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SPANISH EXPERIENCE IN NUCLEAR EDUCATION AND TRAINING

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The Spanish Nuclear Society has provided valuable services to nuclear education and training to the large and varied nuclear workforce responsible for the safe and reliable operation of the Spanish nuclear fleet, its contractors and service and equipment suppliers. Since its inception, the Society has promoted, supported and contributed to nuclear education and training during its General Annual Meetings, in organizing specific informative and training courses and through its official monthly publication Nuclear España. The Society has been present in most of the activities described below.

1. The early years

The decision of a country to develop a nuclear power programme, establish a moratorium on new builds, decide to close or renew the operating plants is taken by the government upon considering the advantages, as well as the technical and economic demands and international requirements that nuclear energy implies. This decision requires a high level of understanding and experience, which is generally absent in new entrant countries. Valid advice is obtained from the International Atomic Energy Agency and other international organizations. In all cases, it is highly recommended that a team of nuclear experts on nuclear legislation, economics, technology demands, international requirements and education and training needs is promptly created.

In the early days**,** in Spain**,** as in many other countries, a National Nuclear Energy Board was created in 1951. In 1964 the Nuclear Energy Law was enacted. The law created an Institute for Nuclear Studies, strongly connected with some of the most advanced universities, where courses on the different aspects of nuclear science and technology were conducted, in cases with the participation of foreign experts. A wise policy of mobilisation permitted Spanish experts to be trained in the most advanced countries mainly France, the United Kingdom, United States and Germany. This effort permitted the country, in 1972, to have in operation the three units of the so called first generation of nuclear power plants.

2. The years of euphoria

In 1972 the government promulgated an ambitious National Electrical Plan which envisaged the development of 15 GWe in 11 nuclear units. That Plan prompted the electrical utilities to look for suitable sites and prepare for issuing international bids to then suppliers. Close to 20 different sites were selected for license and prospection for sites were done along the Spanish coasts and in the major rivers. The utilities decided to jointly establish a bid for six units to enter into operation from 1982 to 1986. Four of these six units, Almaraz I and II and Ascó I and II, were built and are in operation. Apart from these four units six additional units were proposed and all of them started construction but only three of them reached operation, Cofrentes, a GE-BWR/6in operation since 1985; Vandellós II, a W-PWR-3L in operation since 1988, and Trillo I, a KWU-PWR-3L, in operation since 1988.

2.1 Training on site selection

In my duties as professor of Nuclear Technology, I used to take my young students to visit nuclear proposed sites. When visiting nuclear sites under characterization, the students were surprised by the extraordinary efforts under development to understand the physical parameters of the site, including seismicity tests, soil morphology and composition analysis, current and extreme meteorology and hydrology, communications, population distribution, use of the land and radiation background.

They soon realized that the geology of the site had to be compatible with the demands of the plant and that the earth science and technology experts also needed to have a good understanding of the nature and demands of the plant. It was also noted that the site characterization was conducted by national experts using national machinery for the simple reason that nobody knows better the characteristics of the site and its surroundings than the national experts. The only additional specific training that the Spanish experts on the earth sciences needed was on the strict safety requirements from the site of the nuclear power plants. Through that observation it was born the national commitment on increasing as much as possible the national participation in sitting, design and construction of the power plants, which at the end of the process was closed to 90 %.

2.2 Training on design and construction

When visiting plants under construction, the reaction of the students was always the same, they were surprised by the deep excavation, the dense net of reinforcing rods for the thick concrete structures and the large dimension, weight and transport difficulties of some of the components, such as pressure vessels, steam generators, pipes and pumps. They also acknowledged the large number of people participating in the construction and the many skills required. They also were surprised by the complexity of the construction and on the need of a strong and superior management system.

Sometimes I requested the students to be briefed by the engineer responsible for quality control for them to appreciate the extraordinary control on welding, concrete pouring and laying pipes and electrical cables, as well as the certification of *passed for duty* of materials and components.

After formulating their observations, the students complained that reality did not mach my teaching efforts on nuclear science and technology. I have to defend myself by explaining that the design, construction, procurement and assembly of the large structures, complicated systems and huge components have to be done by civil, mechanical, electric and electronic engineers with a basic knowledge of the nuclear application demanding such new structures, systems and components. In essence, these engineers have to be nuclearized. Likewise, I also had to explain that the extreme quality control on skills and materials were necessary to ensure the needed safety and reliability I was preaching on in my lectures.

Nuclear euphoria was a clear incentive to create a large number of new activities in existing and new companies, ready to provide services and equipment. It was of relevance the creation of two national companies, ENUSA to manufacture nuclear fuel, and ENSA, with capacity to design and build heavy equipment, including assembling reactor pressure vessel and steam generators and to build spent fuel containers, among other products. They were also a multitude of enterprises ready to supply turbines, electrical equipment such as generators, transformers, motors and cables, all types of valves, pipes and tanks, among other pieces of equipment. A long list of services were also established, mainly engineering companies ready to participate in the design of large parts of the plant and provide quality control and other types of services. All these activities required a long list of engineers with knowledge of nuclear codes and standards and relevant experience, mainly acquired during the design and construction of the first units.

To train these *nuclearized engineers* the already mentioned Institute for Nuclear Studies conducted first two year, later on one year, courses on basic nuclear technology. Likewise the curricula in the mayor technical faculties offered courses on nuclear science and nuclear technology which provided a sufficient number of nuclearized engineers. A few of them were offered the chance of attending nuclear courses in foreign universities.

2.3 Training on operation

When visiting plants under operation, the students were astonished by the strict entrance controls, the need to be escorted by a plant official who first explained the actions to be taken in case of an emergency. When the plant was in normal operation, they noticed that the visit was limited to a few places of less interest. For PWRs and BWRs the turbine hall (generally no for BWRs because of residual radiation carried with the steam), some auxiliary buildings and the ultimate heat sink were generally visited, entrance to the main control room and spent fuel building was limited to only a few people and entrance within the containment strictly prohibited. They were disappointed with those restrictions and heavily protested against that. I had to explain that safety and security reasons prohibited such entrances.

Those that had a chance to visit the main control room were surprised by the limited number of operators, the complexity of the control panels and the silence and order of the people working there. Those who entered into the spent fuel pool commented on the extraordinary radiation controls, the need to dress overalls, hardened shoes and hats, globes and other individual protection devices, as well as to secure that the visitor will not loose any foreign material.

In all cases, the students noticed that very few people were seen around buildings and they did not believe that there would be a few hundred people working in the premises at that time. They also appreciated the discipline and the order that was present in the plant. They recognized that the operating plant was very close to the theory they were learning mainly on nuclear safety and radiation protection.

After the visit, during the debriefing session, we had the opportunity of discussing what they have learned. The most appreciated issue was about the order and discipline that they observed and the needed leadership that was considered necessary to achieve that. It was explained to them that work in the operation of a nuclear power plant was similar to that of a symphony orchestra, but with hundreds of players at the same time. There was a conductor, the plant director; a first violin, the management line, and the players, the many skills necessary to keep the plant in a safe and reliable condition. There was also a kind of musical script, the operating procedures for the different operational modes. It was also clarified that the plant operation is a continuous concert which has to last for sixty or more years, since commissioning to decommissioning, 24 hours a day, only the players work in turns.

In one occasion we have the rare opportunity of visiting a plant during an outage for refuelling. That gave us the opportunity of a brief visit to the reactor containment. At that time there were close to one thousand people working at the plant at a given time; nevertheless, although a large number of people were seen all over the place, the same order and discipline than in normal operation was observed. The most repeated observation related to the management of so many people performing hundreds of different activities at the same time. It was explained that any outage is well prepared, months in advanced, all activities are previously closely defined and scheduled to avoid interferences and a lot of training is performed to make it sure that the plant staff and the contracted companies knew with precision what to do, how it should be done and how to prove that it was done correctly.

Nuclear engineering is clearly seen in any operating nuclear power plant and during an outage, but the students very early discovered that the type of nuclear engineering demanded during operation was not the one most of them wanted to undertake, mainly because it was not perceived as creative, as in design or research; the operating persons are given the operating procedures and all they have to do is to play them in tune. It may take them more than four years to obtain the necessary initial knowledge and experience, mainly working in simulators, and the operators have to comply with a continuous effort in keeping their abilities.

The plant owners soon realized that the current university courses were not sufficient and that the operating personnel needed a different type of training, very close to the plant they have to operate. The Electrical Utilities with nuclear interest promptly recognized the need and decided to convert the old Tecnatom in a company owned by them to provide engineering services for the new builds mainly in the areas of training, quality assurance and in-service inspection. To that purposes Tecnatom acquired two simulators for the PWRs and BWRs already being built, as well as in-service inspection equipment for large components, namely reactor pressure vessels and steam generators. Tecnatom decided to develop its own technology through an intense successful period of research and development to gain technology independency.

3. The nuclear moratorium

The1984 National Energy Plan established a moratorium on the construction of new nuclear power plants and cancelled the construction of five nuclear units, some of them in an advanced status of construction. This decision was a tremendous blow to the previous euphoria and limited nuclear activities to maintaining the operation of the current eight units. Since that time, no new nuclear utilities have been built or proposed in Spain.

The Plan also created an independent regulatory authority, the CSN, from the former Department of Nuclear Safety in the Nuclear Energy Board then charged on licensing and inspection. The Plan converted the Nuclear Energy Board in a National Research Centre for Energy, Environment and Technology, CIEMAT, with the dismantling of most of the nuclear research facilities. The Institute for Nuclear Studies was converted into an Institute for Energy Studies. The Plan also created a national institution for waste and spent fuel management, ENRESA, and declared open the nuclear fuel cycle.

The moratoria substantially decreased the interest for nuclear studies and the number of university degrees dwindled considerably. Only the new regulatory body and the national agency for waste management were active in demanding graduates for their activities. To serve that purpose, the Chair of Nuclear Technology in the Engineering Faculty of the Madrid Polytechnic University created a successful 50 hours course on radioactive waste management, under the auspices of ENRESA and with the help of CIEMAT, which is maintained along the years.

Tecnatom, forced to limit their activities to provide services to the plants in operation, decided to intensify their international activities through cooperation with the IAEA, INPO; EPRI and other international institutions. The international activities of Tecnatom in training and in-service inspection amounted in 1990 to about 40% of the total.

3.1 Education and training for the regulatory body

The creation of the regulatory body increased the need for training on nuclear safety and radiation protection. The regulatory body has to provide the limits and conditions under which the license holder has to select and characterize the site, review design and construction, oversight commission, operation and decommission of the plant. It has to do it through a satisfactory and complete set of regulations. It also has the duty of oversighting all these activities though an elaborated programme of permanent and selected inspections and periodic safety reviews and operating experience.

When visiting a plant in operation, my students were told that the plant in operation is constantly observed by the regulator, that each player has to be in tune with the procedures that the player will be dismissed from the team when deviating and that the whole orchestra will be penalized, that is the plant license holder. Any of the many physical variables must have a clearly specified value margin; any unforeseen deviation of the limit of any of the variables puts the whole system out of tune and the whole operating orchestra is in disarray until the initial desired situation is recovered.

When these functions are presented to students, they expressed two different opinions. On one side, having that authority pleases many of them; on the other side, this type of policy work is not considered attractive to others. It has to be explained that regulatory work is aimed to assure that the power plant does not represent any unacceptable risk to the health and safety of the workers, the surrounding population and the environment. The regulatory body has to act independently from any other type of interest; formally respond to any application for a license and respect the intentions and desires of the applicant when formulated in accordance with the established regulations.

The regulatory functions are close to courts of justice so that the following attributes are considered of paramount importance: independence of judgement, respect for the interest of the regulated and knowledge of the subject to be regulated. This implies that education and training of the regulatory body is bounded by three requirements: 1) an in depth and well balanced knowledge of nuclear science and technology and consolidated experience on the different phases in the life of the nuclear power plant; 2) when enacting regulations or establishing limits and conditions for a licence, a respect for the consequences of the regulations and the for the limits and conditions impose to the applicants for a license, and 3) when verifying compliance with regulations, a consideration of the reasons given by the license holder to explain any incompliance.

3.2 Education and training on decommissioning

The creation of Enresa increased the need for experts on waste management and decommissioning. When visiting plants under decommissioning, Vandellós I in the past and the Zorita plant at present, the first reaction of the students is of sadness. It is difficult to understand why such high technology installations has to be demolished just to recuperate the original green site, mainly if the plant has been closed down for political, not for technical and economical reasons, as it is frequently the case.

The students easily recognize that the symphony has ended; there is no more nuclear process, apart from the decay of the radioactive nuclides there present. They also observed that the minimum five year long decommissioning process also requires a well orchestred organization, experienced expertise and sophisticated tools for cutting and moving the activated large components, pressure vessels, steam generators, pumps and pipes. The scarification and demolition of thick, highly reinforced concrete walls also requires expertise, skill technicians and sophisticated tools.

All those activities have to be performed under the presence or radioactive materials which demands strict radiation protection measures in two ways: the first one to protect the workers from external radiation and potential internal contamination; the second to manage the radioactive waste which is produced and to separate highly radioactive long life waste from intermediate life and low level wastes and valid non-contaminated materials which could be recycled.

All these operations require many nuclearized engineering disciplines and radiation protection experts. In general, the cited course on radioactive waste management conducted by the Chair on Nuclear Technology and some specific courses on radiation protection conducted within the CIEMAT Institute for Energy provided sufficient details and expertise to the needed nuclearized engineers and to the radiation protection experts.

4. The nuclear renaissance

The arrival of the new century brought the appreciation that nuclear energy was a needed commodity. Nevertheless, in Spain, the so called *thermal gap* prevented new nuclear builds. The Spanish electricity generation mix included a large fraction of renewables-wind and solar-and a large number of gas in combined cycles. The existing operating plants were sufficient to cover the base demand and the rest was covered by renewables backed by the gas stations. This situation did not reduce the interest for nuclear and electrical utilities and the regulatory organization started to consider plant life extension, not yet consolidated.

The number of students interested in nuclear grew considerably and the universities created new nuclear related masters, mainly under the impulse received from ENEN.

The regulator decided that each nuclear power plant should have a dedicated training centre in the proximity of the site, with a full scale simulator. The utilities called on Tecnatom to build and populate such centres and installations in each one of the nuclear sites. These activities increased the capabilities of the company and a notorious increase was noticed in the international training projects.

The 2011 Fukushima Daiichi accident has created an uncertainty in the future development of nuclear power in Spain. For the moment, all the units have passed the European Stress Tests and are ready to comply with the required modifications and additions and be prepared for a long life.

5. The final government decision

Soon after the beginning of the life of the nuclear power plant, certainly well before decommissioning, a spent fuel management system has to be in place. This implies a significant national decision which has to be respected by all governments. The spent fuel can be declared as radioactive waste and stored in a geological repository or considered as a valid source of fissile material and be reprocessed.

Countries not able to take a final decision can select the temporal storage of spent fuel within the plant premises or in national storage facilities away from the power plants. In any case, there should be a national expertise on the technical, economical and international implications and requirements related to spent fuel management and in managing the highly radioactive wastes produced by the nuclear power plant and the recycled fuel. Most nuclear countries have created national institutions to cover these needs which have to staff with well training personnel on waste and spent fuel management.

The Spanish government has recently decided to build a central temporal spent fuel Storage facility, ATC, where all Spanish spent fuel will be guarded during sixty o more years. The site has already being selected and it is now in the characterization phase. A site and construction permit is being prepared.

For the ATC project there will be a demand for experts on the earth sciences, as well as on the design and construction and future operation of the storage facility. The experience already gained is considered as a good basis for a high national participation in those coming activities. But these activities can not be the end of the government responsibilities, at some time the government has to decide on the final policy to mange the stored spent fuel.

Madrid, 22 October 2013.
Agustín Alonso

Plenary

MAINTAINING NUCLEAR COMPETENCE WITHIN THE EUROPEAN UNION

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ABSTRACT

The ENS Higher Scientific Council (HSC) is concerned about the current negative developments within some Member States of the EU and the consequential reduced perspectives in the field of nuclear energy technology, education, research and development. The HSC believes that the use of nuclear energy provides an essential contribution to the secure, clean and affordable energy supply for electricity generation, and that this will remain for at least the rest of this century.
The HSC, therefore, strongly recommends that within the EU the resources that are allocated to nuclear education and training and to nuclear R&D reflects the increasing globalization of nuclear power and the needs of Member States that will have nuclear power or decommissioning programmes for decades to come.
In addition, the HSC recommends that the nuclear industry should actively encourage the setting up of knowledge transfer mechanisms to ensure that the knowledge, know-how and experiences of the current generation of professionals within the industry is not lost to the young people entering nuclear careers. Mobility programmes to support and encourage young professionals to work across the EU to gain wider experience of nuclear power operations should be set up. These activities should help young professionals working in the nuclear technology field to expand long-life networks and business connections and thereby be better prepared for the challenges of the 21st century.

1. Introduction

The ENS Higher Scientific Council (HSC) is concerned about the current negative developments within some Member States of the EU and the consequential reduced perspectives in the field of nuclear energy technology, education, research and development. The HSC believes that the use of nuclear energy provides an essential contribution to the secure, clean and affordable energy supply for electricity generation, and that this will remain for at least the rest of this century.

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In addition, the HSC recommends that the nuclear industry should actively encourage the setting up of knowledge transfer mechanisms to ensure that the knowledge, know-how and experiences of the current generation of professionals within the industry is not lost to the young people entering nuclear careers. Mobility programmes to support and encourage young professionals to work across the EU to gain wider experience of nuclear power operations should be set up. These activities should help young professionals working in the nuclear technology field to expand long-life networks and business connections and thereby be better prepared for the challenges of the 21st century.

2. Background

2.1 Use of Nuclear Energy in Europe –Education, Training and R&D

The use of nuclear energy for electricity production within the European Union is mixed with some countries planning to enhance the use of nuclear energy, some aiming to maintain their current programmes and others intending to withdraw from the use of nuclear energy and decommission their nuclear facilities. Irrespective of whichever path is being taken the provision of suitable qualified and experienced people to undertake the necessary tasks associated with the design, construction, commissioning, operation and decommissioning, is of vital importance not only to the safety and security of the nuclear industry, but also to its sustainability.

The uncertainty within the European Union over the use of nuclear energy over the past thirty years as a result of a combination of worries caused by nuclear accidents and the abundance of cheap gas has resulted in the stagnation of the nuclear industry in many countries. This stagnation and the perceived lack of a long-term future has had an adverse impact on the attractiveness of the nuclear industry to young engineers and scientists. The lack of interest from young people in the industry and the lack of support from some Member States and from the EU as a whole has had a consequential knock-on effect in the universities, higher education colleges and technical training schools. The number of universities and colleges delivering nuclear education programmes has declined.

A consequence of all this is that the age distribution of the workers in the nuclear industry is now biased toward the upper end with many likely to retire in the next 10 years. This presents all Member States with nuclear power programmes with a problem irrespective of which trajectory they are on. Even countries planning to withdraw from nuclear power and decommission their plants will need nuclear engineers and scientists for many decades to come to safely decommission the nuclear power plants, manage the spent fuel and radioactive waste.

The current state of affairs presents the EU with a number of challenges:

1. How to capture the knowledge of those in the nuclear industry who will retire in the next decade so that all their experience and the lessons learned by the nuclear industry will not be lost.
2. How to make the nuclear industry attractive to young engineers and scientists so that the aspirations of Member States; whether to expand their use of nuclear power, maintain their current programmes or withdraw from nuclear power and decommission their nuclear power stations and other nuclear facilities; can be met for decades into the future.
3. How can the decline in the nuclear education and training programmes be reversed and universities and colleges be persuaded to develop and deliver the necessary nuclear engineering and science programmes to provide the nuclear workforce of the future.

Meeting these challenges will not be easy, it will take commitment and resources.

3. The Renaissance Challenge

At the beginning of this century the growing recognition of climate change and the need to decarbonize the generation of electricity was becoming obvious. The perception of nuclear power changed and it became seen as a major source of "CO_2 free" electricity production. Many countries initiated new nuclear programmes to cope with the future electricity needs. However, the short timescales needed to deliver the new power station programmes highlighted a number of challenges. It was immediately obvious that there were insufficient manufacturing facilities to meet the potential demand and it was also obvious there would be skill shortage not only in the supply chain but also to design, construct, commission, operate the new facilities, and to decommission the old plants.
Organizations such as NEA, IAEA, and the JRC, published a number of reports [1-8] indicating the loss of knowledge and experience due to ageing and retirement of staff. In the UK because of its extensive nuclear programme lasting over 6 decades the challenge was not only to decommission its old nuclear power stations and other fuel cycle related sites, but also to maintain its existing programme and deliver a new nuclear power programme. The COGENT sector skills council, in conjunction with the National Skills Academy for Nuclear, produced three excellent reports on the skills needed to deliver the UK's nuclear programme up to 2025 [9, 10, 11].

4. The Fukushima Effect

The accident at Fukushima had mixed implications for the EU. Some accepted, without being complacent, that the accident could have been avoided and that their nuclear power plants and the nuclear safety regulatory frameworks were sufficiently robust. Others, such as Germany, Switzerland and Belgium, in spite of successfully using nuclear power for some 50 years, decided to shut-down earlier or not extend their nuclear power plants lifetime. These decisions have caused young engineers and scientists in the affected countries to again question the attractions of a future in nuclear power. Young, talented people are not surprisingly leaving for other sectors.
The EU Member States that have turned their backs on nuclear power are contributing to the demise of nuclear R&D and education within Europe. However, the situation is not uniform across the EU and some Member States have recognized the dangers, such as the report from the Science and Technology Committee of the House of Lords [12] in the United Kingdom. The UK has also recognized the need to rebuild its specialist nuclear related education and training [13] to meet the projected skills shortfall.

5. European Energy Needs

Europe depends on nuclear energy for 27% of its electricity generation [14]. If Europe is to maintain its standard of living, meet the challenges from climate change and the need to reduce greenhouse gas emissions, together with the increasing global demand for fossil fuel, the contribution from nuclear power will have to increase throughout the rest of this century. The challenge to maintain European prosperity and at the same time reduce dependency on fossil fuels will only be met by an appropriate mix of affordable energy sources. Nuclear energy is a proven, reliable and affordable means of generating electricity without having an adverse impact on climate change. On a global scale the use of nuclear energy is increasing. The projected growth in the use of nuclear energy in the developing world will make the large-scale use of nuclear power a reality as developing countries increase their prosperity. Europe should welcome this as a positive contribution to the protection of our planet and be prepared to contribute to this growing market opportunity.

