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COMMISSION STAFF WORKING DOCUMENT

**Second Situation Report on Education and Training in the Nuclear Energy Field in the
European Union**

COMMISSION STAFF WORKING DOCUMENT

**SECOND SITUATION REPORT ON EDUCATION AND TRAINING IN THE NUCLEAR
ENERGY FIELD IN THE EUROPEAN UNION**

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1. Introduction

On 13 November 2008, at the initiative of the Presidency, the Council of the European Union in its Conclusions 15406/08¹ emphasized the need to ensure the necessary skills in the nuclear field, encouraged the Member States and the Commission to establish a review of professional qualifications and skills, and invited the Commission to report to the Council on a regular basis regarding the follow-up of these Conclusions. The Commission responded to these Conclusions by establishing the "European Human Resources Observatory in the Nuclear Energy Sector" (EHRO-N)².

Another response consisted in the adoption of the "first Situation Report on Education and Training in the Nuclear Energy Field in the European Union"³ on 16 September 2011, now updated and further developed in this second report. This first report provided a comprehensive picture of the situation of human resources in the nuclear energy sector in the EU, identified the challenges and presented initiatives in this field, both on-going and planned - mainly at EU and international levels.

This second report provides an update of the EU and international situation.

Today in the EU there are around 130 nuclear reactors, with an average age close to 30 years, in operation in 14 Member States, supplying nearly 30% of the electricity consumed in the EU. Two of these Member States have nuclear phase out policies, the 12 others have policies, some of which are open to long term operation (lifetime extension) of their reactors. Most of these Member States and some others have started or have plans for new build. The present economic situation in the EU leads to believe that an intense period of plant upgrades for long term operation will take place in the period 2015-2035, due to the high economic attractiveness of lifetime extension.

For the coming decades, not only the nuclear power sector but also those industrial and medical applications making use of ionising radiations as well as fusion energy research will continue to require highly educated personnel with very specific knowledge, skills and competences. The rapid advances and growing use of radiation-based medical imaging create particular concerns regarding the education and training of medical professionals. These are discussed in more detail in the Communication on Medical Applications of Ionizing Radiation and Security of Supply of Radioisotopes for Nuclear Medicine⁴ and the supporting Staff Working Document.

The final outcome will depend on a number of factors, one of them being the availability of skilled personnel. Education and training, combined with experience gained in the workplace, are key to achieving this.

A key concern of policy makers, regulators and industry world-wide is that human resources could be at risk, especially as a result of the high level of retirement expected in countries with nuclear installations, and a lack of nuclear experience in "newcomer" countries world-wide (more than 45 Member States of the IAEA have approached the Agency expressing interest in commencing a

¹ <http://register.consilium.europa.eu/pdf/en/08/st15/st15406.en08.pdf>

² <http://ehron.jrc.ec.europa.eu/>

³ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0563:FIN:EN:PDF>

⁴ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52010DC0423:EN:NOT>

nuclear power programme). Whether for power generation or for medical applications, highly qualified people are needed over long periods of time in order to safely operate installations and build new facilities, as well as manage radioactive waste and address radiation protection requirements. In this context, wide-ranging research and training programs, at both national and international level, are essential to ensure adequate supply of suitable personnel to the many disciplines used in the nuclear domain and for the strengthening of the nuclear safety culture.

It is worth recalling that one of the main goals of Euratom actions, in compliance with the Euratom Treaty, is to contribute to the sustainability of nuclear energy by (1) issuing policies and regulations (e.g. Euratom Directives), (2) generating appropriate knowledge (research) and (3) developing the required competences (training). As a result of the “stress tests” conducted in all nuclear power plants (NPP) then operating in the EU following the Fukushima accident, the focus of all Euratom actions – in particular, of education and training – is quite naturally on the continuous development of a common nuclear safety culture, based on the highest achievable standards. This is performed in synergy with national programmes within the EU Member States and together with IAEA and OECD/NEA.

