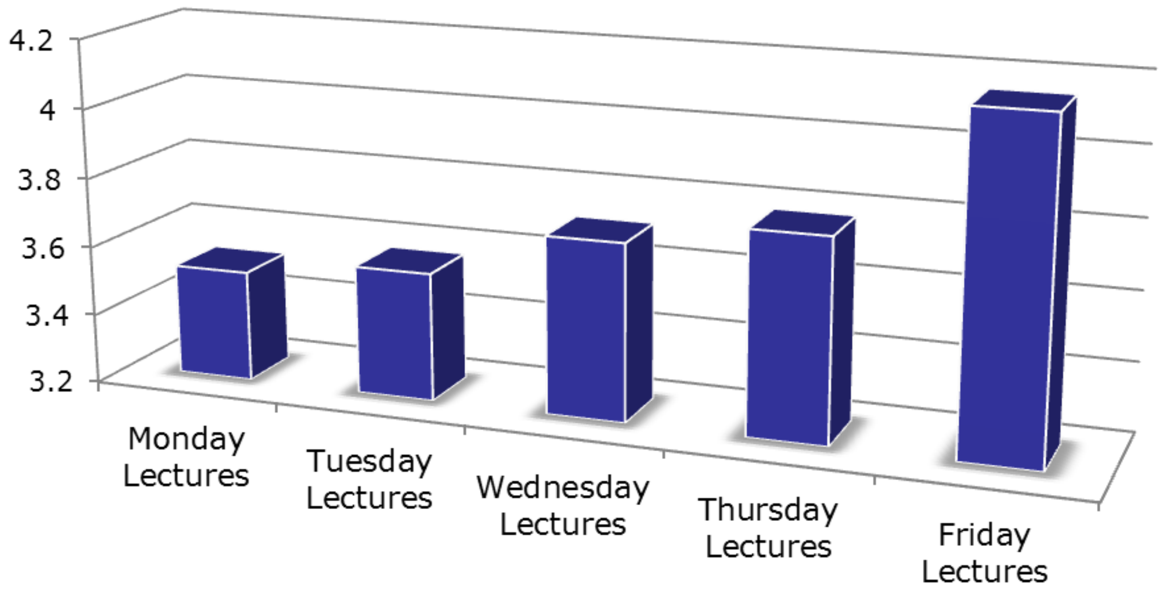


Figure 3, Average lectures' appreciation (1 to 5)

"Difficulty evaluation" is another interesting indicator, showing how the level of every single presentation (from the technical point of view) is perceived by participants, and if it suits their expectations and competences: the following table contains average participant evaluations, and is evaluated on a different range: 1 being "too simple", and 5 being "too complicated".

Day	Session	Average indicator
Monday 9th	Involvement with society and stakeholders	3,15
Tuesday, 10th	Radiation Protection	3,12
Wednesday, 11th	Clearance, characterization and Release	3,32
Thursday, 12th	Decommissioning	3,12
Friday,13th	Waste Management	3,11

Table 1 , Participant evaluations of lecture "difficulty"

Again, the positive indication coming from this evaluation is that lecture levels were not beyond the average level of expectation and of competence of participants.

7. Future evolution of the "Summer School"

Possible evolution options for the DSS format are under study: this will imply an important change in future DSS duration and structure, and a considerable additional amount of preparatory work for lecturers and tutors.

A possible evolution of the DSS may consider a more direct and active involvement of participants in the development of a (previously prepared) “Case Study”. The *case study* could possibly be chosen from amongst the JRC-ISPRA nuclear and radiological facilities. The facilities would be visited in the previous days and the basic radiological and engineering data would be made available to the participants (after proper security clearance!). During the DSS week, after morning lessons participants would be divided in groups and requested to develop the safety case, with the help of tutors,. This will consider different aspects namely; decommissioning activities, waste management, clearance and site release, and stakeholder involvement. For each topic both safety demonstration and technological aspects will be taken into account. Finally, a public presentation to the participants of the work developed by each single group would allow a deeper discussion with tutors and a larger involvement of the students in the safety case.

Another development under consideration is the possibility to increase the duration of the DSS to 8 working days, including a weekend, and separating more basic lectures in radiation protection, decommissioning, and waste pre-disposal and disposal (a sort of *refresher courses* for more experienced participants and an *introduction* for those with less experience. This new organisation hence, will better specify the DSS target group, "*young professionals in the D&WM field*", and help in setting the scene for the safety case development in the following week.

This possible new format would entail a large amount of preparatory work and is still under discussion.

Figure 4, Some Participants and Lecturers in DSS2010

8. References

1. Nuclear Education and Training: From Concern to Capability, NEA No. 6979, Nuclear Energy Agency, Organisation For Economic Co-Operation And Development, 2012
2. "Managing Nuclear Knowledge: Strategies and Human Resource Development", Summary of an international conference, 7–10 September 2004, Saclay
3. "On nuclear training and education prospering from the EURATOM Treaty", Greet Janssens-Maenhout, Pascal Daures, Willem Janssens, Ulrik Von Estorff, Asuncion Fernandez Carretero, Atoms for Peace: an Int. J., 2009 Vol.2, No.3, pp.281 - 295
4. Putting into perspective the supply of and demand for nuclear experts by 2020 within the EU-27 nuclear energy sector", European Commission, Joint Research Centre. EUR 25291 EN
5. "Shortage of qualified EU nuclear personnel", Veronika Simonovska and Ulrik von Estorff, Joint Research Centre, Nuclear Engineering International, April 2013
6. 2009/C 155/02: Recommendation of the European Parliament and of the Council of 18 June 2009 on the establishment of a European Credit System for Vocational Education and Training (ECVET), Official Journal of the European Union
7. (2008/C 111/01): Recommendation of the European Parliament and of the Council of 23 April 2008 on the establishment of the European Qualifications Framework for lifelong learning, Official Journal of the European Union
8. César CHENEL RAMOS: The Preparation of an ECVET-oriented Nuclear Job Taxonomy: Concept and Progress Report, Report EUR 25644 EN, European Commission
9. W. Janssens, M. Scholz, T. Jonter, M. Marin Ferrer, A. De Luca: "Nuclear Safeguards and Non Proliferation Education and Training, initiatives by ESARDA, INMM and JRC"
10. Daniele GIUFFRIDA, Celso OSIMANI: "Radiation Protection Training Programme at the EU Joint Research Centre in Ispra, Italy", ETRAP 2009 proceedings

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