The continued, safe and secure, use of nuclear energy to support both European and global electricity supply will require well-educated and trained people with a deep knowledge of nuclear related technologies for decades to come. The continued supply of such people will require Europe to have comprehensive science and engineering education capability and robust nuclear R&D programmes at national and EU levels.

6. Funding Challenges

The lack of enthusiasm for the use of nuclear energy for electricity production in some parts of the EU has meant that nuclear fission energy related budgets are being cut. Nuclear fission R&D budgets within Europe which have effectively been reduced in the past decade are now under more pressure because of the lack of political commitment and realism regarding the need for the use of nuclear power to ensure that Europe has an adequate energy infrastructure in the coming decades.

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Towards a new governance for Euratom research and training programmes in nuclear fission and radiation protection

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ABSTRACT AND KEY MESSAGES

In a rapidly changing world, research and training (R&T) in nuclear fission and radiation protection is faced with a number of scientific-technological and socio-economic challenges that require a new type of governance. In the EU, those challenges are, for example, technological developments aimed at optimising the role of nuclear fission in the energy mix and the related competence building process.

Faced with a number of common issues regarding Euratom R&T, the main stakeholders are discussing needs, vision and implementation instruments. Focussing on education and training (E&T), which is also the focus of this paper, the commonly accepted approach can be summarized as:

1 – Analysis of needs of society and industry: e.g. what kind of knowledge, skills and competences should be taught to meet the end-users' demand in the nuclear sector ?

2 – Convergence towards a common vision: e.g. towards a new governance for Euratom R&T, aiming at a better scientific support for nuclear decision making in the EU

3 – Development of common instruments: e.g. synergy of national and Euratom E&T schemes aimed at academic recognition and lifelong learning and cross-border mobility.

The above approach is aligned with the "*Europe 2020 strategy for smart, sustainable and inclusive growth*". As a result, a new way of "making / teaching science" is proposed, closer to the end-users, aiming at the construction of robust, equitable and socially acceptable systems. A new type of "*European governance*" for R&T is thus under development, based on improved *participation*, *openness*, *accountability*, *effectiveness* and *coherence*.

1 – INTRODUCTION: DRIVERS AND ENABLERS FOR CHANGES IN EURATOM RESEARCH AND TRAINING (R&T)

One of the main goals of the Euratom R&T programme [1], in compliance with the Euratom Treaty (1957), is to contribute to the sustainability of nuclear energy by generating the appropriate knowledge (research) and developing the required competences (training). The focus is on the continuous development of a common nuclear safety culture, based on the highest achievable standards, as this is also one of the main lessons learnt from the "stress tests" conducted in the EU after the Fukushima accident (Great East Japan Earthquake, 11/03/2011). This is done of course in synergy with national programmes in the EU and with IAEA and OECD/NEA.

[1] EC DG Research and Innovation /RTD/ Euratom - http://ec.europa.eu/research/energy/euratom/index_en.cfm

- **Drivers = EU policy (top down) and "end-user requirements" (bottom up)**

The drivers for changes introduced in the upcoming Euratom research and training programme are of two types: (1) EU policy (top down) and (2) "end-user requirements" (bottom up).

(1) EU policy to improve the synergy within the Knowledge Triangle

The "*Europe 2020 strategy for smart, sustainable and inclusive growth*" [2] was launched by the European Commission (EC) in 2010 as a set of seven "*Flagship Initiatives*" [3]. Of particular interest are the EC Communications dedicated to research (2011), energy (2011) and education (2010), all aiming at meeting the above objectives of "*smart, sustainable and inclusive growth*".

As a result of the above Communications, the EC is proposing a number of research and training actions related to energy technologies under the upcoming Horizon-2020 (2014-2020). In this paper, the emphasis is on nuclear fission energy (Euratom programme), and, in particular, on the synergy in the nuclear sector, within the Knowledge Triangle, between (1) research, (2) innovation and (3) (higher) education and training (E&T), i.e.:

- research: knowledge creation, usually in RTD organisations (public and private)
- innovation: technological applications usually in industry and services
- (higher) education and training: knowledge transfer and competence building.

(2) End-user requirements of scientific-technological as well as socio-economic type (non exhaustive list based on the "*2012 Interdisciplinary Study*" – see Section 2.2)

➢ scientific-technological end-user requirements for Euratom R&T

- continuous improvements in (1) Sustainability (e.g. minimize nuclear waste and reduce the long term stewardship burden); (2) Safety (e.g. eliminate the "technical" need for offsite emergency response) / (1) and (2) are at the heart of Euratom R&T programmes

- continuous improvements in (3) Economics (e.g. have a life cycle cost advantage over other energy sources); (4) Proliferation resistance and physical protection (e.g. provide increased protection against acts of terrorism) / (3) and (4) are left traditionally to industry and governments

- towards a better scientific support for nuclear regulations in the EU; multi-sectorial approach (e.g. integration of nuclear generated electricity in smart grids); emphasis on a common nuclear safety culture, based on technical and organisational excellence

➢ socio-economic end-user requirements for Euratom R&T

- long-term solutions to (1) possible shortage of nuclear skilled professionals and ageing population; (2) decision making processes over long time scales ("*from cradle to*

[2] *Europe 2020 strategy* - http://ec.europa.eu/europe2020/index_en.htm
[3] Flagship initiatives:http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/flagship-initiatives/index_en.htm

grave may exceed 100 years") and amid tough international competition in a global economy

- long-term solutions to (3) rebuilding the public confidence climate regarding nuclear technologies (a new way of "making / teaching" science); (4) coherence of national policies (including R&T) regarding the role of nuclear fission in the energy mix

- towards the construction of robust, equitable and socially acceptable systems; a common language between the worlds of education and of work, using the EU tools for E&T (e.g. ECVET) and taking into account the new sociological characteristics.

- **Enablers = European Technological Platforms and Euratom R&T programmes**

The enablers for changes introduced in the Euratom research and training programme are principally the *European Technological Platforms* (ETP) and a number of authoritative expert associations as well as the Euratom R&T programmes.

The ETPs bring together the main stakeholders of nuclear fission research, namely:

- research organisations (e.g. public and private sectors, industrial and radio-medical)
- systems suppliers (e.g. nuclear vendors, engineering companies, medical equipment)
- energy providers (e.g. electrical utilities, co-generation plants for process heat)
- nuclear regulatory authorities and associated technical safety organizations (TSO)
- higher education and training institutions, in particular universities
- civil society (e.g. policy makers and opinion leaders), interest groups and NGOs.

Traditionally, the implementation of the Euratom research and training programmes is left exclusively to the EC, principally in the form of :
(1) *indirect actions* (carried out by private and public research organisations in the Member States, co-funded by and under the umbrella of EC DG RTD, Brussels – see CORDIS [4])
(2) *direct actions* (conducted in the laboratories of EC DG JRC [5], that is, principally: ITU located in Karlsruhe (DE); IET distributed between Petten (NL) and Ispra (IT); and IRMM located in Geel (BE).

2 – Scientific-technological and socio-economic challenges for Euratom R&T

2.1 Governance: participation, openness, accountability, effectiveness and coherence

The EC has established its own concept of governance in the *White Paper on European Governance* [6] issued on 25.7.2001, in which the term "European governance" refers to the rules, processes and behaviour that affect the way in which powers are exercised at European level, particularly as regards *openness*, *participation*, *accountability*, *effectiveness* and *coherence*. These five "principles of good governance" reinforce those of *subsidiarity* and *proportionality* (see also Laeken European Council of 14 and 15 December 2001, and, in particular, the *Laeken Declaration on the future of the Union*).

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[4] *Community Research and Development Information Service* - http://cordis.europa.eu/fp7/wp-2013_en.html
[5] "The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies" - http://ec.europa.eu/dgs/jrc/index.cfm
[6] European legislation and International Conventions - http://ec.europa.eu/energy/nuclear/governance_en.htm

The five principles of good governance are further defined as follows:
• *Openness*. The Institutions should use a language that is accessible and understandable for the general public.
• *Participation*. Improved participation is likely to create more confidence in the end result and in the Institutions which deliver policies.
• *Accountability*. The Institutions must explain and take responsibility vis-à-vis those affected by their decisions or actions.
• *Effectiveness*. Policies must be effective and timely, delivering what is needed on the basis of clear objectives and an evaluation of future impact.
• *Coherence*. Coherence requires political leadership on the part of the Institutions to ensure a consistent approach within a complex system.

Ethics considerations are of course very important in this context. At this stage, it is worth recalling the authoritative Ethics report, issued on January 16, 2013, by the European Group on Ethics (EGE) and published together with the "2012 Interdisciplinary Study" (see Section 2.2), called: "*Ethical framework for assessing research, production, and use of Energy*" (Ethics Opinion n°27) . The EGE which is a team around the Bureau of European Policy Advisers (BEPA), reporting directly to the President of the EC, was asked by Mr. Barroso on 19/12/2011 to contribute to the debate on a sustainable energy mix in Europe by studying the impact of research on different energy sources on human well-being. In their conclusions, the EGE recommends achieving a *fair balance between four criteria - access rights, security of supply, safety, and sustainability - in light of social, environmental and economic concerns*. Interesting recommendations are also made regarding "educational projects" related to "the responsible use of energy" (excerpt of Ethics Opinion n°27 in footnote [7]).

The creation of the European Technological Platforms (ETPs) [8] in general is an application of the above five "principles of good governance". The ETPs play an increasingly important advisory and implementation role, in particular, in the Euratom R&T programmes.

Another important contributor to Euratom energy policy and legislation is the *European Nuclear Energy Forum,* launched in November 2007 (ENEF has three Working Groups: "Opportunities"; "Risks"; "Transparency"). With regard to the need for a better understanding of the skills gaps in the nuclear industry and in research organisations, the ENEF (WG "Risks") was active in the creation of the *European Human Resources Observatory - Nuclear Energy* (EHRO-N) [9]: the implementing agent of the EHRO-N is EC DG JRC. They published, for example, in May 2012 a report about the shortage of nuclear skills: "*Putting into Perspective the Supply of and Demand for Nuclear Experts by 2020 within the EU-27 Nuclear*

[7] Excerpt of «Ethics Report» / "Recommendations" (p 63): «*4. enhance the awareness of citizens (starting from an early age) regarding the need to adopt new attitudes and lifestyles for the responsible use of energy by promoting and financing educational projects and awareness-raising initiatives …»*
[8] List of *European Technological Platforms* (reactor safety, geological disposal, emergency, radioecology, etc)
- SNE-TP = "*Sustainable Nuclear Energy Technology Platform*" - http://www.snetp.eu/
- IGD-TP = "*Implementing Geological Disposal of Radwaste TP*" - http://www.igdtp.eu/
- ENEF = "*European Nuclear Forum Energy*" - http://ec.europa.eu/energy/nuclear/forum/forum_en.htm
- NUGENIA = *NUclear GENeration II & III Association* (1921 Belgian law) - http://www.nugenia.org/
- NERIS = legal association c\o CEPN, established in June 2010 - http://www.eu-neris.net/
- ALLIANCE = legal association c\o SCK-CEN, established in October 2012 - http://www.er-alliance.org/

[9] European Human Resources Observatory - Nuclear Energy (EHRO-N) - http://ehron.jrc.ec.europa.eu/

Energy Sector". This type of report is useful to develop the EU governance for R&T under discussion.

Besides the above ETPs, a number of authoritative expert associations [10] are playing an increasingly important role in the Euratom research and training programmes. With regard to safety enforcement, an important role is played by the *European Nuclear Safety Regulators Group* (ENSREG), launched in October 2007, which is composed of senior officials from national nuclear safety authorities. This Group focuses on nuclear safety (they were also in charge of the specification of the EU "stress tests" in the NPPs), waste management and spent fuel, in synergy with the "*Western European Nuclear Regulators Association*" (WENRA), the network of Chief Regulators of EU countries with nuclear power plants (+ Switzerland). Another important association is the "*Heads of European Radiological protection Competent Authorities Association*" (HERCA), created in 2007.

The EU research strategy for radiation protection is in the hands of the Multidisciplinary European Low Dose Initiative. MELODI is a non-profit making association focussing on research related to the impact of low dose radiation (including the competing theories of "linear no-threshold" /LNT/ model and "hormesis").

Faced with a number of common challenges regarding Euratom R&T, the main stakeholders are discussing needs, vision and implementation instruments in the above-mentioned European Technology Platforms and authoritative expert associations. As a result, they developed a common approach in the main areas of Euratom research, i.e. (1) Safe operation of reactor systems; (2) Management of ultimate radioactive waste; (3) Radiation protection. This common approach is described in a series of guidance documents produced by the ETPs, called: "*Vision Report*", "*Strategic Research* and *Innovation Agenda"* and "*Deployment Strategy"*. The "Vision Reports" are particularly interesting to understand the objectives fixed by the stakeholders to the scientific research communities associated to each ETP.

Focussing on E&T, the common approach developed by the above ETPs and authoritative expert associations can be summarized as follows:

1 – Analysis of needs of society and industry, in particular with regard to nuclear safety:
E.g. excellent science and technology; continuous improvements in nuclear safety culture in all installations, based on technical and organisational excellence; what kind of knowledge, skills and competences should be taught to meet the end-users' demand ?

2 – Convergence toward a common vision that puts the needs in a EU perspective:

[10] List of independent authoritative expert associations (dealing with "stress tests", medical applications, etc)

- ENSREG = "*European Nuclear Safety Regulators Group"* - http://ec.europa.eu/energy/nuclear/ensreg/ensreg_en.htm
- Western European Nuclear Regulators Association (WENRA) - http://www.wenra.org/
- HERCA = "*Heads of European Radiological protection Competent Authorities Association*" - http://www.herca.org/index.asp
- MELODI = "*Multidisciplinary European Low Dose Initiative*" - http://www.melodi-online.eu/

E.g. towards a new governance for Euratom R&T, aiming at a better scientific support for nuclear decision making in the EU; need for a multi-disciplinary and multi-sectorial approach; towards excellence in all parts of the EU (nuclear capacity building)

3 – Development of common instruments that respond to the above needs and vision:
E.g. synergy of national and Euratom funding schemes for R&T (Horizon-2020, ERC, EIT/KIC, PPP, P2P, etc); implementation of ECTS (academic recognition) and ECVET (lifelong learning and cross-border mobility); other E&T instruments of "Erasmus +".

Besides the above European Technology Platforms and authoritative expert associations, there are many other applications of the five "principles of good governance" in Euratom R&T. For example, as far as radioactive waste decision-making processes are concerned, there is an increasing effort to better identify and understand societal expectations, needs and concerns, notably at the local and regional levels. The related Euratom projects are involving, in particular, the civil society (with a significant representation of local communities, elected representatives, and NGOs, as well as social and natural scientists) together with the traditional actors in the field such as industry, Public Authorities, experts and research institutions.

As a result, a new type of governance for European R&T in energy technologies is under development, integrating the local, national and European levels of decision while involving the key non-technical and technical dimensions. This is also one of the main recommendations of the "2012 Interdisciplinary Study".

2.2 "2012 Study - Benefits and limitations of nuclear fission for a low carbon economy"

In view of their decision on the Euratom part of Horizon-2020, the EU Council (meeting of 28 June 2011) requested that the Commission *"organise a symposium in 2013 on the benefits and limitations of nuclear fission for a low carbon economy. The symposium will be prepared by an interdisciplinary study involving, inter alia, experts from the fields of energy, economics and social sciences"*.

As a consequence, the *"2012 Interdisciplinary Study - Benefits and limitations of nuclear fission for a low carbon economy: Defining priorities for Euratom fission research & training (Horizon 2020)"* [11] was launched in April 2012. This study is composed of two parts: a scientific-technological and a socio-economic part (described below). The Terms of Reference of this study were oriented towards answering "*why – and how – continue developing research and training activities in nuclear fission and radiation protection at EU level?*".

The "2012 Interdisciplinary Study" and the accompanying Ethics study have been published on the occasion of and presented at the 2013 Symposium *"Nuclear Fission Research for a low carbon economy"* (co-organised by EC and European Economic and Social Committee /EESC/, Brussels, 26-27 February 2013). The aim was to discuss the conclusions of the study to understand better the common needs, vision and instruments under Euratom Horizon-2020.

[11] Sympos. - http://www.eesc.europa.eu/?i=portal.en.events-and-activities-symposium-on-nuclear-fission-forum

(A) Scientific-technological part of the "2012 Interdisciplinary Study" (9 experts)

A total of 10 Topics were identified for the scientific-technological part (Topic 10 being the Synthesis), pertaining to three domains, namely:

- EU Energy Policy (2 Topics), namely:
  (1) three pillars of the EU Energy Policy (sustainability, security of supply and competitiveness); (2) European Strategic Energy Technology (SET) Plan
- Euratom Treaty and other EU policies (5 Topics), namely:
  (3) Research and Development; (4) Education and Training and Skills; (5) EU Nuclear Safety and Security Aspects; (6) People, quality of life and environment; (7) Safety and Security Culture beyond EU borders
- Principles of good governance (2 Topics), namely:
  (8) Science based policies and nuclear safety and security legislation; (9) Ethics.

(B) Socio-economic part of the "2012 Interdisciplinary Study" (16 experts)

For the socio-economic part, a total of 6 Questions were asked, pertaining to three main domains, namely: (1) decision making, (2) risk governance, (3) Euratom research. A number of socio-economic scientists (16 in total) were selected. The civil society was also represented (including interest groups and NGOs) as follows: (1) by the EESC who is co-organising the "2013 Symposium" with the EC; (2) by some of the scientific-technological experts who used to be national regulatory experts; and (3) by experts of the various Technological Platforms and authoritative expert associations concerned as well as by non-EU experts who produced written evidence.

3 - Nuclear fission in the energy mix - Emphasis on nuclear safety culture competences

It should be reminded that, in the EU (28 Member States since July 2013), the generation of electricity through nuclear fission is a fact of life. In the EU, nuclear power stations currently produce more than a quarter of the electricity and more than a seventh of the primary energy consumed in the EU. At the end of 2012, a total of 131 units were operable in 14 Member States (MS), representing a total installed electricity capacity of 122 GWe net and a gross electricity generation of 848 TWh. Twelve MS have given signs that nuclear remains in their longer-term low carbon energy strategy. One Member State (Poland) considers including it in its energy mix and another (Lithuania) is ready to re-introduce it.

Mankind enjoys many benefits from nuclear-related technologies, most notably electricity production. For generations to come, electrical, medical and other applications of ionising radiations will continue to require highly educated experts with very specific knowledge, skills and competences. Nuclear fission activities require in fact an interdisciplinary approach covering not only Science, Technology, Engineering and Mathematics (STEM) but also policy making (research, education, regulatory, industrial, economic, foreign affairs, etc). Moreover a special effort is necessary to inform the public at large and to improve public engagement in actions related to nuclear decisions.

Following the "*Energy Policy for Europe*" [12] it is up to each Member State, however, to decide whether or not to pursue the option of nuclear power. This statement is aligned with the Treaty of Lisbon which places energy at the heart of European activity: the EU energy mix, which may contain renewable, fossil and fissile sources, is treated, in particular, in Article 194 [13].

A key concern of policy makers and industry, however, is the continuous strengthening of the nuclear safety culture, as it is demonstrated e.g. in the Euratom "*Nuclear Safety Directive*" (EU Council, Brussels, 23 June 2009): *"Whereas .... (19) The establishment of a strong safety culture within a nuclear installation is one of the fundamental safety management principles necessary for achieving its safe operation"*. It is worth noting that safety culture is an issue in most of the power generation technologies, as it is stressed in the Ethics report (excerpt in footnote [14]).

Another concern of policy makers (in particular, of regulators) and industry world-wide is that human resources could be at risk, especially because of high retirement expectations in "old" countries (with nuclear installations) and a lack of nuclear experience in "new" countries (more than 45 Member States of the IAEA have approached the Agency with an expression of interest). Whether for power generation or for medical applications, highly qualified people are needed over a long time period to build new facilities and / or to safely operate installations, and, in particular, to manage radioactive waste and to deal with radiation protection issues.

4 - Euratom Education and Training: from knowledge transfer to competence building

In the specific field of E&T in STEM (science, technology, engineering and mathematics), both DG RTD (Research and Innovation) and DG EAC (Education and Culture) play a key role, a.o. by providing financial and organisational instruments. Of particular interest is the focus of DG EAC on *Continuous Professional Development* (CPD) or *Vocational Education and Training* (VET). The aim is to continuously improve knowledge transfer and competence building, in particular by fostering lifelong learning and cross-border mobility, thereby improving the employability across the EU (Copenhagen 2002 process, follow-up of Bologna 1999 process).

Making lifelong learning and cross-border mobility a reality is an important objective of the *Education, Youth and Culture* policy of the EU – see *Council Conclusions on a strategic framework for European cooperation in education and training ("ET 2020"),* Brussels, 12

[12] Energy policy for Europe (DG ENER)-
http://europa.eu/legislation_summaries/energy/european_energy_policy/

[13] Lisbon Treaty 2007 - Article 194 ….. "*Union policy on energy shall aim, in a spirit of solidarity …: ….. Such measures shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply* "..

[14] Excerpt of the "Ethics Opinion n°27", dated 16/01/2013 (p 59) – Section 3.6.4 Safety:
"*Reducing the risks down to purely technical aspects would not fulfil the requirement for an integrated approach and comprehensive assessment. Consequences in terms of the environment and health should receive the same amount of attention as the cultural, social, economic, individual and institutional implications. A* ***safety culture*** *embraced by governments and operating organisations is necessary in the production, storage and distribution of energy in maintaining a low level of risk."*

May 2009 [15]. Lifelong learning requires in fact a common EU approach for assessing and validating the learners' qualifications by ad-hoc authorities, taking into account a variety of E&T paths (CPD programmes). Cross-border mobility, in particular, implies mutual recognition of learners' qualifications within the EU.