The main EU tool to foster Education and Training, as well as developing and monitoring nuclear skills and competences at EU level is the Horizon 2020⁵ – the framework programme for research and innovation. Activities in the field of nuclear energy are an integral part of the programme and are subject to the Council Regulation (Euratom) No 1314/2013 of 16 December 2013 on the Research and Training Programme of the European Atomic Energy Community (2014-2018) complementing the Horizon 2020 Framework Programme for Research and Innovation⁶.

2. Education and Training (E&T) at the EU level

The importance of education and training is recognised in the Euratom Treaty⁷, Article 33 which asks the Member States to “lay down the appropriate provisions, whether by legislation, regulation or administrative action, to ensure compliance with the basic standards which have been established and shall take the necessary measures with regard to teaching, education and vocational training”. The Member States have therefore the responsibility to ensure that adequate expertise is available in the nuclear field, inter alia via education and training programmes. It is also worth recalling that the title of any *Council Decision concerning the Research Framework Programme of the European Atomic Energy Community* always refers explicitly to “nuclear research and training activities”.

2.1 E&T as elements of the EU Flagship Initiatives

The EU's ten-year growth strategy – Europe 2020⁸ – sets five targets to be achieved in order to create conditions for a growth that is smart, sustainable and inclusive. These targets cover employment,

⁵ <http://ec.europa.eu/programmes/horizon2020/en>

⁶ http://ec.europa.eu/research/participants/data/ref/h2020/legal_basis/fp/h2020-euratom-establact_en.pdf

⁷ http://europa.eu/legislation_summaries/institutional_affairs/treaties/treaties_euratom_en.htm

⁸ http://ec.europa.eu/energy/energy2020/index_en.htm

education, research & innovation, social inclusion & poverty reduction and climate/energy. Seven flagship initiatives were identified to provide a framework through which the EU and national authorities can mutually reinforce their efforts to support the Europe 2020 priorities. The three flagship initiatives that are linked to education and training within the nuclear field concern Climate and Energy Policies, Innovation Union and an Agenda for Growth and Jobs. These actions are explained in more detail in the Annex.

2.2 E&T as elements of nuclear related initiatives by DG Energy

2.2.1 Nuclear Energy Framework

Nuclear Energy Policy

Three out of five decarbonisation scenarios of the Energy Roadmap 2050⁹ show nuclear energy continuing to play an important role in the production of electricity in the EU. Selecting the national energy mix however is the responsibility of the Member States. Today, as a result of a consultation of the Atomic Questions Group (reporting to the Council of the European Union), out of 16 Member States having operating nuclear power reactors or considering development of nuclear power, 12 have indicated the intention to have nuclear in their mix over an extended period, through long term operation of existing plants and/or new build. A rough estimation, based on the Roadmap scenarios, leads in the EU to the perspective of a fleet of around 100 nuclear reactors in operation, between today (existing fleet) and 2050 and beyond (incorporating new build). Today the EU nuclear sector employs in the order of 400 000 to 500 000 jobs (direct and indirect). It is possible that this would increase, if one extrapolates a study performed for the French nuclear sector¹⁰, showing that lifetime extension programmes, followed by new build programmes (both based on the assumption of a fleet of 100 reactors), would require additional jobs in the order of 100 000 to 150 000 by 2030. In any case, considering that a rather large portion of the current "nuclear" manpower will retire in the coming decade, a challenge lies ahead in terms of global qualified manpower requirements. In addition additional manpower will be necessary, for decommissioning and spent fuel and radioactive waste management programmes, including long term storage before final disposal is available, which will become much more extensive in the coming decades, as the plants in operation today are shut down.

Nuclear Legislative Framework

⁹ http://ec.europa.eu/energy/energy2020/roadmap/index_en.htm

¹⁰

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/le_poids_socioeconomique_de_l_electronuclaire_en_france.pdf

The need to provide a sufficient level of education and training in the nuclear area is an obligation to be fulfilled by the EU Member States. Directive 2009/71/EURATOM¹¹ includes an article (Art. 7) for the provision of expertise and skills in nuclear safety. The Directive was amended¹² on 8 July 2014, and the importance of education and training in nuclear field was further reinforced.

On 19 July 2011, the Directive 2011/70/EURATOM¹³ on the management of spent fuel and radioactive waste was adopted and it similarly obliges Member States to have a system in place, as that described in the nuclear safety directive, to cover the need of the national programme for spent fuel and radioactive waste management to acquire, maintain and to further develop necessary expertise and skills.

Chapter IV of the Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation¹⁴, adopted by the Council on 5 December 2013, sets requirements for radiation protection education, training and information including provisions for recognition of the “Radiation Protection Expert” and “Medical Physics Expert” as well as the “Radiation Protection Officer”.

2.2.2 Stakeholder Groups

After the initiative of the European Commission and endorsement of all 27 Member States, the European Nuclear Energy Forum¹⁵ (ENEF) was inaugurated in 2007 as a platform for broad discussions on the opportunities and risks as well as transparency, between all the stakeholders in the field of nuclear energy.

Following discussions in the ENEF framework the European Human Resources Observatory in the Nuclear Energy Sector (EHRO-N) was established, which has become the central source of information for issues related to education and training and human resources.

The EHRO-N was set up in 2009 and has been fully operational since 2011. It is based in Petten, the Netherlands at the premises of the EC Joint Research Centre's (JRC) Institute for Energy and Transport¹⁶, which acts as operating agent and coordinates all the activities of EHRO-N. The stakeholders are involved in the work of EHRO-N through a dedicated Senior Advisory Group, which meets twice a year, and provides guidance and ideas for future work of the observatory. It consists of more than 30 experts representing different stakeholder groups. Both DG Energy and DG Research and Innovation are also members of the Senior Advisory Group.

¹¹ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0071:EN:HTML:NOT>

¹² http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.219.01.0042.01.ENG

¹³ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:199:0048:0056:EN:PDF>

¹⁴ http://ec.europa.eu/energy/nuclear/radiation_protection/doc/2012_com_242.pdf

¹⁵ http://ec.europa.eu/energy/nuclear/forum/forum_en.htm

¹⁶ <http://iet.jrc.ec.europa.eu/>

The European Nuclear Safety Regulators Group¹⁷ (ENSREG) is an **independent, authoritative expert body** created in 2007 following a decision of the European Commission. It is **composed of senior officials from the national nuclear safety, radioactive waste safety or radiation protection regulatory authorities and senior civil servants** from all 27 EU MSs as well as representatives of the European Commission. ENSREG's role¹⁸ is to help to establish the conditions for continuous improvement and to reach a common understanding in the areas of nuclear safety and radioactive waste management, including also aspects of competences, skills and education / training.

In recent years DG Energy performed several projects and activities to support education and training of staff in different areas of radiation protection. In 2008, DG Energy supported the establishment of European Training and Education in Radiation Protection (EUTERP) network, which operates since 2011 as an independent foundation¹⁹. In the medical area, DG Energy carried out projects to develop "Guidance on Radiation Protection Education and Training of Medical Professionals in the EU"²⁰ and "European Guidelines on Medical Physics Expert"²¹, using the approach proposed in the general EU policy for *Education, Youth and Culture* under DG EAC (i.e.: description of learning outcomes related to knowledge, skills and competences).

2.3 E&T instruments proposed by DG Education and Culture²²

2.3.1 E&T Policy Framework

EU education and training policies have gained impetus since the adoption of the Lisbon Strategy in 2000, the EU's overarching programme focusing on growth and jobs. The strategy recognised that knowledge, and the innovation it sparks, are the EU's most valuable assets, particularly in light of increasing global competition.

EU Member States and the European Commission strengthened co-operation in 2009 with the strategic framework for European cooperation in education and training²³ ("ET 2020") under the umbrella of the EU policy for *Education, Youth and Culture*.

The approach recognises that high-quality pre-primary, primary, secondary, higher and vocational education and training are fundamental to Europe's success. However, in a rapidly changing world, lifelong learning and borderless mobility need to be a priority – it is the key to employment, economic success and allowing people to participate fully in society.