In this context, the *European Credit System for* VET (*Vocational Education and Training)* (= ECVET) [16] was launched ten years ago and successfully tested in a wide range of service and industrial sectors (notably aeronautics and automotive). There are similarities with the Bologna process for academic education and the associated *European Credit Transfer and accumulation System* (ECTS). ECVET's objective is to promote mutual trust, transparency and recognition of learning outcomes, regardless of the system or context in which they were acquired. This EU policy for E&T is also aimed at facilitating the freedom of establishment (including for regulated professions), thereby enabling the free circulation of individual citizens (and, in particular, service providers) amongst the EU Member States.

At this stage, the main efforts of the ECVET policy are focussing on three issues:

(1) a common qualification approach: a European reference system is needed to improve transparency between different countries' national qualifications systems and frameworks (*European Qualifications Framework for Lifelong Learning* /EQF/)

(2) "*Personal Transcript of records*" (that might be associated to a "*Europass*"): portfolios of documents, to be used by individuals, to describe their learning achievements and acquired qualifications in a coherent manner recognized by all potential employers in the EU

(3) taxonomy: a common language is needed between the world of education and the world of work (*European Skills, Competences and Occupations Taxonomy* /ESCO/) – work on a common *taxonomy* has started in the nuclear sector.

In this context, it should be recalled that Euratom E&T actions are addressing primarily research and industry workers with higher education, i.e. levels 6 to 8 of the *European Qualifications Framework* /EQF/ (= bachelor, master and doctorate levels or equivalent, resp.). The focus is on CPD, taking advantage of existing instruments and best practices for E&T.

As far as training is concerned, there are two types of initiatives in the Euratom FP7 projects:

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[15] Lifelong learning should be designed to cover learning in all contexts whether formal, non-formal or informal / OJ C 119, 28.5.2009 / - http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/educ/107622.pdf

[16] Sources for EU policy in lifelong learning (DG Education and Culture, EAC-executive agency and Cedefop):
(1) EU instruments for lifelong learning and borderless mobility, and list of National Agencies (32 countries) - http://ec.europa.eu/education/lifelong-learning-programme/national_en.htm
(2) the Copenhagen Declaration on enhanced European cooperation in vocational education and training (30 November 2002) - http://ec.europa.eu/education/pdf/doc125_en.pdf
(3) *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 2009/C 155/02) - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2009:155:0011:0018:EN:PDF
(4) Cedefop - The Cedefop is the "*Centre européen pour le développement de la formation professionnelle*" or "European Centre for the Development of Vocational Training" - http://www.cedefop.europa.eu/EN/

- interdisciplinary training workshops embedded in research and innovation FP7 projects, aiming at transferring the main results to the scientific community
- *Euratom Fission Training Schemes* (dedicated FP7 projects), aiming at upgrading CPD programmes towards an improved safety culture across the EU (see ENEN below).

5 - "EURATOM FISSION TRAINING SCHEMES" AND "EUROPEAN NUCLEAR EDUCATION NETWORK" (ENEN)

The "*Euratom Fission Training Schemes"* (EFTS) were – and are still - launched in specific areas where a shortage of skilled professionals has been identified. They are FP7 "coordination actions", taking into account the scientific-technological and socio-economic "end user requirements" and using the education and training instruments developed by the EU (ECTS /Bologna 1999/ and ECVET /Copenhagen 2002/ processes). The proposed training schemes consist of portfolios of units of learning outcomes (made not only of *knowledge*, but also *skills* and *competences* /KSC/) that are needed to perform jobs or functions identified by the "end-users" as being critical.

The EFTS is thus a significant development across the EU, aimed at structuring training and career development along the above ECVET lines. Those training schemes are ambitious CPD programmes (usually 3 years, total budget of circa 1 million Euro each, modular course approach). Portfolios of units (or modules) of "learning outcomes" and their description in *Personal Transcripts of Records* are discussed with the stakeholders. First attempts are made to develop common EU approaches for assessment and validation of portfolios related to specific jobs or functions. Some Euratom Fission Training Schemes are planning to involve European authoritative expert associations with regulatory background (e.g. ENSREG or HERCA) to discuss mutual recognition across the EU. It is clear, however, that the above mentioned "Personal Transcript" will never constitute *per se* a license or an official authorisation (in the legal national regulatory sense).

As a result, the Euratom research and training programme contributes to the creation and transfer not only of *knowledge* but also of *skills* and *competences*, taking advantage of instruments developed by various EU policies.

It is no surprise that the IAEA training programmes are based on a concept very close to the above KSC. Following the IAEA definition [17], *competence means the ability to apply knowledge, skills and attitudes so as to perform a job in an effective and efficient manner and to an established standard* (S.S.S. No. RS-G-1.4 / 2001). *Knowledge* is usually created in higher education institutions and in (private and public) research organizations. *Skills and attitudes* are usually the result of specific training and on-the-job experience, enabling one to acquire the requested *competences* throughout professional life. Euratom and IAEA are working together in the design and execution of joint E&T programmes.

To ensure the highest achievable standards for nuclear education and training, a non-profit association was formed in September 2003 (under French 1901 law): it is the *European Nuclear Education Network* (ENEN) [18]. This legal entity, located at CEA-INSTN Paris, is composed of 64 members (universities, research organisations, industry) from 18 EU Member States + Switzerland, South Africa, Russian Federation, Ukraine and Japan. As far as

[17] "*Building competence in radiation protection and the safe use of radiation sources*" (jointly sponsored by IAEA, ILO, PAHO, WHO), IAEA 2001 (p 4) - http://www-ns.iaea.org/standards/documents/pubdoc-list.asp
[18] *European Nuclear Education Network* (ENEN) - http://www.enen-assoc.org

international collaboration is concerned, ENEN has signed a Memorandum of Understanding (MoU) with the Joint Research Centre (JRC) of the European Commission, with the European Nuclear Society (ENS), with the International Atomic Energy Agency (IAEA), with the Nuclear Energy Agency (OECD / NEA) and with the World Nuclear University (WNU). The synergy of ENEN with national E&T networks and with the European Technological Platforms and authoritative associations is also instrumental to the success of Euratom E&T actions.

The ENEN members play a key role in the design and implementation of the above "*Euratom Fission Training Schemes"*. As of June 2013, there are 11 EFTS in total - more are planned in the future, following the standard competitive process of EU research programmes. Here is their list together with their respective "end-users" and contractual duration:

- ENEN-RU - *Cooperation with Russia in Nuclear Education, Training and Knowledge Management*: mirror project by ROSATOM and MEPhi (Nov. 2010–Oct.2012)
- ENETRAP II - *European Network on E&T in Radiological Protection*: addressing mainly the nuclear regulatory authorities and TSOs (March 2009 - December 2012)
- ECNET - *EU-CHINA Nuclear Education and Training Cooperation:* mirror project financed by the Chinese Atomic Energy Authority (March 2011 - February 2013)
- ENEN III Training schemes - *Generation III and IV engineering*: addressing mainly the nuclear systems suppliers and engineering companies (May 2009 – April 2013)
- TRASNUSAFE - *Nuclear Safety Culture*: addressing mainly the health physics sector (e.g., ALARA principle in industry and medical field) (Nov. 2010 - October 2014)
- CORONA - *Regional Center of Competence for VVER Technology and Nuclear Applications*: focus on VVER personnel training (December 2011 – November 2014)
- CINCH-II - *Cooperation in education and training In Nuclear Chemistry*: focus on the European master's degree in nuclear and radiochemistry (June 2013 – May 2016)
- PETRUS III - *Program for Education, Training, Research on Underground Storage*: addressing mainly the radwaste agencies (15 January 2009 - 14 January 2012)
- EUTEMPE-RX - *EUropean Training and Education for Medical Physics Experts in Radiology*: focus on Euratom Directive COM(2011) 593 (August 2013 – July 2016)
- GENTLE - *Graduate and Executive Nuclear Training and Lifelong Education*: focus on synergy between industry – academia (January 2013 – December 2016)
- NUSHARE – *Project for sharing and growing nuclear safety culture competence*: focus on policy makers; regulatory authorities; industry (Jan. 2013 – Dec. 2016).

Online and blended learning are also tested in some EFTS. As far as cross-border mobility of experts is concerned, it is worth drawing the attention to a potential barrier: in some EU countries, a national licensing process is requested for specific jobs or functions ("regulated" safety-related jobs, usually at higher education level).

As success stories of the implementation of ECVET (in particular, the KSC approach), the following list of jobs or functions is worth mentioning:

- "*Fluid System Construction and Commissioning Engineers*" (ENEN III project)
- "*Radiation Protection Experts*" (ENETRAP II project)
- "*Medical Physics Experts*" (EUTEMPE RX project).

6 - CONCLUSION : TOWARDS A NEW WAY OF "MAKING / TEACHING SCIENCE" IN NUCLEAR FISSION

The facts about energy in today's world, in particular when it comes to "*Sustainable, Competitive and Secure Energy*", show that energy problems cannot be taken for granted, and demand a specific governance structure, integrating non-technical and technical aspects. This is particularly true for Euratom research in nuclear fission energy and radiation protection.

The political and legislative background of Euratom research and training is based principally on the *Euratom Treaty* (1957), the *Lisbon Treaty* (2007) and the *Europe 2020 strategy* (2010) which encompasses the European *Strategic Energy Technology Plan (2007).* The SET-Plan has two major timelines (2020 and 2050), which are important for the planning, in particular, of long-term R&T actions in the energy field. Another important input is of course the set of conclusions made after the "*stress tests*" in all NPPs following the 2011 disaster in Japan.

Two general objectives are particularly important in this context, and are guiding the Euratom R&T priorities in all areas selected for Horizon-2020:

- towards a common nuclear safety and security culture world-wide, based on the highest achievable standards related to technical, human as well as organisational aspects
- towards scientific and technological excellence in all parts of the EU, thereby fostering a new generation of European highly qualified experts in all nuclear fission applications.

The above objectives are aligned with the *"Europe 2020 strategy for smart, sustainable and inclusive growth"*. As a result, the Euratom research and training programme is planning to strengthen the following priorities under Horizon-2020:

(1) contribute to the creation and transfer not only of *knowledge* but also of *skills* and *competences,* taking advantage of instruments developed by three EU policies, namely: research and innovation, energy and education

(2) develop a governance for Euratom R&T based on improvements in participation, openness, accountability, effectiveness and coherence, leading to a new way of "making / teaching science", closer to the end-user needs (society and industry).

(1) Contribute to the creation and transfer of *knowledge*, *skills* and *competences*

An analysis is made of the question "*who are the drivers and enablers for changes in Euratom Research and Training ?*" The "end-user requirements" are an important *driver*: they are of scientific-technological or socio-economic type. The *enablers* are the stakeholders providing human and financial resources (e.g. the European Technological platforms and authoritative expert associations) as well as the Euratom research and innovation programmes.

Euratom E&T programmes make use of the instruments proposed under the *Education, Youth and Culture policy*, in particular: the *European Credit System for Vocational Education and Training* (ECVET). Those instruments are used in a number of "*Euratom Fission Training*

Schemes" (EFTS), launched as "coordination actions" by higher education institutions (usually in collaboration with the ENEN association) and by "stakeholders" (industry, research organisations, governmental bodies, etc) in areas where human resources could be at risk. The EFTS projects are contributing to the definition of requirements for recognition of certain job profiles or functions. The proposed training schemes consist of portfolios of learning outcomes (made not only of *knowledge*, but also *skills* and *competences* /KSC/) that will be recognised by the employers across the EU, thereby improving the employability.

(2) Develop a European governance for R&T (closer to the end-users: society and industry)

The EC has established its own concept of governance in the *White Paper on European Governance* (2001), in which the term "European governance" refers to the rules, processes and behaviour that affect the way in which powers are exercised at European level, particularly as regards *openness*, *participation*, *accountability*, *effectiveness* and *coherence*. Ethics is very important in this context. Interesting recommendations regarding "educational projects" related to "the responsible use of energy" were made in an authoritative report, produced in January 2013 by the European Group on Ethics (EGE) and published together with the "2012 Interdisciplinary Study".

The creation of the European Technological Platforms and authoritative expert associations gathering the main stakeholders is an application of the above principles of good governance. It is a mix of bottom-up and top-down approaches for the management of future Euratom R&T programmes. Through their discussions on common needs, vision and implementation instruments, the stakeholders developed a common approach in the main areas of Euratom research.

There are other applications of the above principles of good governance. For example, in regions where massive investments in experimental facilities are necessary in connection with research and innovation, all local stakeholders should be involved in the decision making process. The same is true in the debates around the deep geological disposal of radioactive waste or around exposures to low doses of ionising radiation. Integrating public, policy, and expert knowledge will receive increasing attention in the nuclear fission and radiation protection research community, as it is also one of the main recommendations of the "2012 Interdisciplinary Study".

Wherever advisable, Euratom research and training programmes will aim at a fair balance between scientific-technological and socio-economic approaches, thereby coming closer to the needs of the end-users, i.e. society and industry. As a consequence, a new way of "making / teaching science" is under development (focussing, in particular, on how to select the "*Best Available Science*") in order to contribute more effectively to the development of robust, equitable and socially acceptable systems.

In the specific case of Euratom research, because of the very limited available EC funding and because of the current socio-economic climate, a very strong coordination is required regarding management and financing in order to ensure stability and clear commitments from the parties involved. In other words: a strong EU governance is needed in Euratom matters.

CURRENT CHALLENGES FOR EDUCATION OF NUCLEAR ENGINEERS: BEYOND NUCLEAR BASICS

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ABSTRACT

In past decades, curricula for the education of nuclear engineers (either as a major or minor subject) have been well established all over the world. However, from the point of view of a nuclear supplier, recent experiences in large and complex new build as well as modernization projects have shown that important competences required in these projects were not addressed during the education of young graduates. Consequently, in the past nuclear industry has been obliged to either accept long periods for job familiarization, or to develop and implement various dedicated internal training measures.

Although the topics normally addressed in nuclear engineering education (like neutron and reactor physics, nuclear materials or thermo hydraulics and the associated calculation methods) build up important competences, this paper shows that the current status of nuclear applications requires adaptations of educational curricula.

As a conclusion, when academic nuclear engineering curricula start taking into account current competence needs in nuclear industry, it will be for the benefit of the current and future generation of nuclear engineers. They will be better prepared for their future job positions and career perspectives, especially on an international level.

1. A need for change?

As an Original Equipment Manufacturer, AREVA provides comprehensive solutions for new build of nuclear power plants (NPP), as well as modernization, life time extension or power upgrade of operating NPPs and supply of safety important products for NPPs, such as digital safety related Instrumentation and Control (I&C) systems.

As such, in the past years the growing number of related projects increased the demand for soon to be recruited personnel. However, due to the stagnation of the nuclear market in the 1990s, in general and in almost all countries with a considerably share of nuclear in electrical energy production, nuclear education had been kept at a level that only allowed for replacement of people leaving the nuclear sector.

Consequently, nuclear industry (e.g. nuclear operators or nuclear system suppliers such as AREVA) had to design, develop and implement appropriate training curricula to prepare newly recruited staff (both young graduates and people with a professional career) for their future job positions. Here, the focus was laid on engineers to be engaged in NPP design, construction, commissioning, operation, maintenance, or management of related projects. These engineers often had no nuclear background or experience at all.

However, even in the most desirable case of a well grounded nuclear education, experiences in nuclear projects have shown that some important competences were missing. Often this resulted in reduced team or even project performance, and consequently a need to design, develop and implement appropriate training measures on the spot to avoid long periods of job familiarization. Analyzing these experiences, and considering the current status of nuclear education curricula, it may be concluded that these should be revised to adopt currently missing key competencies.

Various factors have contributed to this need for change, i.e. better adaptation to new demands on the nuclear market: not only the societal demand for enhanced levels of nuclear safety (reinforced by the recent Fukushima incident), but also the demand for highly competitive cost and schedule schemes for new build as well as modernization projects. The latter has been further fuelled not only by reduced investment and financing possibilities as a consequence of the recent global financial crisis, but also by the recent availability of other competitive energy resources (like shale gas). Considering also the limited numbers of capable and competent vendors and the limited demand of utilities, the nuclear market has now evolved into an international market, with a restricted number of international companies acting globally, i.e. with internationally distributed subsidiaries and project teams as well as an international supply chain. Hence the ability to act efficiently in an international environment with diverse national as well as business culture is highly desirable.

2. Nuclear Safety

A nuclear safety culture, as an enveloping set of competencies and attitudes, should be established and fostered already during university education. Nuclear engineering education curricula should address nuclear safety as a starting point for all further measures. This means focusing on safety culture, national and organizational culture, national and international regulatory frameworks and their applications in regard to fostering safety culture, and how the emphasis on safety of nuclear power improves the quality of safety not only in the energy sector, but in society as a whole.

In past decades, also as a response to industrial incidents, the importance of safety culture and how to develop and foster it has been the focus of several institutions or organizations, like the International Atomic Energy Agency (IAEA), the Institute of Nuclear Power Operations (INPO), or the World Association of Nuclear Operators (WANO). As numerous guidelines, standards and related recommendations for implementation as well as accompanying information or training resulted from these activities, there is now an abundance of material available to be further transferred into educational curricula.

Safety culture should be introduced into engineering curricula at least on a more generalized level, not necessarily specific to the nuclear field. In covering this in a wider sense, the course could also be used for engineering education outside nuclear. Here, the nuclear application could serve as an example for other technologies, the application of which bear an inherent risk for people and the environment (e.g. aviation, chemical, automotive, civil construction). The course should address those topics already listed above, and case studies or examples from diverse technical applications as well as their impact on further development of the technology or of related legal and regulatory framework and associated codes and standards. As such, the course could serve as an introduction to the field of codes and standards, which is a successive topic also to be addressed in engineering curricula (see chapter 3). Role games could supplement course objectives and support a deeper and thorough understanding as well as implementation of the principles of safety culture.

Course implementation could be further enhanced by site visits to design, construction, manufacturing or operation / maintenance facilities that are appropriate for achieving the learning objectives of the course. In particular, these site visits could demonstrate examples for the implementation of safety culture in practice. Facilities will certainly be found close to any educational institute. Of course this will include contacts to other non-nuclear applications, if they are dealt with in the wider sense as mentioned above.

3. Codes and Standards

One important aspect of safety culture is the strict adherence to codes and standards to be applied in the appropriate work (i.e. engineering) environment. This implies that educational curricula should address various guidelines and standards (e.g. from the IAEA[1]), regulatory codes and standards (e.g. ASME code[2], IEEE[3], RCC-E[4] and RCC-M[5], YVL guides[6]). Furthermore, how to apply the relevant codes and standards in regular nuclear engineering activities should be dealt with, clarifying also the roles and responsibilities of the different stakeholders.

As material is largely available on different aspects of these codes and standards, as well as different institutions already providing introductory or advanced training on these codes and standards, suitable education courses should be developed that at least provide an overview on existing codes and standards, and on their importance for licensing and respective design and operation of nuclear facilities (also including, as example, nuclear fusion facilities like ITER[7], in particular when becoming nuclear). Briefly describing the history of codes and standards development from different national points of view, as well as the different areas of application, will lead to a thorough understanding of their importance. If possible, some examples for application in nuclear engineering should be included, too.

In summary, this will greatly enhance the students' abilities to act not only in a national environment, but also to adapt to a global environment which will become more and more harmonized in a global and very competitive nuclear market. Furthermore, this will help employees in the future to boost their global as well as institutional mobility, e.g. between research institutions, operating organizations, industry and regulatory bodies.

4. Engineering Workflow

Closely related to the application of codes and standards is the engineering workflow in the different phases of a nuclear project. Starting with design, 2 aspects have to be considered.

At first, as different technical disciplines need to work together on the upcoming project respecting the engineering workflow, numerous interfaces need to be defined between the involved trades, requiring an awareness of involved engineers on how to pass on information across those interfaces. To illustrate this on an overview level: the design of the power plant pro-

1 see http://www-ns.iaea.org/standards/
2 American Society of Mechanical Engineers, see http://www.asme.org/
3 Institute of Electrical and Electronics Engineers, see http://www.ieee.org/index.html
4 Règles de Conception et de Construction des matériels Electriques des îlots nucléaires, see e.g. http://www.afcen.org/V11/index.php?menu=rcc_e_fr
5 Règles de Conception et de Construction des matériels Mécaniques des îlots nucléaires REP, see e.g. http://www.afcen.org/V11/index.php?menu=rcc_m_fr
6 Regulatory Guides on nuclear safety, see http://www.stuk.fi/julkaisut_maaraykset/viranomaisohjeet/en_GB/yvl/
7 International Thermonuclear Experimental Reactor, see http://www.iter.org/

cess(es) will result in a structure of plant systems with different components to be designed, and with supporting electrical as well as instrumentation and automation systems, and moreover with further equipment like heating, ventilation and air conditioning (HVAC) systems, all to be placed in an appropriate building with optimal layout and civil design. As a result, the input resp. requirements and the results of each specific activity have to be well understood and correlated, often in an iterative way. Here, of utmost importance is the competence to fully understand the technical interdependencies.

Secondly, the format in which input resp. requirements and the results of each specific activity have to be developed, and in particular the information content will strongly influence the performance of the engineering workflow. Typically, the results will be published as system descriptions or functional requirements, normally in different levels of design (conceptual / basic / detailed /actual), using not only a coherent structure, but also dedicated formal descriptions or symbols. In this case the requirements of codes and standards will play an important role, as well as the intended use of the design results for further activities in NPP new build or modernization projects, like procurement, manufacturing, inspection, construction, erection, commissioning, operation or maintenance.

Providing students with a global overview about the technical interdependencies in the engineering workflow, and about format, content and structure of typical engineering documentation will greatly enhance their ability to understand one important aspect of current nuclear engineering activities. And they will be better prepared for starting their engineering work, e.g. specifying functional requirements and deriving specifications from these requirements as well as applying numerical methods and codes for this purpose. Thereby they will better find their place in the nuclear work force, and better understand their roles and responsibilities in the engineering workflow, and in related activities like project management, procurement, manufacturing, inspection, construction, erection, commissioning, operation or maintenance.

5. Engineering Tools

Closely connected to an introduction to the engineering workflow are the engineering tools that are applied for this purpose. Here, the focus is not on the application of calculation methods for process or system analysis as well as specification. In the past, the rapid development of information technology together with the application of numerical methods has provided scientists as well as engineers with powerful tools e.g. for structure loads / thermal hydraulics / reactor core, fuel calculations or other simulation analysis. To some extent the basics of these codes have already been introduced into nuclear engineering education. Consequently students can already familiarize themselves with these types of tools during their university curricula.