¹⁷ <http://www.ensreg.eu/>

¹⁸ <http://www.ensreg.eu/members-glance/role-ensreg>

¹⁹ <http://www.euterp.eu/>

²⁰ http://ec.europa.eu/energy/nuclear/radiation_protection/doc/publication/175.pdf,
<http://www.medrapet.eu/>

²¹ http://ec.europa.eu/energy/nuclear/radiation_protection/doc/publication/174.pdf

²² http://ec.europa.eu/dgs/education_culture/index_en.htm

²³ http://ec.europa.eu/education/lifelong-learning-policy/framework_en.htm

With each EU Member State responsible for its own education and training systems, Union-level policies are designed to support national actions and help address common challenges such as: ageing societies, skills deficits among the workforce, and global competition. These areas demand joint responses and countries can benefit from sharing experiences.

The long-term strategic objectives of EU education and training policies are:

- Making lifelong learning and borderless mobility a reality;
- Improving the quality and efficiency of education and training;
- Promoting equity, social cohesion and active citizenship;
- Enhancing creativity and innovation, including entrepreneurship, at all levels of education and training.

EU level activities are being developed to address priority areas in each of the different levels of education and training – early childhood, school, higher, vocational and adult education – based on these overall aims.

These include, for example, expanding opportunities for learning mobility or enhancing partnerships between education and training institutions and the broader society.

Other actions are relevant to all levels of education, such as promoting multilingualism, innovation, creativity and adoption of ICT (Information and Communication Technology).

2.3.2 ECVET

Making lifelong learning and borderless mobility a reality is one of the objectives of the *Education, Youth and Culture* policy of the EU, as stated in the *Council Conclusions on a strategic framework for European cooperation in education and training ("ET 2020")*, Brussels, 12 May 2009²⁴. In this context, the *European Credit System for VET (Vocational Education and Training)* (= ECVET) was launched and successfully tested in a wide range of service and industrial sectors (including aeronautics and automotive). There are some similarities with the Bologna process for academic education and the associated *European Credit Transfer and accumulation System* (ECTS), but also several differences. ECVET's objective is to promote mutual trust, transparency and recognition of assessed learning outcomes, that refer not only to *knowledge*, but also to *skills* and *competences* (KSC), acquired through *Continuous Professional Development* CPD or VET, in either formal or non-formal settings.

²⁴ OJ C, 28.5.2009 - http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/educ/107622.pdf

The implementation of ECVET in Member States is monitored by the Commission through the EU agency Cedefop²⁵ (depending on DG EAC). Some Member States (e.g. Finland, Belgium-FR) have mainstreamed ECVET into their VET systems, others (e.g. Poland, Portugal) have adopted many of its main concepts (for instance qualifications are composed of units of learning outcomes). Many mobility experiences throughout Europe, such as traineeships abroad or exchanges between VET schools, use ECVET documents, in particular the Memorandum of Understanding between institutions, the Learning Agreement between sending partner, host partner and the mobile learner, and the Personal Transcript of Record, which document the KSC developed by the learner. The Personal Transcript of Record can also be used to record KSC developed in experiences other than mobility, such as CPD schemes.

The ECVET initiative is being evaluated and a Commission Report will be published in autumn 2014.

2.4 E&T related initiatives by DG Research and Innovation²⁶ and by DG JRC²⁷

One of the main goals of the Euratom research and training (R&T) programme, in compliance with the Euratom Treaty, is to contribute to the sustainability of nuclear energy by generating the appropriate knowledge (research) and developing the required competences (training). Hence Euratom contributes to the construction of both the *European Research Area* (ERA) and the *European Higher Education Area* (EHEA).

The Euratom R&T programme is driven by a number of "end-user requirements" of scientific-technological as well as socio-economic type. The focus is on a common nuclear safety culture based on the highest achievable standards, as this is also the main lesson learnt from the Fukushima accident in 2011.