Instead, in this context information systems that support engineering activities are of high importance. Here, the focus is on the information stored and processed, and their support of engineering workflow as well as the roles and responsibilities of different persons involved in these. These information systems / engineering tools can be considered as comparable to those that are offered by companies like Oracle or SAP, and that support the workflow and related information in nearly all business related internal processes of enterprises.

Examples of these engineering tools include those that support document management, time scheduling, plant configuration management, and the resulting material management (including logistics and spare parts), considering also the interfaces to layout design as well as other business information tools (e.g. finance and accounting)

Students should be introduced to these tools, to better understand how only the application of these tools may currently facilitate an efficient and competitive engineering workflow. One good example, like the other tools also in service in other technical applications outside nuclear, is document management. Here, a simple software system, to be used in a dedicated course on the subject of engineering tools, could easily show which type of information can be managed with it, and how this will greatly enhance the efficiency of an engineering workflow.

As the listed engineering tools are well being used outside nuclear, a cross cutting special course on engineering tools will be for the benefit of other engineering disciplines outside nuclear, too, enabling a broad application in engineering education.

6. Cooperation between Academic Institutions and Industry

As can be easily understood from the above chapters, cooperation between academic institutions and industry would optimally support the extension and adaptation of nuclear engineering education as outlined above, thereby also enhancing the link to the nuclear professional environment in support of a better consideration of students' future professional environment.

Examples could include handover of appropriate basic material for course development, visits of nuclear sites, common workshops, or the provision of lectures by industry experts. These lectures could provide examples, case studies and data from industrial applications that are often not available at academic institutions. One example is presented in [1]. Another example refers to simulation codes (see above): in this case, industry may provide opportunities for working with these simulation codes (e.g. by demonstrations, workshops, and internships).

7. Conclusions

The chapters above have shown a concise overview about the most stringent competence needs in the current nuclear field, valid not only for nuclear suppliers such as AREVA, but also for nuclear operators, safety authorities, technical support organizations, and further service providers or other companies active in the nuclear supply chain, in particular when active on an international level.

When academic nuclear engineering curricula start taking into account these competence needs of nuclear industry, it will be for the benefit of the current and future generation of nuclear engineers. They will be better prepared for their future job positions and career perspectives, above all on an international level, in particular as regards mobility and for a lifelong professional development.

As a matter of course this will also imply a reduction of time spent on the subjects that are covered by now by the current educational curricula. In this case, a close cooperation between academic institutions and industry will be very beneficial for selecting the right balance.

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TRAINING OF LEADERS FOR NUCLEAR NEW-BUILD

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ABSTRACT

Most corporate strategies fail – not primarily because of poor strategy definition but due to deficiencies in strategy implementation. Nuclear new-build is no exception in this respect. This paper presents training by business simulation as a tool for successful strategy implementation in general, and its application in the nuclear power sector in particular.

1. Introduction

Why do we not see effects of our strategy? This question is asked in board rooms all over the World in all various types of businesses. The question is real – most corporate strategies fail:

- 90% of well-formulated strategies fail due to poor execution. [1]
- Only 5% of employees understand their corporate strategy. [2]
- Only 3% of executives think their own company is successful at executing strategy. [3]
- 75% of business improvement initiatives fail due to lack of execution. [4]

It is notable that research points out that definition of strategy is not the most common culprit. Executive management is often well aware of the intricacies and challenges in their business. The problem is that strategy execution is rarely up to standards.

This is not only a waste of resources; it is in fact often counter-productive. If the executive management launches a new strategy but the implementation is inferior, several negative effects often occur:

- The executive management realizes after some time that little if any changes in the behaviour of the staff has occurred. It is common to blame the strategy for being ill-founded, and a new strategy is defined, not necessarily a more successful one.
- The workers notice no real change due to the new strategy. This nurtures a cynical attitude, especially if several consecutive strategy changes have been announced from the leadership, with little or no effect due to any of them. Sooner or later, the workers might land in an attitude that "well, let them play – in a few months another programme will be launched. We have seen this before".

Strategy is important. Execution is everything.

JP Garnier, former CEO GlaxoSmithKline

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2. Successful strategy execution

The largest strategic project for a nuclear power company is new-build. Building a new single-unit nuclear power plant can cost more than 5 billion Euro. Reducing the time from starting paying interests on such a huge investment to the point in time when positive cash flow thanks to electricity sales sets in is a major success factor in such a project. Obviously, this is an area when successful strategy implementation is of paramount importance.

However, as has been described above, most strategies fail, and the main culprit seems to be failure in strategy implementation and execution. So what can be done to remedy this situation? Like in so many other human activities, proper training can make a difference. It has to be recognized that the first and foremost change needed is changed behaviour. If the staff does things in the same way as before, no strategy change will take place. However, changing human behaviour is a difficult matter. Words only do not suffice; few if any change their behaviour due to new instructions, neither written nor oral.

Training a new behaviour is significantly more successful as indicated in the figure below.

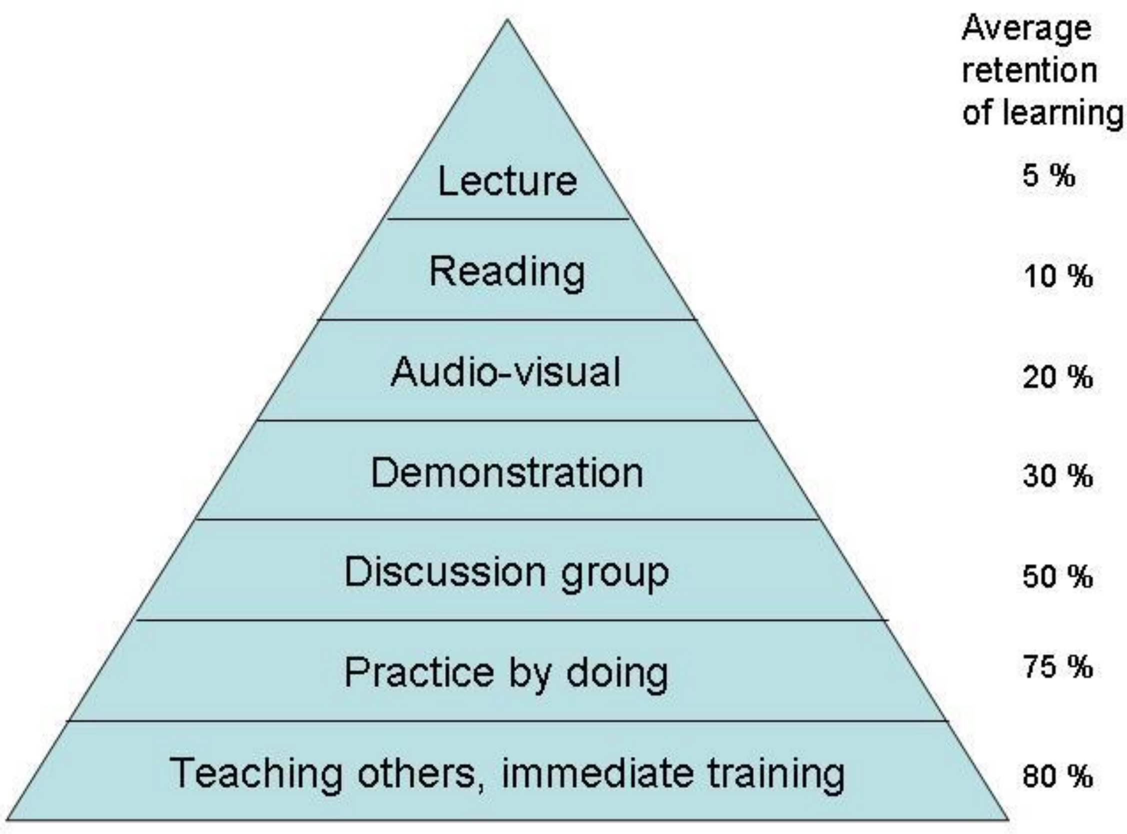

Fig. 1. Knowledge retention for various methods.

As can be seen, there is a dramatic effect when going from traditional lecturing to gradually deeper involvement of the recipients. The top four layers of the pyramid have in common that the recipient is passive, essentially consuming the information presented. In the three lower layers, the recipient is active and practices the skills being the target of the strategy change.

The most efficient learning is by teaching others, a fact many teachers can testify. Next best is practice by doing. This is also a well-established fact in teaching research.

In nuclear power, there is international consensus that operations should be practiced in simulators. This is not unique to nuclear power; various technologies like aviation and off-shore oil drilling have since long used simulators, and medical surgery is gradually coming into the game.

So when is the use of simulators for training motivated?

- There is a need to practice how to handle challenging situations.
- The situations are complex.
- Practical learning is different from what can be learnt by theory studies.

When looking through these features, it is striking that all are relevant for executive decision-making as well. The decisions to be taken by a CEO and an executive management team are often complex, challenging and hard to find a compelling answer to by studying theory. Moreover, when a new business strategy has been defined, the implementation of it also fulfils all the criteria above. For the staff requested to change their behaviour to align with the new strategy, all the challenges above apply.

Why simulations? Because you forget where you put your car keys, but not how to drive.

So can business decision-making and strategy implementation be practiced by simulation? The simple answer is yes. Many of the Fortune 500 companies in the World use business simulations as a tool to train their employees in strategy execution. If restricting to the nuclear power sector, many of the largest utilities in Europe and North America use such methods, whereas the Asian utilities have so far been less prone to use simulations in their staff competence development.

3. Nuclear business simulation

The use of simulations for executive decision-making is still in a far earlier stage. Vattenfall, the largest nuclear power operator in Northern Europe, has developed the simulation *Käftudden*[2] to train nuclear business acumen.

In such a simulation, participants with different skills and backgrounds are composing fictitious management teams of a fictitious nuclear power plant. Typically, such a team has five members with background in operations, maintenance, finance, human resources, communication or any other discipline represented in a typical real-life management team. They are presented with a

[2] Named after a nuclear power plant planned in 1965 but never built.

case describing the state of their plant, and they are challenged by the owners to improve the performance.

Their first task is to define a strategy, including a time table, for the performance improvement process. Should we try to modernize the plant by replacing old parts or even upgrade the power production? Maybe improved maintenance of existing parts is a better option? Should we try to improve all reactors at once, or one after the other?

Nuclear Business Acumen is the insight, knowledge and ability to manage the unique interactions between the technology, economics, human and organizational factors and safety, in a changing nuclear generation environment.

IAEA definition

Like in real life, the budget is limited. If going for expensive purchases of equipment, less funding can be spent on staff competence development, and vice versa. Also resembling real life, the team faces a mix of planned and unexpected events. Annual outages need to be planned, and fuel failures can appear any time. However, the consequences of the latter could be reduced if a "clean-system program" had been implemented earlier in the simulation.

These teams are graded on several different parameters, like plant safety, staff competence, regulator satisfaction and business results. They need to score above a pre-set minimum in all four parameters. Thus, concentrating on one of them does not pay off. It is indeed a training in balancing all important features simultaneously, i.e., a nuclear business acumen training.

This simulation was developed as a response to previous investigations that had indicated that the best improvement potential for the company was in communication between different specializations. The technical experts were top-notch on technical matters, but had limited understanding of the business implications, which was visible in prolonged outages and procurements that in hindsight was found unnecessarily expensive. Similarly, the finance department did not fully grasp the technical implications of their decisions. For instance, the easiest way to reach short-term success in a program on cost reduction is to reduce maintenance, but in a long-time perspective this can have grave consequences.

There had been a number of initiatives to train technical experts in economy and economists in technical matters, but with little or no visible effect on the business results. Performing simulations mean a few distinctive differences comparing to the approach of separate training:

- Experts of different backgrounds meet and share their expertise. This does not happen equally well when economists study technology and vice versa.
- A larger part of the complexity of the decision-making is taken into account.
- After training, all participants have personal networks of people with different expertise. It is natural to contact your previous teammates in the simulation for consultation in real-life situations afterwards.
- Much more of the learning stays.
- Last but not least, this type of training is *fun*.

4. Boosting the effect of training

The last point should not be underestimated. Participants testify in evaluations that the exciting nature of this type of training has meant a lot not only to their learning (which they deem superior to other types of training) but also to their motivation to work in a different and more professional way when back at work after completed training.

Finally, the effect of this training can be significantly improved further by a structured combination of actions. Many managers have sent their staff to training courses and found limited lasting effects afterwards. This is corroborated by science. In an experiment two groups were sent to a training course. For one of the groups, their managers were contacted beforehand and organized the work so that staff practiced the course content in their daily work immediately after the course. The other group had no real-work connection to the training until far later in time. The knowledge retention was almost twice as high in the group that practiced their course learning in real life. [5]

This serves as food for thought for managers. The benefit of a course can be doubled just by scheduling course-training and on-the-job-training close in time. These benefits can be further augmented by considering a four-pillar model for competence development. [6]

The four pillars of competence:	**Daily work = on-the-job-training**
	Change work (project, new job)
	Mentorship (for both parties)
	Formal Course
Prime success factor:	**Combine them**

These four pillars are different in character, and the learning is different for each of them. By going into a project or moving on to a new position, you learn other things than in ongoing daily work. Being a mentor or mentee provides better opportunities for reflection and personal growth than going to a course, etc. It has been shown in research and practical experience that combining two or more of these pillars results in a much faster and deeper competence development than spending all efforts or one alone, or treating them as separate activities without utilizing the potentials for synergy.

5. Conclusion

In conclusion, successful strategy execution requires a structured approach in which the new strategy is not only well communicated, but trained. Business simulations are very powerful tools for this purpose. By combining such training with other actions, like practising the new behaviour in daily work or project work, the effects can be much stronger for the same cost. Timing is very important here; actions coordinated in time have a much higher success rate than separated ones.

6. Acknowledgments

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The securitisation of nuclear energy post–September 11 and its impact on ASEAN's nuclear aspirations

Eulalia Han

Abstract
This article examines the securitisation of nuclear energy post–September 11 and how the current nuclear terrorism discourse will influence Southeast Asia's nuclear aspirations, and its relations with the dominant nuclear powers and international conventions on nuclear energy. The main aims of this study are to highlight the deficiencies of a United States-dominated nuclear security discourse that is focused on nuclear terrorism, and suggest that nuclear energy be desecuritised in light of such deficiencies. This could provide for a more comprehensive engagement with the issue of nuclear energy, refocusing the agenda back to nuclear security as a whole, and opening up discussions to include the concerns of other regions, such as Southeast Asia, who look to acquire nuclear technology. The study first explains the concept of securitisation through the lens of the Copenhagen School, as well as how, through speech acts, nuclear energy has been securitised alongside terrorism discourse. It then highlights the contrasting narratives between the US and Southeast Asia on the issue. The study finds that the securitisation of nuclear energy through a focus on terrorism has sidelined concerns of current and potential nuclear-power states, and could possibly discourage the latter from ratifying international conventions.

Keywords: desecuritisation, securitisation, nuclear energy, nuclear security, Copenhagen School, September 11

Introduction

The terror attacks on 11 September 2001 gave politicians and scholars reasons to reassess the security discourse that dominated the post–Cold War era. For 11 years since, governments have continued to focus defence policies on pre-emption, funding is prioritised in the areas of military and homeland security, the security debate has included terrorism as a new focal point, and the line between Islam as a religion of peace and as a religion of terror acts is now blurred. September 11 also sparked new concerns over the security of nuclear power plants and radioactive materials. The potential for nuclear and radiological terrorism has gained prominence in the minds of governments and the people, particularly when assessing current and potential nuclear power plants (Buzan 2006). After all, Osama bin Laden had considered the acquisition of nuclear power a 'duty' for al

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Qaeda, and it is difficult to crack down on the existing nuclear black-market trade (Booth 2005; Ogilvie-White 2006; Rogers 2008).

While the Cold War was a conflict of competing ideologies among global powers and their allies, the post–September 11 'War on Terror' is both military and psychological warfare between state and non-state actors. The latter 'war' has also significantly influenced the way issues of national security are discussed, and this extends to both traditional and non-traditional security threats. This study looks at the securitisation of nuclear energy post–September 11 and how global terrorism discourse has largely shaped current nuclear security discourse. Furthermore, it examines how the 'Islamisation' of acts of terror has shaped current understandings of security, including energy security.

The purposes of dividing the debate into the US and Southeast Asian perspectives is not to make these divisions more pronounced, but to demonstrate that a nuclear security debate dominated by Western conceptions of terrorism is detrimental to the goals the debate seeks to achieve in the first place. First, focusing on nuclear terrorism as a significant aspect of nuclear security tends to sideline the issue that in many parts of the world, separatist movements and rural energy poverty are more prominent issues. Second, the focus on nuclear terrorism has overshadowed the reality that major nuclear accidents have been the result of natural disasters, and human and/or technology error, rather than a ploy instigated by terrorists. The emphasis on the terrorist threat skews the allocation of national resources, presents an obstacle to comprehensive engagement with the nuclear security and safety debate, and creates a heightened atmosphere of suspicion among countries, leading to over-reactive policies and citizens.

September 11 and the securitisation of nuclear energy

The events of 11 September 2001 sent shockwaves around the globe. Not only did they result in the loss of innocent civilian lives, but they brought about a new dimension to understanding conflict and security: conflict can no longer be analysed through the practice of statecraft, as non-state actors can undermine the legitimacy of the state through acts of terror. It has been purported that the act of terrorism on September 11 was in itself retaliation to US supremacy, and was an act to question the US's position as a dominant super power. Following this, 'the 9/11 attacks have resulted in an extraordinary concentration on a particular form of transnational political violence, focusing mainly on the [al Qaeda] movement and associated Islamic jihadist groups' (Rogers 2008, p. 172). The current War on Terror has now 'been transformed into the "long war against Islamofascism"' (Rogers 2008, p. 172) and could even suggest that religious affiliation is now more useful when understanding prejudice than is race or ethnicity (Sheridan 2006). For example, Muslims travelling to the US from the Middle East are automatically assigned the yellow identity under the three different risk classes (green and red meaning non-dangerous and very dangerous respectively, with yellow in-between) of the Computer Assisted Passenger Prescreening System for visitors travelling to and from the US (Lyon 2003; van Munster 2005).

On 10 June 2002, the arrest of alleged al Qaeda terrorist Jose Padilla at an airport in Chicago, US, allowed the concept of a radiological bomb ('dirty' bomb) to enter the consciousness of Americans and the world (Kuchibhotla & McKinzie 2004). Since then, the threat of nuclear terrorism has become a global security concern. Inherent in preventing infiltration by and propagation of international and domestic terrorist cells, there is now fear for the safety and security of nuclear power plants and materials should they fall into the possession of non-state actors. This fear has even led the US and its allies to demand transparency in relation to nuclear programs, especially in Iraq, Iran and North Korea. The securitisation of nuclear energy has, therefore, taken root since the terrorist attacks of September 11.

The fear of actors (state and non-state) gaining control of nuclear technology for offensive purposes is not new. What is new, though, is the extent to which nuclear terrorism now forms a large proportion of the nuclear security debate. This shifts the debate's focus excessively away from that of ensuring optimal performance of nuclear technology that is resistant to human error and natural disasters. To date, most minor and major nuclear accidents are a result of human error or nuclear plants being vulnerable to natural disasters. While the nuclear black-market trade exists, the only time a nuclear bomb was used for offensive purposes was when the US dropped an atomic bomb on the cities of Hiroshima and Nagasaki in Japan at the end of World War II in 1945.

In addition, it is problematic to excessively focus on nuclear terrorism as part of the nuclear safety debate. As a result of the US-led War on Terror, the Islamisation of security and terrorism will inevitably influence the way (dominant) states think about nuclear terrorism. That is, it is dangerous for states with different political ideologies (North Korea with its Communist philosophy) or religious affiliations (Iraq and Iran both with Muslim majorities) to possess nuclear power. More specific to this study, the securitisation of nuclear energy through these lenses will affect Southeast Asia's nuclear aspirations (where religion plays a significant role in the political and social developments in Indonesia, Malaysia, Brunei and the Philippines) and future relations with the international nuclear community. Before looking at these issues, it is necessary to highlight how this study interprets the concept of securitisation.

Securitisation as articulated by the Copenhagen School

Realism has been the dominant approach in security studies and studies of international relations. The approach focuses on the behaviour of actors (mainly states, companies and individuals) by assuming that international relations is a zero-sum game, as these actors are value-maximising, self-interested and rational (Burchill 2005; Smith 2005). Stephen Walt (1991, pp. 212–13) contends that Security Studies should be about the study of military conflict, and widening that agenda

> … runs the risk of expanding 'Security Studies' excessively; by this logic, issues such as pollution, disease, child abuse, or economic recessions could all be viewed

> as threats to 'security'. Defining the field in this way would destroy its intellectual coherence and make it more difficult to devise solutions to any of these important problems.

The Copenhagen School, on the other hand, avoids studying security from a military perspective but seeks coherence by 'exploring the logic of security itself, to find out what differentiates security, and the process of securitisation, from that which is merely political' (Buzan 1997, p. 13). There is a subtle difference between the politicisation and securitisation of an issue: politicisation of an issue refers to placing an issue in the public domain, while securitisation usually involves presenting an issue as urgent and as one that should be dealt with decisively by credible leaders, especially at an international level (Buzan 1997; Buzan, Waever & de Wilde 1998). In exploring 'security' as a concept, the Copenhagen School includes the political, military, economic, ecological and economic security sectors in security studies and focuses discussions surrounding the topic of security on the sub-state, state and international system levels (Buzan 1983; Smith 2005).

This study is based on the concept of security and securitisation as articulated by the Copenhagen School, as the main purpose is to study not the threat and control of military force, but how terrorism discourse post–September 11 has shaped perceptions of security and, more specifically, nuclear security.

So what is meant by 'security' and 'securitisation'? According to Buzan, Waever and de Wilde (1998, p. 24), security is 'a self-referential practice' and it is through this practice that an issue gets securitised, 'not necessarily because a real existential threat exists but because the issue is presented as such a threat'. Securitisation then, is the 'intersubjective establishment of an existential threat with a saliency sufficient to have substantial political effects' (Buzan 1997, p. 14; Buzan, Waever & de Wilde 1998, p. 25). More importantly, the threat has to be successfully constructed as a threat and accepted by either a specific or wide, relevant audience (Buzan, Waever & de Wilde 1998; Waever 1995).

In language theory, the process of securitisation is called a speech act (Buzan 1997; Buzan, Waever & de Wilde 1998). A speech act 'is not interesting as a sign referring to something more real, it is the utterance itself that is the act: by saying it something is done (like betting, giving a promise, naming a ship)' (Buzan 1997, p. 14; Buzan, Waever & de Wilde 1998, p. 26). In this instance, it is important to consider the actors that are able to 'speak' security effectively and successfully, and the conditions that are required in order for an issue to become securitised. Therefore, what is essential in a security speech act is that it is 'interesting exactly because it holds the insurrecting potential to break the ordinary, to establish meaning that is not already in the context' (Waever 2000, p. 286).

Terrorism discourse through speech acts post-9/11

The ideology espoused by al Qaeda and other terrorist organisations is seen to be a threat to modern civilisation. September 11 had put an end to the post–Cold War era, solving the 'threat deficit problem' for the US, and 'triggered a substantial shift in security definitions and priorities in many countries' (Buzan 2006, p. 1103).

Almost immediately, Muslims and Arabs, or those who appear to be either, have been subjected to crude forms of racial profiling (Akram 2002; Akram & Johnson, 2002). Islam and Muslims have received considerable attention in the media since the Iranian Revolution of 1979 and the Gulf War of 1991. The terrorist attacks of September 11, however, were almost like the final reinforcement of the negative image of Muslims. This time, the revival of this fear is no longer perceived as a stereotype or a conflict taking place away from home, but the 'Muslim threat' is now 'real' and happening on home soil.

The 'you're either with us or against us' rhetoric espoused by former US President George W. Bush set the precedence for how the international community should approach the War on Terror. Given that acts of terror are often viewed in relation to Islam, the securitisation of terrorism has taken a religious slant and has been ingrained in the consciousness of governments' and people's approaches to acts of terror and Muslims. In India, for example, thousands of Indians fled from the northeast to the southern cities as rumours had spread through text messages that they were the target of Muslims, after violent clashes in Assam between the indigenous Bodo tribe and Muslim settlers (Loh 2012; Mahr 2012).

The successful securitisation of any issue involves three components: 'existential threats, emergency actions, and effects on interunit relations by breaking free of rules' (Buzan, Waever & de Wilde 1998, p. 26). Since the beginning of the War on Terror, the most effective way of securing its urgency is to link local problems with the wider terrorism framing. This is effective in establishing the 'existential threat' in society. It has been noted that in the US, Israel, Russia, China and India, international terrorism has been viewed as a common threat, and local problems have been closely linked to the problem of terrorism so as to justify other policy initiatives (Buzan 2006). The problem of terrorism, then, is often linked with problems of drug trafficking, international crime, rogue states and the proliferation of weapons of mass destruction, forcing countries to allocate a greater portion of the nation's budget to homeland security, with the threat of terrorism as the main focus.

The media also play a significant role in shaping terrorism discourse. In a study conducted on television's coverage of September 11, Kellner (2002, p. 143) notes that

> the mainstream media privileged the 'clash of civilizations' model, established a binary dualism between Islamic terrorism and civilization, and largely circulated war fever and retaliatory feelings and discourses that called for and supported a form of military intervention.

Ryan (2004) also conducted an analysis of editorials in the 10 most read newspapers in the US specifically on the War on Terror and found that Americans and their allies were described as 'tolerant', 'patriotic', 'heroic' and 'generous', while terms like 'extremist', 'cowardly', 'jealous' and 'vicious' were used to describe everyone else (pp. 376–7). It is also useful to point out that in his study, Ryan notes the distinction between describing Arabs as either 'good' or 'bad'.

While terrorism, both actual and perceived, poses a security threat to the sovereignty of a state, the terrorism discourse in other parts of the world is constructed differently. In Southeast Asia, for example, while states have stepped up their homeland and military defence against a potential terrorist attack, governments have steered clear of suggesting or including religious motivations as part of the terrorism discourse. This means that the region propagates the view that acts of terror are not the result of specific religious teachings but are the result of resentment against the dominance of another culture over one's own. This could be a direct reflection of the region's geopolitical realities with three Muslim-majority nations (Indonesia, Malaysia and Brunei), Indonesia being the largest Muslim-majority country in the world, situated in the region. While the region remains sensitive to irrational inferences, this is not to say that their governments do not recognise that some acts of terror have been motivated by religious affiliations, but terrorism should not be seen as representative of Islam, as it is only adhered to by a minority of Muslims.

Certain Southeast Asian leaders are also more critical of the Western discourse of terrorism and have the impression that the US is waging a war on Islam and Muslims specifically (Simon 2002, p. 29; Nesadurai 2004). This started when the US applied immigration and visa restrictions on Muslim countries, Malaysia being one of them, and the war on Iraq further reinforced these ideas (Nesadurai 2004).

Some Southeast Asian countries also suggest the need to question the motivations of religious terrorism. At the XIII Conference of Heads of State or Government of the Non-Aligned Movement held in Kuala Lumpur in 2003, former Malaysian Prime Minister Dr Mahathir Mohamad traced the routes of terrorism to the injustice and oppression of Palestinians as a result of Israel's aggression:

> The world now lives in fear. We are afraid of everything. We are afraid of flying, afraid of certain countries, afraid of bearded Asian men, afraid of the shoes airline passengers wear ... These blatant double standards [of the West], is [sic.] what infuriates Muslims, infuriates them to the extent of launching their own terror attacks. If Iraq is linked to the al Qaeda, is it not more logical to link the persecution and the oppression of the Palestinians to September 11?
>
> (Mahathir 2003)

Sharing the same sentiments in an earlier speech at the Extraordinary Session of the Islamic Conference of Foreign Ministers on Terrorism in 2002, Mahathir defined terrorism as '"acts of violence consciously committed against civilians by any actor, including states, which thus required firm US condemnation of *both* Palestinian suicide bombers targeting Israeli civilians and Israeli security forces targeting Palestinian civilians"' (quoted in Nesadurai 2004, p. 17).

Post–September 11 public debate in both Malaysia and Indonesia also questioned if the US was at least partially responsible for 'inciting' the attacks as it has embarked on a unilateral and hegemonic foreign policy, and has shown indifference to causes in which Muslims are victims of oppression (Means 2009, p.

172). Indonesia's response to the terrorism debate, however, has been remarkably different from that of Malaysia. During the time of the September 11 attacks, Megawati Sukarnoputri became Indonesia's President only six weeks before the attacks and almost immediately offered her commitment to the US War on Terror. Vice President Hamzah Haz, however, said that September 11 might have been the push for the US to reflect upon their current policies and to make up for their past (Sebastian 2003; Means 2009).

In Singapore's national document *The Fight Against Terror: Singapore's National Security Strategy*, then Deputy Prime Minister and current Singapore Prime Minister Lee Hsien Loong cautioned that terrorism '"will be a long war for Singapore and the region, and the end is not yet in sight"' (quoted in National Security Coordination Centre 2004, p. 14). In this light, it has been noted that

> Singapore will continue to be vulnerable because of the very strong stand we have taken against terrorism, the arrests we have made to crack down on JI [Jemaah Islamiyah] in Singapore, the assistance we have extended to regional efforts against terrorist groups, and the support we have given to the American reconstruction actions in Afghanistan and Iraq.
>
> (National Security Coordination Centre 2004, p. 14).

Also important in Singapore's National Security Strategy is the emphasis that a multiracial and ethnic Singapore should be

> … careful not to link acts that are perpetrated by terrorists, whether globally or in Singapore, to the local Muslim community and cause them to be defensive for no reason other than sharing a common faith.
>
> (National Security Coordination Centre 2004, p. 65)

At the Inter-Racial Confidence Circles forum in 2003, what Prime Minister Lee was concerned about was that an extremist minority could heighten '"distrust and fear among the different communities"' (quoted in National Security Coordination Centre 2004, p. 66).

There is stark contrast between the Western and Southeast Asia's approach to the terrorist problem. The governments of Indonesia, Malaysia and Vietnam have been openly critical of the Western discourse, voicing their concerns that 'the West-centric counter-terrorism agenda is forcing institutional change' within regional institutions such as the Asia-Pacific Economic Cooperation (APEC), and that 'they do not wish to be associated with the US "War on Terror", which is widely regarded among their populations as anti-Muslim, unilateral, pre-emptive, and disproportionately military' (Ogilvie-White 2006, p. 12). This difference is reflected in Southeast Asia's approach to nuclear security, and, more importantly, this difference is what hinders their full engagement and adherence to existing international agreements on nuclear energy.

'Terrorising' nuclear energy through speech acts

The rhetoric of the threat of nuclear terrorism and of the proliferation of weapons of mass destruction gained prominence in the US and some of its ally states after September 11: now, not only is the possession of nuclear technology a problem associated with 'rogues states', it is a problem associated with terrorist organisations. Then Senator and now President of the US Barack Obama commented in 2008 that nuclear terrorism is '"the gravest danger we face"' (quoted in Mooney 2008). Prior to his presidency, former US President George W. Bush noted in September 2002, a few months before the invasion of Iraq, that the

> … greatest danger our Nation faces lies at the crossroads of radicalism and technology. Our enemies have openly declared that they are seeking weapons of mass destruction, and evidence indicates that they are doing so with determination. The United States will not allow these efforts to succeed … History will judge harshly those who saw this coming danger but failed to act. In the new world we have entered, the only path to peace and security is the path of action.
>
> (Bush quoted in US Government 2002, p. v)

These same sentiments are shared by the former European Union's High Representative for the Common Foreign and Security Policy, Javier Solana, who contended that

> [p]roliferation of weapons of mass destruction is potentially the greatest threat to our security … The most frightening scenario is one in which terrorist groups acquire weapons of mass destruction. In this event, a small group would be able to inflict damage on a scale previously possible only for States and armies.
>
> (Solana 2003, pp. 7–8)

These speech acts on the securitisation of nuclear energy have been translated into domestic and international legislations. Post–September 11, the US Nuclear Regulatory Commission 'embarked on an effort to overhaul and strengthen the security of the nation's nuclear plants' (US Nuclear Regulatory Commission 2011). International institutions such as the United Nations (UN) and the International Atomic Energy Agency (IAEA) commissioned and adopted new safety standards and updated existing ones, focusing mainly on the threat of nuclear terrorism as part of the nuclear security discourse. It is important to note that out of the six multilateral instruments that underpin current international nuclear security standards, four of them were adopted after September 11 to specifically take account of international concerns over the terror attacks. These six multilateral instruments are the Convention on the Physical Protection of Nuclear Material[1] (adopted in 1979, entered into force in 1987), The Physical Protection of Nuclear Material and Nuclear Facilities[2] (INFCIRC/225, adopted in 1999), United Nations Security Council Resolution 1373[3] (adopted 29 September 2001), the

Code of Conduct on the Safety and Security of Radioactive Sources (CCSSRS)[4] (adopted 19 September 2003), United Nations Security Council Resolution 1540[5] (adopted 28 April 2004) and the International Convention for the Suppression of Acts of Nuclear Terrorism Convention (ICSANT)[6] (adopted 13 April 2005). Out of these six multilateral instruments, only United Nations Security Council Resolution 1373 and United Nations Security Council Resolution 1540 are universally binding, imposing nuclear security resolutions on all states (Boureston & Ogilvie-White 2010). Within Southeast Asia, for example, only Indonesia and the Philippines have ratified the Convention on the Physical Protection of Nuclear Material (Ogilvie-White 2006).

The securitisation of nuclear energy in Southeast Asia has taken on a somewhat different nature to that in the US. The governments of Southeast Asia are concerned about the threat that nuclear terrorism might pose given the existence of terrorist networks and separatist movements in the region, but the difference is that while the US largely views nuclear security through the lens of containing nuclear terrorism, Southeast Asian countries, on the whole, understand 'the importance of nuclear security as an international norm, rather than a specific reaction to a specific threat' (International Centre for Security Analysis 2012, p. 33).

In 2010, Singapore's Prime Minister Lee commented that nuclear terrorism is 'no longer an improbable threat, but a disaster which can realistically happen if stronger preventive efforts are not adopted' (Chua 2010), but he stressed that this issue was 'important although not urgent' (Prime Minister's Office Singapore 2010). Malaysian Prime Minister Najib Razak asserted that 'the threat of nuclear terrorism is real' (quoted in Ministry of Foreign Affairs 2010) and that Vietnam

> …did consider that the terrorist attacks of 9/11 had provided a sense of universalisation of the threat from terrorism and had thereby provided an incentive to all countries to take measure to improve nuclear security.
>
> (International Centre for Security Analysis 2012, p. 29)

But interviews conducted with Southeast Asia's officials by the International Centre for Security Analysis (2012) suggest that nuclear terrorism does not factor high on the priority list of nuclear security in Southeast Asia, much less allowing the concept of nuclear security and terrorism to be perceived almost interchangeably (as in the US security discourse).

Southeast Asia views nuclear security not through the perspective of terrorism, but sees adhering to nuclear security as part of fulfilling its international obligations, and a natural consideration behind any important decision. Some Southeast Asian countries do not think it is necessary to sign on to international nuclear conventions when the region is still free of nuclear power plants. More importantly, there are concerns raised over the unequal application of international agreements between states, and between Nuclear Weapon and Non-nuclear Weapon States. Very often, the '*what about Israel?*' question is raised, especially when Israel is 'allowed' to remain a non-signatory to the Non-Proliferation Treaty and maintain an ambiguous and undisclosed nuclear program, while Iran faces sanctions and calls for transparency regarding its intentions. Along the same lines, it is important to ask if Iran's civilian use of nuclear energy has been given enough coverage or if Iran will continue to be a threat even without its nuclear program.

Giving proper considerations to these issues is significant to informing the nuclear security debate: not only does it shed some light on why Southeast Asia is not fully embracing the current discussions and international conventions on nuclear security, but it could bring the focus of nuclear security back to the issue of security itself, and not construct it as the result of a specific threat, especially Islamic-motivated terrorism.

Desecuritising Nuclear Energy

The terrorism discourse in the US and some of its ally countries has insinuated the link between Islam and terrorism. There is, however, a fine line between religious-motivated violence and religion itself as the cause of violence. The motivations for terrorism are deep-seated, and focusing on Islam as the main cause of terrorism marginalises the discourse to one that understands the roots of terrorism very simplistically. Even more problematic is the exacerbation of the hostilities between Muslim-majority countries and the West, already a problem caused by the latter's one-sided treatment of the Israel–Palestine conflict. As terrorism has often been viewed as an 'Islamic threat', the nuclear terrorism discourse in the US has also taken on that character.

When examining political treatment of the nuclear programs among those forming the 'axis of evil', namely Iraq, Iran and North Korea, the demonising of Islam is made more pronounced. For example, the US led a war on Iraq in 2003 on the grounds of suspected possession of weapons of mass destruction, and imposed international sanctions on Iran and North Korea, but only provided the North Korean government with the 'carrot' in terms of aid—North Korea being dominated by religions other than Islam. Though, Iraq and Iran might have given the US reasons to believe that their nuclear programs were for offensive purposes. The former government of Iraq and the current Ahmadinejad government have been ambiguous about their nuclear capabilities and have made offensive statements targeting Western dominance and allies, especially Israel's policies. These statements often suggest a possibility of a military or terror attack on the US and its allies. However, for the US to target Iran's and North Korea's nuclear capabilities while allowing Israel to maintain an ambiguous nuclear program questions Washington's credibility, purposes and commitment to nuclear non-proliferation and terrorism.

One of the main problems of the current established international discourses on nuclear security is that it remains largely dominated by the US and some of its allies, focusing on nuclear terrorism as a significant portion of nuclear security. By not including other perspectives, such as those of Southeast Asia, the current nuclear security discourse may reduce the likelihood of states fully engaging in an international nuclear security strategy. States that might have already taken significant steps in ensuring the security of their current and potential nuclear technology might not necessarily sign up to established conventions, as they may be skeptical of the purpose and legitimacy of these conventions. International conventions have to be equally applied and made more inclusive so that while acknowledging that nuclear security is about safeguarding access to the technology and radioactive materials from terrorists, they also acknowledge that it is about ensuring energy security for urban and rural communities, the security of nuclear power in regions that are prone to natural disasters and bureaucratic corruption, *and* the prevention of the illegal trafficking of nuclear materials by separatist movements and unauthorised personnel (Fitzpatrick 2009). These issues are more prominent in regions like Southeast Asia.

Southeast Asia is a diverse region that is made up of both developed and developing economies, different political systems and colonial history, and is home to various religious and ethnic groups. The region has experienced immense economic growth and all-round development, but it struggles to deal with problems such as piracy, illicit trafficking networks, terrorism, erratic environmental conditions, and rural poverty. These geographical, and historical and present realities, are reflected in the region's approach towards nuclear energy and security.

At present, Vietnam has concrete nuclear ambitions to build ten nuclear reactors by 2030, with the first going online by 2020 (Fitzpatrick 2009; International Centre for Security Analysis 2012; James Martin Center for Nonproliferation Studies, Center for Energy and Security Studies and Vienna Center for Disarmament and Non-Proliferation 2012). Indonesia, Malaysia, Thailand, the Philippines, Laos and Myanmar have also expressed their interest, while Singapore has also conducted a pre-feasibility study (Woo 2012; James Martin Center for Nonproliferation Studies, Center for Energy and Security Studies and Vienna Center for Disarmament and Non-Proliferation 2012). Only Cambodia and Brunei have yet to express any nuclear energy plans. There are various considerations that factor into Southeast Asia's decision to develop nuclear energy, including recognising the importance of diversifying the region's energy mix; the availability of expertise; public acceptance; the ability to meet rising electricity demands; global prestige that comes with having nuclear energy; and ensuring energy security and autonomy (Fitzpatrick 2009; James Martin Center for Nonproliferation Studies, Center for Energy and Security Studies and Vienna Center for Disarmament and Non-Proliferation 2012).

Southeast Asia's approach to nuclear security is also a reflection of its historical and present-day realities, and is in keeping with its domestic, regional and international commitments. Regional cooperation on nuclear security is already in place in Southeast Asia. Ten Southeast Asian countries are Member States of the Association of Southeast Asian Nations (ASEAN) and are signatories to the Southeast Asia Nuclear-Weapon-Free Zone Treaty.[7] They also participate in regional security forums and initiatives such as the Forum for Nuclear Cooperation in Asia, the Asian Nuclear Safety Network and the Asia-Pacific Safeguards Network.

A study conducted on the nuclear ambitions of Indonesia, Malaysia, Singapore and Vietnam by the International Centre for Security Analysis (2012) suggests that nuclear security is 'taken seriously and was considered decades ago, but not necessarily because of the terrorist threat' (International Centre for Security Analysis 2012, p. 19). The study notes that Indonesia sees nuclear security as adhering to international standards while improving domestic capabilities, and Malaysia sees compliance with international norms as part of its international obligations and necessary to access nuclear technology. In addition, Singapore does not hold strong views on nuclear security as yet due to the fact that the region is still nuclear-free, the lack of any perceived nuclear-related threat and 'the strongly held dissociation of terrorism from nuclear matters' (International Centre for Security Analysis 2012, p. 24). As the country that is most likely to be the first to acquire nuclear energy, Vietnam sees it necessary to meet international requirements for its nuclear plans to be successful, as observing them will also allow the development of a safe civilian nuclear energy program. The study also found that

> [c]oncern was expressed that if the US remains the only state behind an international initiative such as nuclear security—it is unlikely to succeed. Furthermore, the nuclear security agenda will look like the NPT [Non-Proliferation Treaty] if imposed by 'arrogant Western states'.
>
> (International Centre for Security Analysis 2012, p. 26).

Southeast Asia continues to express its interest in acquiring nuclear energy, despite the Fukushima nuclear accident that devastated Japan in March 2011. As a region that is currently nuclear-free, and bearing in mind the other problems that the region face such as natural disasters, and the existence of terrorist cells and illicit trafficking networks, 'Southeast Asia remains a salient region in any global effort to manage nuclear security risks' (James Martin Center for Nonproliferation Studies, Center for Energy and Security Studies and Vienna Center for Disarmament and Non-Proliferation 2012, p. 3). To fully engage the region in future regional or international nuclear cooperation initiatives, however, the overall nuclear security agenda should reflect wider concerns. As discussed, the US is seen to be the dominant voice in articulating the current international nuclear security agenda. Since the conception of the 'axis of evil', the US has focused on nuclear terrorism in nuclear security debates, from the invasion of Iraq in 2003 through to its policies on North Korea and the recent toughening of sanctions against Iran. The Fukushima nuclear accident should have allowed governments to refocus their attention to the safety of nuclear power plants, as it exposed the vulnerability of this technology to human error and natural disasters. Instead, the later part of 2011 saw the reinvigoration of the US' stance against Iran's nuclear program, bringing nuclear terrorism back to the forefront of nuclear security discussions. The problem is not demanding the transparency of Iran's nuclear program, but the disproportionate emphasis on such issues in the international nuclear security agenda.

The desecuritisation of nuclear energy, where nuclear terrorism is no longer dominant in the discourse, is needed to bring the focus back to a comprehensive nuclear security agenda. Fukushima and Southeast Asia's approach to nuclear security shed light on the range of concerns of existing and potential nuclear-power countries. These concerns need to be equally addressed so as to encourage the participation of countries in international norms and cooperation surrounding nuclear energy, and to counter the perception that the US determines the international nuclear security agenda. Bearing in mind that nuclear disasters, to date, have been caused predominantly by natural disasters or human error and/or faults in technology, the desecuritisation of nuclear energy to include other security issues will also lead to well-considered solutions to nuclear-related disasters and assist aspiring nuclear-power states to focus on gathering the right intelligence and technology.

Conclusion

September 11 has affected the way the world approaches issues to do with safety and security. The fears of terrorism have influenced nuclear security discourse, particularly in the US, and the prevention of nuclear terrorism is high on the agenda. To fully engage the international community in the nuclear security discourse, however, international institutions should employ a more comprehensive and inclusive approach to take account of a wide range of concerns of current and potential nuclear-power states. These concerns should be reflected to provide balance in the way nuclear security is discussed. When the nuclear security debate takes on a new dimension and direction, the terrorism discourse that has dominated the Western world and international diplomacy for the past 11 years could follow suit.