As far as EU nuclear research policy is concerned, it should be mentioned that the EU Council of 28 June 2011 requested to "*organise a symposium in 2013 on the benefits and limitations of nuclear fission for a low carbon economy*". The symposium was preceded in 2012 by an interdisciplinary study involving, inter alia, experts from the fields of energy, economics and social sciences²⁸.

Four general recommendations came out of the "2012 interdisciplinary study" and subsequent 2013 Symposium, as guidance for the future Euratom R&T priorities in all sectors (nuclear fission, waste management, radiation protection and medical applications of ionising radiation):

- 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 more inter-disciplinary (e.g. nuclear engineering and socio-economic sciences) and inter-sectorial (e.g. synergy research ↔ academia ↔ industry) actions under Euratom;

²⁵ <http://www.cedefop.europa.eu/EN/Index.aspx>

²⁶ http://cordis.europa.eu/home_en.html

²⁷ <http://ec.europa.eu/dgs/jrc/index.cfm>

²⁸ <http://www.eesc.europa.eu/?i=portal.en.events-and-activities-symposium-on-nuclear-fission-forum>

- Towards the creation and transfer not only of *knowledge* but also *skills* and *competences*, taking advantage of instruments developed by EU and national policies;
- 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.

2.4.1 Implementation of ECVET (European Credit System for Vocational Education and Training) in the sectors of nuclear fission and radiation protection

Lifelong learning requires common EU approaches for assessing and validating the learners' qualifications by ad-hoc authorities, taking into account a variety of E&T paths (Continuous Professional Development, CPD). Borderless mobility implies mutual recognition of learners' qualifications and freedom of establishment (including for regulated professions), thereby enabling the free circulation of service providers amongst the EU Member States.

In this context, a number of "*Euratom Fission Training Schemes*" (EFTS) were launched under Euratom FP7 (2007-2013) in specific areas where a shortage of skilled professionals has been identified. Similar initiatives will continue under Horizon-2020. The EFTS is 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 0.5 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 involving European authoritative regulatory expert bodies (e.g. ENSREG or HERCA) to discuss mutual recognition across the EU. It is clear, however, that the above mentioned "*Personal Transcript*" does not constitute *per se* a license or an official authorisation (in the legal national regulatory sense).

Also worth mentioning is the Euratom fusion energy research: in this framework, a number of Goal Oriented Training (GOT) initiatives were launched, with a yearly budget from the European Commission of 5 million Euros benefiting to about 40 professionals.

2.4.2 Euratom FP7 "indirect" actions involving the EU Member States organisations under the umbrella of DG RTD

The Euratom FP7 research programme was aiming at establishing a sound scientific and technical basis for the safe operation of nuclear systems, the management of long-lived radioactive waste, and the implementation of a robust system of protection of man and environment against the effects of ionising radiation. Euratom FP7 topics during the period 2007-2013, were grouped in 3 thematic and 2 cross-cutting areas²⁹:

²⁹ http://cordis.europa.eu/fp7/euratom-fission/about-fission_en.html

- (1) Safe operation of reactor systems: for their continued safe operation, taking into account new challenges such as plant life-time extension, and research to assess the potential, safety and waste-management aspects of future reactor systems (e.g. Generation IV);
- (2) Management of ultimate radioactive waste: implementation-oriented R&D on all remaining key aspects of deep geological disposal of spent fuel and long-lived radioactive waste, and research on partitioning and transmutation and/or other concepts aimed at reducing the amount and/or hazard of the waste for disposal;
- (3) Radiation protection: in particular, research on the risks from low protracted doses, medical uses and emergency management in order to provide the scientific basis for a robust, equitable and socially acceptable system of protection;
- (4) Infrastructures: supporting the availability of and access to key infrastructures of pan-European interest in the above research activities;
- (5) Human resources, mobility and training: to support the retention and further development of scientific competence and human capacity, that is: knowledge transfer and competence building.