Notes

1 In July 2005, the Convention was amended and it is now 'legally binding for States Parties to protect nuclear facilities and material in peaceful domestic use, storage as well as transport. It also provides for expanded cooperation between and among States regarding rapid measures to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences' (International Atomic Energy Agency 2012).

2 The Physical Protection of Nuclear Material and Nuclear Facilities states that 'The Convention on the Physical Protection of Nuclear Material (INFCIRC/274) obligates parties to make specific arrangement and meet defined standards of physical protection for international shipments of nuclear material; co-operate in the recovery and protection of stolen nuclear material; make as criminal offences specified acts to misuse or threats to misuse nuclear materials to harm the public; and prosecute or extradite those accused of committing such acts' (International Atomic Energy Agency 1999, p. 1).

3 Under United Nations Security Council Resolution 1373, 'all States should prevent and suppress the financing of terrorism, as well as criminalize the willful provision or collection of funds for such acts. The funds, financial assets and economic resources of those who commit or attempt to commit terrorist acts or participate in or facilitate the commission of terrorist acts and of persons and entities acting on behalf of terrorists should also be frozen without delay' (United Nations Security Council 2001).

4 The CCSSRS recognises that 'a global nuclear, radiation and waste safety culture is a key element of the peaceful uses of nuclear energy and that continuous efforts are required in

order to ensure that the technical and human elements of safety are maintained at the optimal level' and stresses 'the important role of the IAEA in enhancing nuclear, radiation and waste safety through its various safety programmes and initiatives and in promoting international co-operation in this regard' (International Atomic Energy Agency 2003).

5 United Nations Security Council Resolution 1540 'affirms that the proliferation of nuclear, chemical and biological weapons and their means of delivery constitutes a threat to international peace and security. The resolution obliges States, *inter alia*, to refrain from supporting by any means non-State actors from developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their delivery systems' (United Nations Security Council 2004).

6 The Convention 'imposes an obligation on State parties to establish the offences within the scope of the Convention as criminal offences under their national laws and to make these offences punishable by appropriate penalties, which take into account their grave nature' (Perera 2005).

7 The 10 ASEAN Member States are Brunei, Cambodia, Indonesia, Laos, Myanmar, Malaysia, the Philippines, Singapore, Thailand and Vietnam.

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NUCLEAR SECURITY CURRICULUM DEVELOPMENT IN MOROCCAN UNIVERSITIES, UNIVERSITY OF CASABLANCA CASE.

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ABSTRACT

Many Moroccan universities have been developing a nuclear science and technology curriculum, in several topics, for many years, following the development of several nuclear science and technology applications in various social and economic sectors, including agriculture, industry and medicine. The main role in this development could be attributed to the Nuclear Centre of Maâmoura (CNESTEN), with the Triga reactor, and research laboratories dedicated to those applications.

U.S. department of state's Partnership for Nuclear Security has been sponsoring this development by allowing Moroccan academic experts to participate INMM annual meetings for the last four years (2010-2013), thus giving them the possibility to meet hundreds of international security and nuclear material managers. In the 52nd INMM meeting in Palm Spring (2011), the INMM Moroccan chapter was launched; it was the first chapter.

Recently, Moroccan nuclear experts have been working with the international community to develop a nuclear security curriculum that will be taught within the Moroccan academic community.

In February 2012, the CNESTEN hosted an international workshop focused on developing a nuclear security curriculum. This event received over 40 participants, many of them from the Middle East and North Africa region (MENA). Efficient facilities, well-organised tours, interesting lectures, and well-planned following development steps have made this workshop to be very well received in the MENA region; thus allowing for the planning of another workshop which will be based on the successes of the former. With the assistance of the U.S. Department of State's Partnership for Nuclear Security (PNS), the International Atomic Energy Agency (IAEA), and the international academic community, Morocco was able to gather experts from the MENA Region to discuss the topics related to nuclear security.

As a result of their participation in the PNS, IAEA and CNESTEN activities, several academic institutions, including the Hassan II University in Casablanca, have made remarkable efforts to include nuclear security considerations in their nuclear science and technology curriculum. In an effort to incorporate international best practices from universities all around the world into the Moroccan nuclear development, six professors have participated in an Academic Study Tour in four American nuclear security institutions, namely the University of Tennessee, the University of North Carolina, the University of Texas Austin, and the University of Georgia. We will present throughout this article the Study Tour and the shared experience. The beneficiaries of the study tour will organize the Train-The-Trainer activity in their own institution; we will also present the activity in Hassan II University of Casablanca and the proposed Nuclear Security curriculum.

1. Introduction

In Morocco, since the 60’s, the first faculty of sciences in Mohamed V University of Rabat developed the first nuclear physics courses. In the 70’s, a bachelor’s degree in Nuclear physics was performed for few students (3-4/year). Some of those students would continue their curriculum, preparing a PhD in France. In the beginning of the 80’s and with the generalisation of education in Morocco, many universities in other regions were built (Figure1) and followed the same curriculum given in the University of Rabat.

- Mohammed V University at Agdal, **Rabat**
- Mohammed V University at Souissi, **Rabat**
- Hassan II Ain Chock University, **Casablanca**
- Hassan II Mohammedia University, **Mohammedia**
- Ibn Tofail University, **Kenitra**
- Sidi Mohamed Ben abdellah University, **Fez**
- Mohamed Premier University, **Oujda**
- Moulay Ismail University, **Meknès**
- Cadi Ayyad University, **Marrakech**
- Ibnou Zohr University, **Agadir**
- Chouaib Doukkali University, **El Jadida**
- Hassan Premier University, **Settat**
- Abdelmalek Essaâdi University, **Tanger**
- Moulay slimane University, **Beni Mellal**

Figure I : Moroccan universities

2. Nuclear Science and Technology Education

During the past 20 years, a Nuclear Science and Technology curriculum was developed in many Moroccan universities in different regions of Morocco: Casablanca, Rabat, Kenitra, Marrakech, Fez and Tetouan. Master’s degrees dedicated to nuclear science and technology are developed with several modules like: Radiation protection, Reactor physics and nuclear safety. Other Masters in various field applications using isotopes and nuclear techniques are promoted, such as Medical Physics in Medical faculty, Water and sustainable development in the faculty of science.

Those education and training curricula related to nuclear science and technology are developed and assured in collaboration with the CNESTEN (Centre National des Etudes des Sciences, des Techniques, de l’ Energie Nucléaire) with its Triga Mark 2MW nuclear reactor.

Figure II : Maâmoura Nuclear Centre (CNESTEN)

The CNESTEN was created in 1986, the laboratories of the Maâmoura Nuclear Centre were built in 2003, and the research reactor (Triga MarkII) installed in 2009.

The centre is working in partnership with universities (Masters and research collaboration), as it is dedicated to nuclear applications: Medical applications, Industrial applications, Water and agriculture applications. The CNESTEN is also a training centre for other national actors in several fields: Health, Industries, and Hydrology. It is also a regional training centre for the IAEA.

3. Nuclear Security Curriculum

3.1 Why nuclear security curriculum development in Moroccan universities?

- The Moroccan national energy strategy for 2025-2030 does include a nuclear program in the energetic mix.
- Various Nuclear Techniques and applications are used in several subjects; Medical, Industrial, Water and agriculture applications.
- Nuclear Research & Development at national or international level takes growing importance.
- The necessity of the fight against illicit use / threat.
- Stay up to the best application of laws and regulations: Independent regulatory body
- The International Engagement
- The Awareness of the Nuclear Security Culture

3.2 Step by step

The U.S. Department of State's Partnership for Nuclear Security has played an important role in the development of Nuclear Security curriculum introduction in the Moroccan academic program. One can consider that the first step was the participation of a Moroccan staff in the 52^{d} INMM annual meeting at Palm Desert – California, July 17th 2011. There was the INMM Moroccan Chapter Launching,

Figure III: INMM Moroccan Chapter Luncheon Palm Desert – CF July 2011

The INMM Moroccan Chapter was the first in the region (Africa and Middle East), Let us indicate that the Moroccan atomic and nuclear specialists are already enrolled in associations and NGO's promoting nuclear science and technology as:

- *Association des Ingénieurs en Génie Atomique du Maroc (AIGAM)*
- *Association Marocaine de Radioprotection (AMR)*
- *Groupe Marocain des Techniques des Réacteurs (GMTR)*

That experience has facilitated the creation the INMM Moroccan chapter.
During this meeting the PNS staff with the colleagues participants from MENA countries agreed to organise the Middle East and North Africa Nuclear Security Curriculum Development Workshop in Rabat Morocco from February 27th to March 2nd in Rabat – Morocco.

Figure IV: Meadle East & North Africa Nuclear. Security Curriculum Development Workshop

The participants are representing their institutions as:

- 10 Moroccan Universities represented 23 participants
- National Centre for Nuclear Energy Sciences and Techniques (CNESTEN) 6

- Alexandria University 2
- Arab Atomic Energy Agency 1
- Jordan University of Science and Technology (JUST) 3
- Khalifa University1
- University of Dar es Salaam 1
- South African Nuclear Energy Corporation (Necsa) 1
- Sandia National Laboratories 1
- U.S. Department of Energy/National Nuclear Security Administration 1
- University of Central Lancashire 1
- University of Pittsburgh 1
- University of Texas at Austin 1
- University of the Witwatersrand 1
- World Institute for Nuclear Security 1
- Lawrence Livermore National Laboratory 1
- Partnership for Nuclear Security (PNS) 1
- CRDF Global 3

During this workshop, many international experiences in Nuclear Security Education and training were reviewed as:

- IAEA : Educational Program in Nuclear Security Publication Recommended Courses for M.Sc
- International Nuclear Security Education Network (INSEN)
- European Master of Science Programme in Nuclear Security
- European Nuclear Security Research Network (ENSERN)
- Word Institute for Nuclear Security (WINS → Wins Academy)
- Naif Arab University for Security Sciences launches Diploma Program ,in Nuclear Security
- Gulf Nuclear Energy Infrastructure Institute 'GNEII' in Khalifa University

4. Recommendations:

- The need to increase the human resources development in Nuclear Security in the university curriculum
- The creation of a university curriculum completely dedicated to N.S. is not realistic
- To integrate fundamentals of Nuclear Security in existing university accredited courses in Bachelor's and Master's degrees.
- The contents and the programs are to be defined by concerned professors.
- To collaborate with local, national, regional and international institutions
- Funding for courses development and public awareness – information
- Attending national and International workshop (Study Tour)

5. USA Study tour:

U.S. department of state's Partnership for Nuclear Security sponsored the participation of six Moroccan professors in an Academic Study Tour in four US nuclear security institutions namely the University of Tennessee, the University of North Carolina, the University of Texas Austin, and the University of Georgia.

Figure V: University of Tennessee: Institute for Nuclear Security: Baker Institute

The beneficiaries are engaged in the application of the study tour organized the Train-The-Trainer activity in their own institution. We present the activity in Hassan II University of Casablanca and the proposed Nuclear Security curriculum.

Figure VI: Participants in Casablanca University workshop

EDUCATION AND TRAINING ON PHYSICAL PROTECTION OF NUCLEAR MATERIAL IN BELARUS

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ABSTRACT

Belarus is a country, which is making its first steps in nuclear energy production. Notwithstanding the historical high level of nuclear knowledge and capacity of the former USSR, which Belarus was a part of, the nuclear energy sector in todays' Belarus requires international assistance. Throughout a long period following the Chernobyl accident and the collapse of the USSR, when Belarus had introduced the moratorium on use nuclear energy, the country was losing many of specialists and much expertise. Now, having made a decision to build a nuclear power plant, we are faced by the challenge to educate and train our national nuclear energy specialists. The local expertise in this area is obsolete, and this necessitates international support and cooperation.

ISEU has been running a training programme for students in the field of nuclear and radiation safety since 2008. One of the essential parts of the programme is teaching physical protection of nuclear material.

The syllabus for this course was designed using the materials from different sources: IAEA's publications and a special Physical Protection of a Research Reactor course, cooperation with Russia and Ukraine and Belarus' own experience.

Our course consists of three main modules, each of them having theoretical and practical parts. Besides, excursions are organized to demonstrate the functioning of the physical protection systems in State Scientific Institution "The Joint Institute for Power and Nuclear Research - Sosny" (Belarus) and Sevastopol National University of Nuclear Energy and Industry (Ukraine).

The objectives of the modules are as follows:

Module 1: Students will understand how to define physical protection system requirements;

Module 2: Students will design a new or characterize an existing physical protection system;

Module 3: Students will learn how to evaluate the physical protection system performance and then will evaluate the system created in the module 2.

To be able to provide adequate training and meet our goals, we need to acquire laboratory benches of different physical protection subsystems, which would simulate real situations. Our instructors also need an opportunity to upgrade their training. They should be involved in international collaboration and exchange of experience to increase their knowledge and understanding physical protection.

1. Introduction

In 2008, Belarus had adopted a plan for the construction of its first nuclear power plant (NPP). From that time, the country has been responding to a challenge of preparing a sufficient number of educated personnel for nuclear energy sector.

During the period within the USSR, Belarus could boast of a rather high level of research and educational system in the field of atomic energy. At that time, it was planned that Belarus would build its own nuclear power plant. But the Chernobyl accident and the collapse of the USSR caused Belarus to introduce a moratorium on the use of nuclear energy. This led to losing specialists and expertise. And now Belarus lacks a young generation of specialists.

Moreover, it experiences a deficit in well-trained teachers, who had practical experience at NPPs and could impart their knowledge to the new generation.
On the positive side, however, one can mention that Belarus has a good educational system for physicists, nuclear physicists, engineers, etc. and there are still some specialists originating from the Soviet scientific nuclear school. This suggests that Belarus has all the potential for carrying out the ambitious training programme for young professionals in the field of nuclear energy, provided there is a significant help from international experts and international cooperation in this sphere.
Since the decision to build a nuclear power plant was taken, a training and advanced training programme for nuclear energy specialists in Belarus has started being implemented. One of the institutions called upon to provide this training is the International Sakharov Environmental University, which has been running a training programme for nuclear and radiation safety students since 2008. The university graduates will be able to fill posts and be in charge of the nuclear and radiation safety, including nuclear security and security of radiation sources in different organisations and nuclear safety at the NPP.

2. Training on physical protection in focus

One of the essential parts of the nuclear security is physical protection of nuclear material. That is why in the training programme there is a course on the *Physical Protection of Nuclear Material*.
The syllabus for this course was designed using the materials from sources as follows:
- IAEA's publications,
- Special Physical Protection of a Research Reactor course organized by the IAEA and
- Cooperation with Russia and Ukraine and Belarus' own experience.

The course consists of three main consecutive modules (see Figure 1), each of them having theoretical and practical parts during which students acquire skills to design a new physical protection system (PPS) or to characterize an existing physical protection system, to evaluate the design or system, and to redesign or to refine the system.

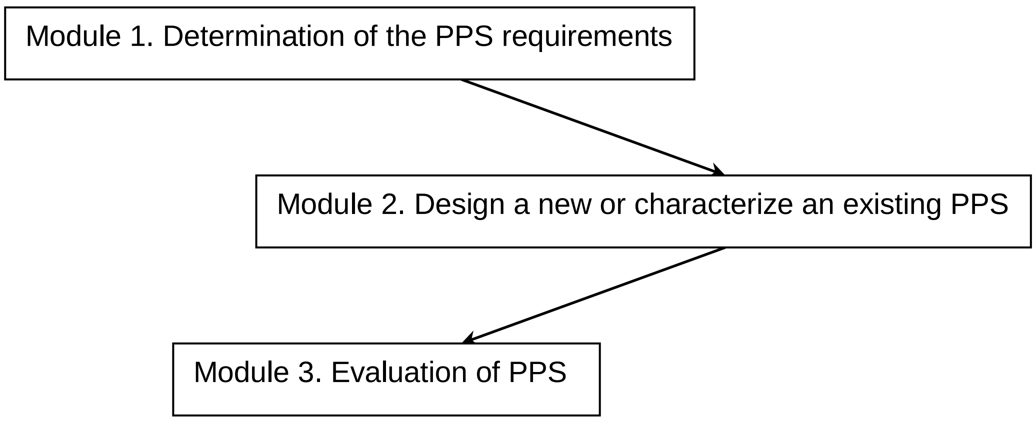

Figure 1: The structure of the *Physical Protection of Nuclear Material* course.

The content of the modules and actions entertained within each of them are briefly discussed below.

3. Module 1. Determination of the PPS requirements

The first module contains the most general information, because it comprises the documents for the physical protection of nuclear material and main definitions. The PPS requirements are defined there while developing them for a hypothetical object.
To develop the requirements, students must start from by gathering information about the operations and conditions of the facility, such as a comprehensive description of the facility, operating states, and physical protection requirements as well as regulatory requirements.

The trainees then need to define the threat; it involves considering factors about potential adversaries: types of adversaries, the adversary's capabilities, and the range of the adversary's tactics. After that, different groups of students should identify adversaries' targets. Determination of whether nuclear materials are attractive targets is based mainly on the type and quantity of material and the ultimate goal of the adversary. Finally, students must identify the regulatory requirements and risk management considerations. Students now know the objectives of the physical protection system, that is, "what to protect against whom."

The main problem of this module is that the teacher does not have enough competence to evaluate the correctness of the PPS requirements. Therefore, it should be mentioned that students receive just basic skills in defining the PPS requirements for their facility.

4. Module 2. Design a new or characterize an existing PPS

The second module is to design the new system or to characterize the existing system. In this module, students are familiarized with different components of the PPS. They explore different fences, vaults, sensors, procedures, and communication devices. At the end, the students should determine how best to combine elements of the PPS to provide the three functions: detection, delay, and response that can satisfy the protection requirements.

In this module, students design the PPS for a particular facility.

The problems of this module are that in Belarus there are no training benches or set-ups for the physical protection that demonstrate the work of different components of the PPS and provide the opportunities for rehearses by implementing a variety of exercises. Having such training equipment one may facilitate understanding and training to the PPS operations more completely.

To demonstrate an existing PPS, some excursions to the State Scientific Institution "The Joint Institute for Power and Nuclear Research - Sosny" (Belarus) and Sevastopol National University of Nuclear Energy and Industry (Ukraine) were organised. In Sevastopol National University of Nuclear Energy and Industry students also learn how to handle some components of the physical protection. But from the point of view of teaching this course, it seems to be not enough.

5. Module 3. Evaluation of PPS

The third module is the evaluation of the physical protection system design. Evaluation must consider the effectiveness of a system of elements that work together to assure protection rather than regarding each element separately. Due to the complexity of protection systems, an evaluation usually requires modeling techniques.

In the theoretical part, the students acquaint themselves with different types of analysis and evaluation of the PPS. And then they use it for evaluation of the PPS at their facility.

At the end of the course, students understand the importance of the physical protection of nuclear material as a part of nuclear security and have theoretical knowledge and practical skills to design and evaluate a PPS.

6. Conclusions

Among the main problems faced by Belarus today, we should mention the appropriate training for the teachers, including the need to acquire laboratory set-ups of different physical protection subsystems, which would simulate real situations. Our instructors also need an opportunity to upgrade their training. They should be involved in international collaboration and exchange of experience to increase their knowledge and understanding of physical protection.

OUTCOMES OF INTERNATIONAL INTERDISCIPLINARY NETWORKING

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ABSTRACT

The nuclear renaissance was expected to bloom in nuclear developed states and it was supposed to lead to the development of new types of advanced nuclear units. Lack of orders, lack of determination, unhappy political decisions made those state fade into a grey future. Such hope arises from states with little or not at all experience in the field, but with a strong will to implement this form of clean energy. Nevertheless the nuclear energy remains an important option for some European countries. EU official position states that in energy sector we need: security of supply, sustainability, feasible prices and investments. Last events in the nuclear field had a strong impact on security demands from the sector. Accordingly, additional requirements are now imposed for nuclear energy. New nuclear requirements following Fukushima accident will be highlighted.

Nuclear Knowledge Management (NKM) is one of the pillars of future development and the IAEA shows support providing programs and projects in the field. The continuity of success depends on how we deal with the accumulated knowledge. All countries face NKM problems and have to deal with it. Developed countries are the main source of knowledge accumulated and face the challenge of transferring it to new generations. On the other hand developing countries must deal with knowledge caption and absorption and must deal with brain drainage. Accepting recent events and endorsing the lessons learned helped NKM make a huge step in building a better approach in E&T.

Another important pillar in efficient collaboration between developing and developed countries is represented by the regional and interregional programs between experienced states and newcomers. There are important outcomes to be achieved through joint collaboration between experts either from different countries with same nuclear background but with different expertise, or experts that have different levels of knowledge regarding Education and Training programs needed by nuclear energy option.

The interdisciplinary objective of networking is to create a multi-level nuclear program that can fulfil the needs of society, industry, R&D entities and E&T institutions.

E&T is the third important pillar in nuclear reshaping. In Romania as a result of strong international networking in projects like REFIN (Romanian Network of Excellence in Nuclear Physics and Engineering) ENEN, ENEN-II, ENEN-III, NEPTUNO, TRASNUSAFE, EURECA!, ENEN-RU, EUJEP, NEWLANCER it has been developed an efficient, flexible and modern training scheme which answers the needs of nuclear industry: NPP, regulatory bodies, dismantling, radioprotection, waste management. This scheme involves and includes reshaping of curricula and course development according to the future needs of nuclear industry, introduction of advanced courses on project topics, exchange of trainers and trainees with institutions that share same concerns about the topic, joint research and

teaching labs, student exchange for collaborative education and research.

In all these activities universities can make significant progress towards building the human capacity necessary to support next generation nuclear power units. Extended research regarding Gen 4 reactors is strongly supported by EURATOM and prototype installations are planned. Involvement of all EU countries in these complex activities should be reflected by the E&T programs too, as education is a key component that needs to be consolidated.
Romania's integration in the Gen 4 program ALFRED represents an important upgrade of the national nuclear initiative. which includes a good national strategy and support on the topic, strong research laboratories supported by good personnel, an education component aimed to provide sustainable and qualified workforce, national/international interest from stakeholders and governments and a well-informed society that needs to be aware of the benefits such program brings.

1. Introduction

Aim of present paper is to analyse the outcomes that can be achieved through joint collaboration between experts coming from different countries, thus with different level of knowledge and different expertise background. Knowledge management plays a key role in creating and supporting skilled and well prepared personnel in nuclear industry and not only. Experts coming from countries that undergo a well-developed nuclear program based on a long history share their expertise with experts from such called newcomer countries. This expertise can be put together by various methods.

Approaches to develop E&T based on knowledge management training schemes can be various. The paper will analyse development of E&T programme based on such joint collaboration programs.

2. What we have

EU official position states that in the energy sector we need: security of supply, sustainability, feasible prices and investments. Last events in the nuclear field had a strong impact on security demands from the sector. Accordingly, additional requirements are now imposed for nuclear energy. New nuclear requirements following Fukushima accident are and will be highlighted, leading to improvement of projects and of legislation.

In the last year more countries adopted plans which define the organization of activities necessary to implement a civil nuclear power program. This includes comprehensive public consultation, nuclear legislation improvement, site selection, tender procedures, licensing activities, enforcement of regulatory bodies, and last but not least, a strong approach to Nuclear Education & Training. Developed countries (EU and USA in the first row) started to cope for better business opportunities with countries formerly situated on an 'exclusion' list.

3. Role and place of Knowledge Management

Building a successful nuclear energy program is based on correct and in-time shaping of E&T demands.

Nuclear Education and Training appear to be one of the pillars of future development. Therefore attention should be oriented towards the investments being made in the E&T field, examples of national schemes taking place, bottlenecks facing the industry in the future, and ultimately showing where the industry is going in the coming years.

An analysis of tools to be used for E&T integration methodology in a development program should overview:

- A good national strategy and support of the topic,
- Strong research laboratories supported by skilled personnel,
- Education component to provide sustainable and qualified workforce,
- National/international interest from stakeholders and governments and a well-informed society that needs to be aware of the benefits such program brings.

At the same time an increased preoccupation is shown towards Nuclear Knowledge Management (NKM), which appears to the driving force and solid tool for future healthy and efficient E&T development.

All countries face NKM problems and have to deal with it. Accepting recent events and endorsing the lessons learned helped NKM make a huge step in building a better approach in E&T. National authorities, as well as the IAEA (should) show support by providing programs and projects in the field.

The continuity of success depends on how we deal with the accumulated knowledge. Developed countries are the main source of knowledge accumulated and face the challenge of transferring it to new generations. On the other hand developing countries must deal with knowledge caption and absorption and must deal with brain drainage.

4. Transferring knowledge via networking

Building a successful nuclear energy program is based on correct and in-time shaping of E&T needs, taking into consideration key aspects as: national and international existing regulations, research infrastructure, education & training capabilities and language barriers to be tackled. Regulatory framework of a newcomer is shaped according to existing international requirements and recommendations promoted by international bodies, and regional and national authorities.

Therefore another important pillar in efficient collaboration between developing and developed countries is represented by the bilateral, regional and interregional programs between experienced states and newcomers.

States who wish to start and develop a nuclear program are considered to be newcomers. They clearly should benefit from the cooperation with experienced states and each of the parties has some expectations as a result of their collaboration.

There are important outcomes to be achieved through joint collaboration between experts either from different countries with same nuclear background but with different expertise, or experts that have different levels of knowledge regarding Education and Training programs needed by nuclear energy option. One key aspect the newcomers are looking for is the expertise record and visibility at international level.

Support and guidance by AIEA in developing the infrastructure and knowledge for nuclear education and training programs should be considered. Networking is a basic tool for that.

The interdisciplinary objective of networking is to create a multi-level nuclear program that can fulfil the needs of society, industry, R&D entities and E&T institutions. An example of international cooperation between states with long experience in nuclear education, training and research and states with less visibility is the EURATOM FP 7 project NEWLANCER-New MEMBER STATES Linking for an AdvaNced Cohesion in Euratom Research. In this project the cooperation at national and international level in different research and E&T areas aims to strengthen the capabilities of each partner/EU member state. E&T is an important pillar in nuclear reshaping. In Romania as a result of strong international networking in projects like REFIN (Romanian Network of Excellence in Nuclear Physics and Engineering) ENEN, ENEN-II, ENEN-III, NEPTUNO, TRASNUSAFE, EURECA!, ENEN-RU, EUJEP, NEWLANCER it has been developed an efficient, flexible and modern training scheme which answers the needs of nuclear industry: NPP, regulatory bodies, dismantling, radioprotection, waste management. This scheme involves and includes reshaping of curricula and course development according to the future needs of nuclear industry, introduction of advanced courses on project topics, exchange of trainers and trainees with institutions that share same concerns about the topic, joint research and teaching labs, student exchange for collaborative education and research.

These projects showed that:

- From technical point of view, networking improves the quality of training in nuclear field, the competence of trainers and students, and permits the efficient use of the facilities and of the research infrastructures;

- The use of modern training and knowledge management methods helps the harmonization with similar education systems in view of integration with other countries with direct effects on increasing economic competitiveness, while fulfilling the sustainable development criteria.

In all these activities universities can make significant progress towards building the human capacity necessary to support next generation nuclear power units. Extended research regarding Gen 4 reactors is strongly supported by EURATOM and prototype installations are planned. Involvement of all EU countries in these complex activities should be reflected by the E&T programs too, as education is a key component that needs to be consolidated.

Romania's integration in the Gen 4 program ALFRED represents an important upgrade of the national nuclear initiative. which includes a good national strategy and support on the topic, strong research laboratories supported by good personnel, an education component aimed to provide sustainable and qualified workforce, national/international interest from stakeholders and governments and a well-informed society that needs to be aware of the benefits such program brings.

Following developed projects represent some good example of multidisciplinary approach for networking between NMS (New Member States) and OMS (Old Member States). The ARCADIA project has been conceived so as to provide a twofold support to the further development of nuclear research programs in the NMS, targeting two major areas included in the Strategic Research and Innovation Agenda of SNETP: ESNII, through the support of the ALFRED project towards its realization in Romania, and NUGENIA, approaching remaining safety aspects of Gen III/III+ that could be built in Lithuania, Poland, Czech Republic and Slovenia. On one hand, it focuses on the identification of the primary needs for the ALFRED project, mainly to what concerns E&T, supporting Infrastructures and Regulatory aspects (and integrating – for the R&D needs – the outcomes of other research projects in a common frame of National and Regional needs); on the other hand, it investigates the existing National and Regional supporting structures – with a particular attention to the ones in Romania and in all the participating New Member States – for defining a map of competences potentially eligible to satisfy the previously identified needs. Considering a different approach, the EAGLE ((Enhancing educAtion, traininG and communication processes for informed behaviours and decision-making reLatEd to ionizing radiation risks) project aims specifically at coordinating the information and communication strategies related to ionising radiation for the general public, in order to get a better understanding of the effects of ionising radiation, taking also into consideration the lessons learnt from the 2011 accident in Fukushima. Education, training and information to the general public are key factors in the governance of ionising radiation risks. Communication about ionising radiation with the general public has to be further improved, as highlighted also by the 2011 accident in Japan. An effort is needed to analyse the state of the art and the existing needs in education, training and information, and to coordinate the information and communication about ionising radiation at European level.

Education & Training networks between experts, gathering universities, research facilities, regulatory bodies and end users can improve existing expertise and can represent a trusted base for international cross linking. Such collaboration programs are intended to provide an efficient training scheme for future qualified personnel that is involved in nuclear field following the needs that industry has. Some good examples of international expert cooperation could be considered as European Nuclear Education Network Association (ENEN), Asian Nuclear Education and Training Network (ANENT), Latin America Nuclear Education and Training Association (LANENT). This way the benefits resulted from joint collaboration programs between experts from different countries with mature nuclear programs and experts coming from countries with a smaller or inexistent nuclear program are highlighted.

5. Conclusions

New nuclear programs did not fulfil the nuclear industry expectations. Despite lack of orders, lack of determination or unhappy political decisions certain hope arise from states with little experience in the field.

Collaboration between developing and developed countries is represented by the regional and interregional programs between experienced states and newcomers. Numerous examples were offered and these projects showed good collaboration results during a period of over a decade of continuous partnership.

As NKM is recognized as key issue of future nuclear development, IAEA strong support is shown by numerous programs provided and numerous projects encouraged. Developed countries face the challenge of transferring to new generations all accumulated knowledge and developing countries proved to be capable of absorbing it but must face the challenge of avoiding brain drainage.

Direct outcomes of international interdisciplinary networking, based on E&T needs, can be considered to be: new curricula and course development; introduction of advanced courses; exchange of trainers and trainees with institutions that share same concerns; joint research and teaching labs; student exchange for collaborative education and research.

NUCLEAR TRAINING OF VIETNAMESE UNIVERSITY LECTURERS IN HUNGARY

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ABSTRACT

Following an agreement between Hungary and Vietnam, nuclear training of 160 Vietnamese university lecturers was realized in four groups in years 2012 and 2013 in Hungary.

The 6-week-long HUVINETT ("**Hu**ngarian-**Vi**etnamese **N**uclear **E**nergy **T**rain the **T**rainers Course") upgrading courses consisted of two parts: in the first three weeks the participants attended lectures and performed laboratory experiments in the Training Reactor of the Institute of Nuclear Techniques of the Budapest University of Technology and Economics (BME). In the second three weeks they improved their practical skills and knowledge at the Paks Nuclear Power Plant, among others in the Maintenance Performance Improvement Center and in the Full Scope Simulator. The efficiency of the training course was demonstrated by the results of the entrance and exit tests written by the participants.

The objective of the training program was to help the 7 largest universities of the Asian country prepare for the education and training of highly qualified nuclear workforce. According to the decision of the Vietnamese government, Russian companies will build and put into operation two 1200 MW units of pressurized water reactors in Vietnam by 2020.

The paper describes the structure of the HUVINETT courses and the experience of the cooperation between the teaching experts of BME, Paks NPP and the Vietnamese universities.

1. The role and infrastructure of nuclear energy in Hungary

The Hungarian electricity consumption was about 43 TWh in 2012, showing a modest decrease in the last years because of the economic crisis. Compared with the Hungarian population (10 million), this figure corresponds to about 4 MWh electricity consumption per capita. The maximum gross peak system load was 6500 MW in 2012. The total installed capacity of the Hungarian power plants was 9 000 MW in 2012. The domestic electricity production was 35 TWh, with an import-export balance of 8 TWh.

The domestic electricity production relies significantly on the only Hungarian nuclear power plant. In the Paks NPP [1] there are four Soviet-built units operating (with VVER-440 type pressurized water reactors). The original nominal capacity of the units was 4*440 MW, but after several power upgrading measures it was increased to 4*500 MW. The units were connected to the electricity grid in the period between 1982 and 1987. Their originally planned lifetime was 30 years, but the operator (MVM Paks Nuclear Power Plant Ltd.) is realizing a lifetime-extension project, in order to obtain an operating licence for further 20 years. Unit 1 received the extended operating licence in 2012 from the Hungarian Atomic

Energy Authority. Paks NPP successfully participated in the EU-initiated stress test after the Fukushima accident.

The Paks NPP offers a unique training facility, the Maintenance Performance Improvement Center (MPIC) used mainly for the training of the maintenance and technical background staff of the plant. In the MPIC – among others – the main components (reactor vessel with its internals, main circulating pump, steam generator, fuel assemblies, different pumps and valves) of the primary circuit are available under inactive conditions.

The first nuclear reactor in Hungary, the Budapest Research Reactor (BRR) started operation in the Energy Research Center of Hungarian Academy of Sciences [2] in 1959 in the capital. The tank-type light water moderated research reactor was refurbished between 1986 and 1992. At present, the reactor has a nominal thermal power of 10 MW. The BRR is used for different research purposes, including irradiation of various materials – such as neutron activation analysis or isotope production, neutron radiography – and as a neutron source for material research applications.


Fig. 1: The Paks NPP


Fig. 2: Training Reactor at BME

Prior to the construction of the Paks units a small training reactor had been built for the establishment of competency of domestic experts and for the training of operating personnel, research and technical support staff. The Training Reactor at the Budapest University of Technology and Economics (BME) started in 1971 based on domestic design and constructed by Hungarian companies [3]. The pool-type reactor has a nominal thermal power of 100 kW, and it is designed to be operated by students as well. The Training Reactor offers a unique possibility for practical education of nuclear experts.

The establishment of the Hungarian nuclear industry was the result of a pragmatic development process. From the 1950's Hungary intended to become an intelligent user of nuclear energy, and to own all the knowledge, education and research capacity that are necessary for the long-term safe operation of the Paks NPP units and for the competent decision-making of the related technical and economical questions. Beside the facilities, also the university and other training programs have been also developed in the last 50 years, as a result of which Hungary is now self-supplying in the field of nuclear expert education.

2. Introducing nuclear energy in Vietnam

The densely populated Asian country has a quickly developing economy (with an annual GPD increase of 5%). The electricity production in Vietnam was 117 TWh, while the installed generating capacity was 26 GW in 2012 [4]. This figure – compared with the population (92 million) – results in 1.3 MWh electricity consumption per capita, approximately one third of the respective figure of Hungary. Together with the quick development of the Vietnamese industry the increase of electricity demand is expected: the projected electricity consumption in 2020 is 320 TWh, more than three times higher than the actual value.

The Vietnamese electricity system is based mainly on hydroelectric and fossil (natural gas and coal fired) power plants. The country is self-sufficient in natural gas production. The electricity import is quite limited: in 2012 Vietnam imported 2.5 TWh electrical energy from China.

Vietnam has now only one operating research reactor at Da Lat (DLRR) with 500 kW thermal power. DLRR is used for training and research purposes. According to a Russian-Vietnamese agreement, Russia will build a new open tank type research reactor for Vietnam with 15 MW power for mainly neutron beam application and irradiation activities. The schedule for the start of the new research reactor is 2020.

The nuclear power development plan of Vietnam (released in 2007) announced the establishment of 8000 MW nuclear power plant capacity by 2025. The first selected nuclear site is Phuoc Dinh in Ninh Thuan province in the south-east region of the country. According to the national development plans, four reactors will be constructed here, they would start operation between 2020 and 2027. These nuclear units will be constructed by the Russian Atomstroyexport according to a 2010 intergovernmental agreement. The construction of the two VVER-1000 units will start in 2014 financed by the Russian counterpart. Unit 3 and 4 will also be Russian-designed VVER type reactors, for which the dates for the commencement of the construction are not determined yet.

There is also an intergovernmental agreement in force with Japan for four Japanese, third generation units. The construction of these units is expected to start in 2015 financed by Japanese companies. The location of these Japanese reactors would be Vinh Hai in Ninh Thuan province.

3. The basis of Hungarian – Vietnamese cooperation

The construction of the Paks NPP was a serious challenge for Hungary even with the background mentioned in Section 1. Significant nuclear knowledge was gained from the nuclear plant construction, but it also improved based on the strong technical, scientific and industrial resources of the country. The Training Reactor at BME, the Budapest Research Reactor of the Energy Research Center and the training facilities in Paks NPP represent a very wide range of competences and possibilities to be used in the education and training of nuclear embarking countries.

These opportunities were recognized in 2009, when the Hungarian and Vietnamese governmental representatives and industrial experts started negotiations about a possible cooperation in nuclear education. Beside the well developed Hungarian educational system and infrastructure the traditional good relationship between the two countries represented an important factor. An additional important argument was that Hungary gained lot of experience on how to localize Russian technology.

As the first step of a long-term cooperation, the need of a special training program was recognized. The government of the Asian country selected seven universities which should be prepared for the education of the future nuclear experts, in other words the nuclear expertise at these universities should be developed first. In order to involve as many lecturers as possible, a 6 week training course was introduced, which aims at the overview of nuclear sciences and demonstration of typical educational methodologies applied in Hungary. The participants of these courses are mainly lecturers of the seven selected universities, but representatives of the Vietnamese power industry, ministries and agencies take part, too.

Fig. 3: The opening ceremony of the 1st HUVINETT course in Budapest

4. Course structure

The two most important locations of Hungarian nuclear education are the Training Reactor at Budapest University of Technology and Economics and the training facilities of Paks NPP. The 6 week long time frame available for the training program was divided into two parts between these two locations: a 3 week program was organized at BME Training Reactor, and the next 3 weeks at Paks NPP. The first 3 weeks at BME were dedicated more to theoretical studies, while the second 3 weeks at Paks gave participants more practical experiences. The course participants had 40 hours of activity every week.

At BME, of the total of 120 hours of time frame 80 hours were spent with lectures, 36 hours with demonstrations of different laboratory exercises in smaller groups and 4 hours for tests.


Fig. 4: Reactor operation exercise at BME Training Reactor

The fields of study at BME were the followings:
- Nuclear fundamentals
- Reactor physics
- Thermal hydraulics
- Nuclear fuel cycle
- Nuclear power plants
- Nuclear safety
- Operation of nuclear power plants
- Nuclear measuring methods
- Radiochemistry
- Radiation and environmental protection
- Reactor laboratory exercises

The Vietnamese colleagues participated in the following laboratory exercise demonstrations:
- Introduction to laboratory exercise, radiation protection and safety training
- Measurement of scintillation and semiconductor detectors
- Measurement of gas filled and neutron detectors
- Reactor operation exercise
- Determination of spatial distribution of thermal neutron flux in the core of the training reactor
- Experimental demonstration of thermal-hydraulics of PWRs during Loss-of Coolant Accidents on TRATEL plexiglas mock-up
- Radiation protection in practice
- Demonstration of PWR primary circuit behavior on simulator
- VVER-1000 simulator exercise

Fig. 5: Laboratory exercise at BME

At Paks NPP from the 120 hours 64 hours were dedicated to lectures and presentations, 52 hours for practical exercises, plant visits and 4 hours for tests and evaluation.

The key subjects in Paks were the followings:
- International, national requirement of NPP operation
- Introduction of the VVER-440 technology and equipment
- Technology development/upgrade at Paks NPP
- Safety related issues at Paks NPP
- Nuclear fuel management and fuel handling at Paks NPP
- Chemistry issues at Paks NPP

- Maintenance activities at Paks NPP
- Radiation protection at Paks NPP
- Emergency response System at Paks NPP
- Severe accident management
- Technical support activities at Paks NPP
- Human resource management and training system at Paks NPP
- Exercises on the full scope plant simulator
- Practical exercises on real primary circuit equipments

Fig. 6: Demonstration of lifting the reactor internals
in Maintenance Performance Improvement Center of Paks NPP

Fig. 7: Hands-on training in Maintenance Training Centre of Paks NPP

All materials presented during the 6 weeks were made available for the course participants.
The nuclear related knowledge of all course participants was measured at the beginning of the program in Budapest by different survey test. Other tests were also applied at the end of the first and the second 3 week period in order to determine the improvement of the level of knowledge gained during the program. The participants have shown a very creditable performance improvement. At Paks, the program was continued with practical application of

nuclear knowledge in an operating nuclear facility with the special focus on the importance of nuclear safety. The whole program was closed with a common evaluation session.

5. Experiences and outlook

We are convinced that Hungary has provided a unique environment for learning useful and interesting subjects from well prepared and well organized training content, delivered by experienced and knowledgeable lecturers in an open and constructive atmosphere which – along with the commitment discipline and diligence of the Vietnamese trainees – all helped achieve the overall objectives, thus come to the conclusion that **the continuation of the HUVINETT program is considered as highly beneficial for Vietnam to better face its endeavors in nuclear education and training.**

Fig. 8: The 3rd HUVINETT group at Paks NPP

Based on the experiences gained during the HUVINETT courses the key stakeholders (the Hungarian Government – Ministry of National Development, Paks NPP and BME Training Reactor) are actually working on the formation of the **Hu**ngarian **N**uclear **E**ducation **N**etwork (HUNEN) for further international courses which will be open for other countries, especially for those embarking upon their national nuclear program.

6. References

[1] http://paksnuclearpowerplant.com/

[2] http://www.energia.mta.hu/

[3] http://www.reak.bme.hu/en/

[4] https://www.cia.gov/library/publications/the-world-factbook/geos/vm.html

POLISH EXPERIENCE IN THE PREPARATION OF THE NUCLEAR PROGRAM AND THE EDUCATION OF STUDENTS IN COOPERATION WITH AREVA

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ABSTRACT

The official report 'Polish Energy Policy until 2030', released in 2009, calls for the construction of a new nuclear power plant (NPP) in Poland. One key element of this policy, in addition to the construction of the NPP, is the education of nuclear technology engineers. The Ministry of Economy has released the Polish Nuclear Power Program, which is expected to be approved by the Council of Ministers by the end of the year. The Program stated that the first Polish nuclear power plant will be operational by the end of 2024.

Several universities have launched specialized nuclear technology courses, notably the Faculty of Power and Aeronautical Engineering at the Warsaw University of Technology (WUT), which was in 2006 the first university in Poland to restart its nuclear power specialization. A total of 43 Master students are currently enrolled in this university program. In addition to the education of engineers, WUT received a grant from the National Center for Research and Development to conduct research in the field of safety analysis. The recipient of the results of this grant is National Atomic Energy Agency - the future Polish regulatory body

The integration of the university in the Polish Nuclear Power Program provides both challenges and opportunities for WUT. The challenges comprise the build up of knowledge and know-how, particularly in the field of safety analyses, and the education of students with a focus on nuclear energy. Cooperation with industry is of great benefit, as it allows students to familiarize themselves with the focus of the nuclear industry. WUT has used this opportunity to develop a cooperation agreement with AREVA, which provides a variety of activities to support the role of WUT in the Polish Nuclear Power Program. AREVA specialists provide lectures at WUT, supplementing the lecture offer of WUT and allowing know-how developed in industry to become part of university education. Also, several students are sent to AREVA laboratories and facilities to work either in internships or on their Master or PhD theses. Groups of students will have the opportunity to visit the unique experimental facilities of AREVA. WUT and AREVA have jointly organized a workshop entitled: Familiarization with calculation codes application and safety analysis workshop.

This paper reviews the tasks and challenges for WUT resulting from current stage of the nuclear new build program in Poland and discusses the opportunities offered by the cooperation with AREVA, as well as its first successes.