Focusing on nuclear education, training and knowledge management, work has been conducted mainly in the scientific-technological domain but some socio-economic studies are also worth mentioning. As far as training is concerned, there are two types of initiatives in the Euratom projects:

- dedicated interdisciplinary workshops embedded in research and innovation projects, aiming at transferring the main results of Euratom FP7 projects to the scientific community;
- *Euratom Fission Training Schemes* (above EFTS) aiming at upgrading CPD programmes towards an improved safety culture in all nuclear sectors (usually in synergy with the European Nuclear Education Network, ENEN).

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 here is on Continuous Professional Development (CPD), taking advantage of the governance and best practices for E&T that are proposed in the EU higher education policy (DG EAC). The aim is to continuously improve knowledge transfer and competence building, in particular by fostering lifelong learning and borderless mobility, thereby improving the employability in the nuclear sector across the EU.

The above mentioned EFTSs are in fact Euratom FP7 "coordination actions", taking into account "end user requirements" of both scientific-technological and socio-economic types. These EFTS are using the education and training instruments developed by the EU: of particular interest are the ECTS ("European Credit Transfer and accumulation System" developed in the framework of the Erasmus programme under the Bologna 1999 process) and the ECVET ("European Credit system for Vocational Education and Training", developed in the framework of the Copenhagen 2002 process). The proposed training schemes are designed as portfolios of units of learning outcomes identified by the

"end-users" for specific jobs or functions (learning outcomes are made not only of knowledge, but also skills and competences).

As success stories of lifelong learning and cross-border mobility programmes under Euratom (using the KSC approach and based on the implementation of ECVET), the following list of jobs or functions in nuclear fission and radiation protection is worth mentioning:

- "Fluid System Construction and Commissioning Engineers" (ENEN III project);
- "Radiation Protection Experts" (/Euratom BSS Directive/ (ENETRAP II project);
- "Safety Analysis Expert for Deep Geological Disposal" (PETRUS II project);
- "Medical Physics Experts" (/Euratom BSS Directive/ EUTEMPE RX project).

List of the current 11 EFTS together with their respective "end-users" and contractual duration (more details in the Annex):

- ENEN-RU II - *Cooperation with Russia in Nuclear Education, Training and Knowledge Management*: mirror project financed by ROSATOM and MEPhi (June 2014 – May 2017)
- ENETRAP III - *European Network on E&T in Radiological Protection*: addressing mainly the nuclear regulatory authorities and TSOs (June 2014 – May 2018)
- ECNET - *EU-CHINA Nuclear Education and Training Cooperation*: mirror project to be 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) (November 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 (September 2013 – August 2015)
- EUTEMPE-RX - *European Training and Education for Medical Physics Experts in Radiology*: focus on Euratom BSS Directive COM(2013) 59 (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; nuclear regulatory authorities; industry (Jan. 2013 – Dec. 2016)

Additionally, in close co-operation with DG RTD, the JRC's Institute for Energy and Transport is participating in the implementation process by developing a job taxonomy in co-operation with

National Experts for more than 150 professions in the field of Nuclear Design, Operation and Decommissioning.

In Euratom FP7, a coordinated support action in the field of fusion education was launched in 2008 under the name FuseNet (EC budget 2 million Euros)³⁰. FuseNet, which has now a legal status, will continue to coordinate education actions on European level including certification and is expected to play a major role in the preparation of skilled professionals for ITER.

2.4.3 Euratom "direct" actions carried out by the DG JRC

The Training and Education Nuclear Activities of JRC derive directly from its obligations within the Euratom Treaty as well as from the Euratom framework programme. These activities are carried out at the JRC's Institute for Reference Materials and Measurements³¹ (IRMM, Geel, Belgium); the Institute of Energy and Transport (IET, Petten, The Netherlands); and at the Institute for Transuranium Elements³² (ITU, Karlsruhe, Germany and Ispra, Italy).