1. Introduction

The official document 'Polish Energy Policy until 2025', released in 2025, called for diversification of energy sources and for construction of environment friendly power plants in Poland. In view of the possible introduction of nuclear energy in Poland, the report also points out the necessity of providing reliable and accurate information on this kind of electricity generation. The official document 'Polish Energy Policy until 2030', released in 2009, calls for the construction of a new nuclear power plant (NPP) in Poland. Key elements of this program, in addition to the construction of the NPP, are creating a research base for the Polish Nuclear Power Program and the education of engineers for nuclear power. The release of the final version of the Polish Nuclear Power Program by the Ministry of Economy is scheduled for October 2013. It is expected that the Program will be approved by the Council of Ministers by the end of this year. The program states that the first NPP in Poland will be operational by the end of 2024.

2. Nuclear Power Engineering at Warsaw University of Technology

Warsaw University of Technology (WUT) realized quickly its mission and capabilities to educate the engineers for Polish nuclear power and as soon as 2006, WUT was the first university in Poland to restart nuclear power specialization. At first the nuclear power specialization was realized in collaboration with the Royal Institute of Technology (KTH, Stockholm, Sweden). Since the academic year of 2009/2010 the specialization was fully taught at WUT.

WUT tries to provide students with the most up-to-date knowledge and the best means to acquire this knowledge and consequently the specialization will be taught exclusively in English starting from the academic year 2013/2014. What is more, by providing the courses in English, WUT sees the opportunity of encouraging international students, especially from Eastern Europe, to choose the nuclear power specialization. Table **1** shows the current curricula of Nuclear Power Engineering at WUT.

	Subject	# of academic hours	ECTS
Semester I	Computational Fluid Dynamics	L2Lab1	3
	Energy Transport	L1E1	2
	Finite Element Method	L2Lab1	4
	Math. Mod. and Pr. Identification	L2E1	4
	Numerical Methods in Heat Transfer	L2Lab1	3
	Partial Differential Equations	L2E1	5
	Elements of Nuclear Physics	L2E1Lab1	4
	Energy Law & Legal Frames for Nuclear Power Industry	L1	2
	Elective courses	L4	3
		Sem. I	30
Semester II	Business Law	L2E1	2
	Neural Networks	L2	3
	Physics 2	L2	3

	Stat. and Noneq. Thermodynamics	L2	2
	Elective courses	L2	2
	Nuclear Reactor Physics	L2E1Lab2	6
	Contemp. Nucl. Reactor Syst. (LWR, HWR)	L3	4
	Nuclear Reactor Modeling and Simulation	L2E1Lab2	6
	Nuclear Fuels and Fuel Cycles	L2	2
		Sem. II	30
Semester III	Engineering Project		3
	Intermediate Masters Project		6
	Information Systems in Management	L2	2
	Project Management	L2	2
	Elective courses	L2	2
	Nuclear Instrumentation and Control	L2L2	4
	NPP Safety	L2E1	3
	NPP Operation and Maintenance	L2	2
	Gen IV Nuclear Reactor Systems (HTR, FBR)	L2	2
	Thermonuclear synthesis	L2	2
	Nuclear Energy and Int'l Security	L1Lab1	2
		Sem. III	30
Semester IV	Internship at a Nuclear Installation		8
	Master Diploma Seminar		2
	Master Diploma Thesis		20
		Sem. IV	30

Table 1. Curriculum for the Nuclear Power Engineering at WUT. 'L' stands for lectures, 'E' for exercises, 'Lab' for laboratories. Ex. L2E1Lab2 – 2 academic hours of lectures, 1 academic hour of exercises and 2 academic hours of laboratory classes. Each academic hour is 45 minutes long.

The Nuclear Power specialization is taught at the Faculty of Power and Aeronautical Engineering, at the Institute of Heat Engineering. The Faculty of Power and Aeronautical Engineering was the first in Poland that started a nuclear power engineering education program in 1959. The education in nuclear power engineering was conducted until 1992, educating 170 graduate students and 500 postgraduate students. As one can notice in Table **2**, WUT is the leading and most experienced university in Nuclear Power Engineering education in Poland.

Universities in Poland	Specialization	Level	Startup year	Graduates	Current students
AGH (Cracow)	Nuclear Power Engineering (conducted in Polish)	M.Sc.	2009/10	0	<10 (no formal student group)
PG (Gdansk)	Nuclear Power Engineering (conducted in Polish)	B.Sc. M.Sc.	2011/12	0	0
PP (Poznan)	Nuclear Power Engineering (conducted in Polish)	B.Sc. M.Sc.	2009/10	16 (B.Sc.).	19 (mostly B.Sc).
PŚ (Gliwice)	Nuclear Power Engineering (conducted in Polish)	M.Sc.	2010/11	0	0
PWr (Wroclaw)	Nuclear Power Engineering (conducted in Polish)	M.Sc.	2012/13	0	0
PW (WUT – Warsaw)	**Nuclear Power Engineering (conducted in English)**	M.Sc.	**2006/07**	15 (M.Sc)	13 (M.Sc.) 8 (III s.) 22 (I s.) **Total: 43**

Table 2. Number of students of Nuclear Power Engineering at Polish universities.

3. WUT international and national cooperation

Since the beginning of the implementation of Nuclear Power Engineering, WUT realized that without the connection to the nuclear industry and institutions that do research in the nuclear field, it would be difficult to develop a research base and educate engineers for the Polish Nuclear Power Program. WUT started the cooperation with:

- KTH-Royal Institute of Technology (Sweden),
- Commissariat à l'Énergie Atomique (France),
- Oregon State University (USA),
- Polish Centre for Nuclear Research,
- National Atomic Energy Agency,
- PGE EJ 1 Sp. z o.o. (future owner and operator of the first NPP in Poland), AREVA,
- Westinghouse,
- General Electric – Hitachi.

There is no national detailed strategy of the development of the research base or educating the engineers in Poland. WUT realizes that it can specialize only in those areas where it has capabilities and experience. Therefore WUT started to integrate the Polish scientific institutions that want to be present in the future Polish Nuclear Power Program. The outcome of this integration will be finished potentially next year. The first concept of the integration and scope division is shown in Figure **1**.

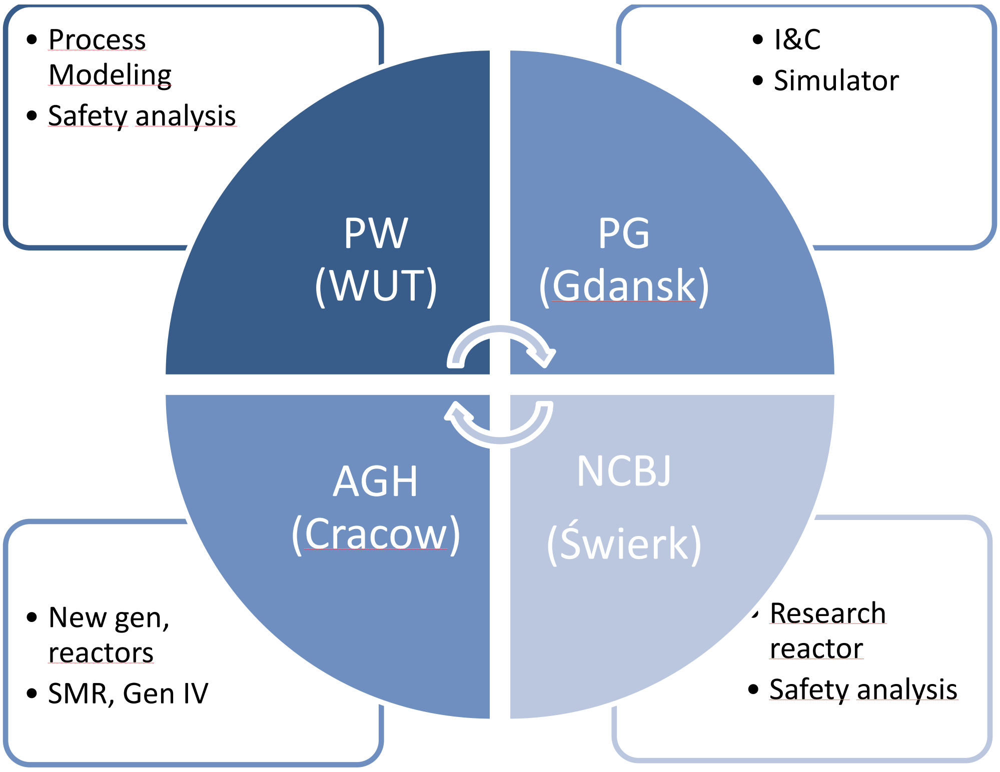

Figure 1. The concept and scope division of the integration of Polish institutions that are interested in participation in the Polish Nuclear Power Program.

4. Cooperation between WUT and AREVA

In the following, the cooperation with French nuclear conglomerate, AREVA is presented as one of the most extensive cooperation in the nuclear field that WUT is realizing. Since the AREVA presence (AREVA started its presence in Poland in 2009), both WUT and AREVA were trying to cooperate closely, aiming to formulate an official agreement. After a series of meetings in 2011, the formal cooperation was initiated in 2012 and the formal agreement was signed in late 2012.

The cooperation with AREVA is governed by a so-called Steering Committee that consists of members from both sides. The structure and members are depicted in Figure **2**. The Committee meets twice a year, once in Poland and the other time either in France or Germany. The Committee agrees on the means of cooperation on an academic semester basis.

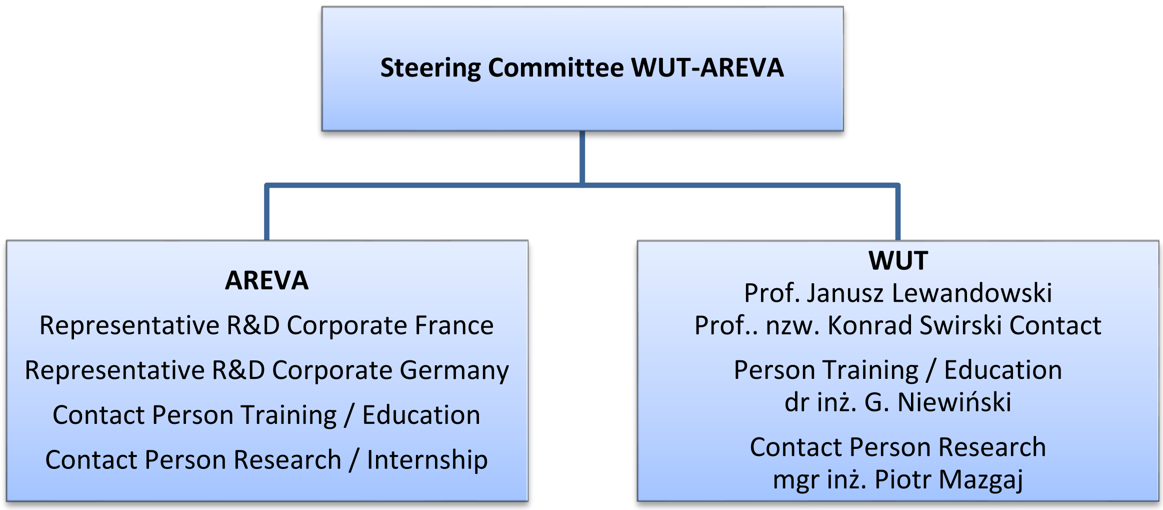

Figure 2. Steering Committee WUT-AREVA.

There are mainly two ways of cooperation, on-site AREVA, that requires physical presence of people from WUT at any AREVA facility for a longer time (more than a week) and off-site AREVA in which WUT acquires information from AREVA by hosting AREVA specialists at the WUT or via electronic means. A more detailed scope is shown in Figure **3**.

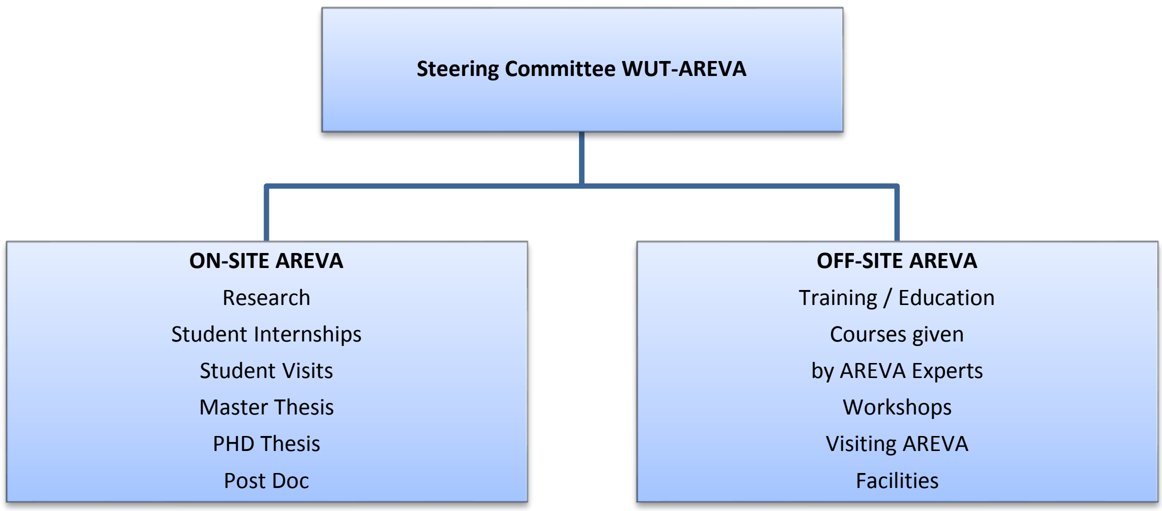

Figure 3. Ways of cooperation between WUT and AREVA.

Both ways are very fruitful for WUT. It enables researchers from WUT to obtain knowledge from AREVA's specialists, as well as extensive and detailed information on reactor technology. It enriches the Nuclear Power Program by providing lectures discussing realistic issues and by offering the possibility to students to complete an internship or work on their theses in AREVA facilities, where they can understand the challenges nuclear industry is facing.

4.1. Visits of AREVA Germany and German institutions specialized in nuclear engineering

In July and August 2012, AREVA Germany helped to organize and participated in visits to German institutions that do research in the nuclear field. The meetings were held with Technische Univerität Dresden, Helmholzzentrum Dresden/Rossendorf and Hochschule Zittau/Görlitz. On each meeting, the scope of the research and possible ways of cooperation were presented. As results of the meetings, one student went on Master thesis to Helmholzzentrum Dresden/Rossendorf.

Furthermore, several research or industrial facilities were visited: the training reactor AKR-2 and laser laboratory at Technische Univerität Dresden, TOP FLOW facility at Helmholzzentrum Dresden/Rossendorf, PKL Loop facility at AREVA Erlangen, INKA facility, Large Valve Test Facility GAP and Multifunction Thermal Hydraulic Test Loop KATHY at AREVA Karlstein.
Each of the visit was very fruitful for WUT representatives. It gave them the true vision how the facilities are being operated and what is needed for successful research. The direct contact with AREVA experts enabled to introduce the student internship program and resulted in first Master theses of WUT students.

4.2. Students internships, visit and AREVA's lectures at WUT

Since 2012, four WUT students have had Master theses at AREVA facilities, namely in AREVA Erlangen and AREVA Offenbach. Two students are about to start Master theses in November 2013 in Erlangen facility. WUT and AREVA seek to extend the cooperation. One WUT student is expected to start PhD thesis in late 2013 at AREVA Erlangen.

WUT Students had chances to visit the AREVA facilities. It is very valuable for them to see the equipment / installation in operation. It gives students an idea of how powerful and complex the processes in nuclear industry are. Students have visited following AREVA sites:

- MELOX AREVA – MOX fuel Fabrication,
- FBFC Romans AREVA – Fuel Fabrication,
- SAINT-MARCEL PLANT – Heavy components manufacturing,
- CREUSOT FORGE – Heavy forgings and machining capacities,
- AREVA NC Pierrelatte.

AREVA specialists provided lectures at WUT, supplementing the lecture offer of WUT and allowing know-how developed in industry to become part of university education. In 2012/2013 AREVA has provided 4 lectures:

- PWR Nuclear Operation Practice,
- PWR Nuclear Instrumentation,
- PWR Technology illustrated on EPR™,
- Steam Generators – Design and construction.

5. Joint workshop of WUT and AREVA

WUT is realizing the strategy to be the source of nuclear power engineers and expertise for the Polish nuclear industry. To achieve these goals, the WUT is not only focusing on the education of young engineers, but it is pushing to establish a team of experts that will be ready to deal with the issues arising during the construction phase of the first Polish nuclear power plant and later on during plant operation. The National Center for Research and Development (NCBiR) is a state body that provides funding for research and development, especially ones that are focused on industrial applications. The topic of the grant supplied to WUT is: "Elaboration of methods for the safety analysis of PWRs and BWRs in case of disturbances in coolant system and serious accidents. The safety analysis is to be conducted by the application of the calculation codes RELAP5, TRACE and MELCOR.

Although the American codes were listed in the grant specification, WUT wants to perform the calculations using different codes. WUT got access to CATHARE (French calculation code comparable to the American RELAP5) in December 2012. AREVA greatly facilitated the process of securing the access to CATHARE.

The research work supported by the grant and performed by WUT is important due to the fact that the recipient of the results is the National Atomic Energy Agency (PAA, future regulatory body in Poland). Some parts of the scope of the grant are agreed on with PAA. Even more, the employees of PAA take part in the calculations that are conducted in the framework of the grant. In this sense WUT is convinced that the work is valuable and will be utilized in the future.

To realize the grant funded by NCBiR, WUT managed to build two teams of experts, with members coming from WUT and the Swedish nuclear industry. WUT understands that there is a great need for direct contact with nuclear technology vendors in order to complete the task. The cooperation between WUT and AREVA facilitates the direct contact with the vendor and improves the realization of the grant. A great example of such direct contact was the organization of a common safety analysis workshop. The workshop was titled: Familiarization with calculation codes application and safety analysis workshop.

WUT conducted and demonstrated the results of the safety analysis for three pre-selected scenarios pertaining to accidents in nuclear reactors. Prior to the workshop, the three scenarios were developed by AREVA and later jointly agreed. During the workshop WUT presented the approach to modeling and calculations, and specialists from AREVA commented and gave guidance to WUT, discussing whether the models had been prepared in accordance with international standards, and analysis had been duly executed. The agenda of the workshop is shown in Table **3**.

The workshop was successful and well received among the participants coming from:

- AREVA,
- Warsaw University of Technology,
- National Atomic Energy Agency (PAA),
- National Center for Nuclear Research (NCBJ),
- Silesian University of Technology,
- Gdańsk University of Technology (PG),
- Polish Nuclear Society (PTN),
- Environmentalists For Nuclear Energy (SEREN Polska),
- Institute of Nuclear Chemistry and Technology (ICHTJ),
- Inspecta AB,
- Baltyn Consulting
- future owner and operator of the first Polish nuclear power plant - PGE EJ 1 Sp. z o.o.

The preparation of the workshop took 4.5 months and was the result of hard work done by WUT and AREVA. There were 35 people directly and indirectly involved in the organization of the workshop (18 – AREVA side, 17 – WUT side or people cooperating with WUT).

Familiarization with calculation codes application and safety analysis Workshop **Agenda** **September 9, 2013 / Room 105, *Institute of Heat Engineering, WUT***		
Registration and lunch		12:00 – 13:00
Welcome and Opening Remarks	*WUT*	13:00 – 13:15
Session 1 – *Workshop Purpose* *Status of SARWUT Project*	*WUT*	13:15 – 13:45
Session 2 – *AREVA EPR general presentation*	*AREVA*	13:45 – 14:15
Coffee Break		14:15 – 14:45
Session 3 – *Scenario 1: SBLOCA, 3-loop model, 900 MWe. Calculations code: RELAP5, CATHARE*	WUT AREVA	14:45 – 16:00
Session 4 – Advanced modeling of core in CATHARE	AREVA	16:00 – 16:45
Dinner		19:00
September 10, 2013 / Room 105, Institute of Heat Engineering, WUT		
Session 5 – *Scenario 2: EPR - 20 cm2 Cold Leg Leak. Calculations code: RELAP5, CATHARE*	*WUT* *AREVA*	9:00 – 10:15
Session 6 – *Scenario 3: EPR – Loss of Offsite Power. Calculations code: MELCOR, MAAP*	*WUT* *AREVA*	10:15 – 11:30
Coffee Break		11:30 – 11:45
Scenarios Summary / Roundtable	*WUT*	11:45 – 12:15
Session 7 – *Safety Analysis for a new plant*	*AREVA*	12:15 – 13:00
Lunch and Adjourn		13:00

Table 3. Agenda of Familiarization with calculation codes application and safety analysis Workshop, jointly organized by WUT and AREVA.

6. Summary of cooperation

The cooperation between WUT and AREVA, as one can observe, runs smoothly and is very successful. Both sides are happy with the result of the up-to-date cooperation.
WUT, thanks to AREVA, is expanding its research base and having a very attractive nuclear power engineering program. The cooperation with AREVA enriches the work done in the frame of the grant that concerns reactor safety analysis. The summary of cooperation between WUT and AREVA can be found in Table **4**.

WUT and AREVA believe that this cooperation poses a good example for universities that want to develop a research base in nuclear engineering and provide education in nuclear power engineering.

Cooperation WUT – AREVA	
Start of cooperation	2012
Student Master theses at AREVA facilities	3 – AREVA Erlangen 2 – planned for November 2014 1 – AREVA Offenbach 1 - Helmholzzentrum Dresden/Rossendorf (with the help of AREVA)
Student Visit	1 - MELOX AREVA – MOX fuel Fabrication, FBFC Romance AREVA – Fuel Fabrication, SAINT-MARCEL PLANT - Heavy components

	manufacturing, CREUSOT FORGE Heavy forgings and machining capacities, AREVA NC Pierrelatte.
PhD Theses	1 (planned for November 2013) – AREVA Erlangen
Lectures by AREVA experts, conducted at WUT	4 – 2012/2013, PWR Nuclear Operation Practice, PWR Nuclear Instrumentation, PWR Technology illustrated on EPR, Steam Generators – Design and construction 3 – planned for 2013/2014
Workshops	1 - Familiarization with calculation codes application and safety analysis Workshop

Table 4. Summary of the cooperation WUT – AREVA.

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