The JRC is operating the "European Human Resource Observatory in the Nuclear Energy Sector" (EHRO-N), which is driven by needs of the European Nuclear Energy Forum (ENEF) and was launched in 2011. EHRO-N, guided by a Senior Advisory Group, initially addressed mapping all EU nuclear stakeholders and gathering data on nuclear Human Resource Demand and Supply. The 2012 EHRON report on the nuclear workforce concluded that the supply of nuclear engineering graduates does not sufficiently respond to the demand in the nuclear energy sector (+/- 30% gap). The latest report from 2013 showed that the peak in nuclear workforce for securing the nuclear energy share in the EU European Energy Roadmap 2050 is lower than in the 1980's, and therefore is probably manageable, with the only difference being a steeper rise in demand in the short-term (i.e. a high demand within a short period).

A gap analysis, focused on knowledge, skills and competences (KSC) can be based once ECVET has been fully implemented in the nuclear energy sector. Initiatives at national level aimed to centralize information on HR Demand and Supply in the nuclear energy sector have demonstrated to be a key for success in Finland and the UK³³. Further examples are expected from Spain, Belgium and France.

The second EHRO-N "bottom-up" survey on Demand and Supply for nuclear HR is ongoing, in order to measure the effect of Fukushima on student registrations (Supply) and stakeholder needs (Demand). The provision of information should be strongly supported by the Member States.

³⁰ The European Fusion Education Network - <http://www.fusenet.eu/>

³¹ <http://irmm.jrc.ec.europa.eu/>

³² <http://itu.jrc.ec.europa.eu/>

³³ <http://ehron.jrc.ec.europa.eu/public-national-reports>

Specific JRC Training and Education Activities

The JRC's nuclear infrastructure is of crucial importance for the nuclear Training and Education activities in the EU. Most academic institutions in the EU Member States do not have facilities for handling nuclear materials as might be needed to train students and young experts in the fields of safeguards, security, fuel cycle or physics and actinide chemistry. With the exception of France, such specialised facilities are very limited in Member States. Thus, the hands-on practical training and work experience that is offered by JRC to students and young researchers in the laboratories is essential to guarantee that the next generation of nuclear scientists in the EU has the skills and knowledge for key areas of nuclear technology.

In this reporting period, for example a transnational access scheme under FP7 project EUFRAT ("European facility for innovative reactor and transmutation neutron data"), coordinated by JRC – IRMM (Geel, Belgium), was developed, providing access and experimental time for external users to JRC's research facilities. On a yearly basis, access and support was granted to users from Member States and outside EU totalling: 1000h per year at the GELINA facility and 400h at the Van de Graaff accelerator, and 400h at the HADES underground facility. PhD students as well as post-doctoral fellows were constantly involved in research and E&T, within grant holder schemes and trainee programmes and in collaboration with universities. EUFRAT, which has been recently completed, will be followed up by a new transnational access scheme, starting in June 2014. The new project will open access to additional JRC nuclear facilities such as the JRC laboratories for nuclear decay measurements and the low-level radioactivity laboratory in the deep-underground facility HADES.

In 2011, the JRC embedded its on-going and future training and education activities into one global JRC training programme on Nuclear Safety and Security. In collaboration with relevant European and international partners, the JRC programme is based on educational and training tracks in the fields of nuclear security and safety. Scientific and technological themes covered by the programme are e.g. nuclear safeguards, safety of nuclear fuel and fuel cycle, nuclear decommissioning and radioactive waste management, nuclear data and actinide science. Four main components are addressed: Higher Academic Education through e.g. grants for PhD students; Vocational Training through specific JRC courses; User facility (access to infrastructure); and Information centre.

The activity focuses on the main lines of the JRC's nuclear program, complementary and in synergy with Member States initiatives and international organisations programmes. It directly involves European entities (e.g. DG ENER, DG DEVCO's Instrument for Stability, DG HOME through the CBRN action plan, EU Member States, non EU Member States), and international bodies (e.g. IAEA, US DoE) which directly contribute to the initiative. In the international domain, the JRC is supporting the IAEA by delivering training for nuclear safeguard inspectors. In the frame of the JRC Enlargement and Integration Action, specialised workshops, conferences and training courses are organised in the field of nuclear data standards and radionuclide metrology.

2.4.4 Stakeholder Groups

At the European level, within the framework of the **Strategic Energy Technology Plan (SET-Plan)**³⁴, stakeholders have formulated a collective roadmap on Education and Training to foster the transition to a low-carbon energy mix by 2050. The SET-Plan Education and Training Roadmap³⁵ puts forward a structural approach, calling for large-scale E&T actions and is designed with the following three main guiding objectives:

- To address knowledge, skills and competences needs and gaps via building networks, pooling capacities and allowing quick and wide replication;
- To reinforce the E&T system's link with the business and research environment;
- To plan and enable skill development and recognition, at the same time facilitating the dissemination of new knowledge, techniques and tools.

A key element of the Roadmap is to bring about a structural change in the European E&T landscape by enhancing the coordination and integration of national capacities through dedicated networks and fostering industrial involvement through targeted instruments and partnerships at EU level.

The Roadmap will serve as a programmatic guide for energy education and training activities within the EU and its Member States. It puts forward comprehensive E&T measures, which are the key for the development and uptake of low carbon technologies in Europe, thus contributing to SET-Plan implementation and the Energy Roadmap 2050 vision.

The implementation framework will involve actively relevant mechanisms and organisations at European level such as the SET-Plan European Industrial Initiatives³⁶ (EIIIs) and the participating European Technology Platforms; the European Energy Research Alliance³⁷ (EERA) Joint Programmes, the European Platform of Universities engaged in Energy research, education and training³⁸ (EPUE), KIC InnoEnergy (European Institute of Innovation and Technology (EIT)), the European Strategic Partnership for Sustainable Energy Education, Innovation and Technology³⁹ (SEEIT), the European Sustainable Energy Innovation Alliance⁴⁰ (ESEIA), relevant Public Private Partnerships, and other organisations. Close cooperation should be ensured with the European Strategy Forum on Research Infrastructures⁴¹ (ESFRI) in relation to activities that grant access to infrastructures for E&T purposes.

³⁴ http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm

³⁵ <http://setis.ec.europa.eu/setis-deliverables/education-training-roadmap>

³⁶ http://ec.europa.eu/energy/technology/initiatives/initiatives_en.htm

³⁷ <http://www.eera-set.eu/>

³⁸ <http://www.eua.be/eua-work-and-policy-area/research-and-innovation/Universities-Engaged-in-Energy-Research.aspx>

³⁹ <http://www.seeit-alliance.eu/>

⁴⁰ <http://www.eseia.eu/>

⁴¹ http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

Of particular interest in this context is the **KIC InnoEnergy**⁴², which was established under the EIT in 2009 as the Knowledge and Innovation Community in the field of energy. It is run as a commercial company, with 27 shareholders and additional 100+ partners - companies, research institutes, universities and business schools covering the whole energy mix. The KIC InnoEnergy has developed an industrial plan, results- and output-oriented, building upon a commitment from its shareholders. Furthermore, it provides different innovation services bridging the gap between ideas and the market.

The KIC InnoEnergy covers all SET Plan themes, shared amongst 6 Co-location Centres: One of them is "*Sustainable nuclear & renewable energy convergence*" (coordinated by the French node *Colocation Centre Alps Valley*). As far as nuclear education and training towards the needs of industry is concerned, the KIC InnoEnergy launched a *European Master in Nuclear Energy* (MSc EMINE) as a partnership between universities (UPC, KTH, Grenoble INP and Paristech), and major companies and research institutes (Vattenfall, AREVA, EDF, ENDESA, CEA) which are hosting EMINE students for in-hands sessions at their experimental reactors (EDF and CEA). Another project is "*Innovative Nuclear Experimental Platform & Training*" (INEPT). It aims to develop a recognized EU platform to maintain and increase the excellence of the nuclear community by providing access and training on nuclear facilities .

The SET Plan Education and Training Roadmap will link also to other European initiatives on energy E&T to ensure a comprehensive coverage of the Roadmap proposals and effectiveness and efficiency of the EU intervention.

Cooperation with international strategic partners to the EU will also be explored when mutually beneficial.

The information system of the SET-Plan (SETIS)⁴³ will support the monitoring of the Roadmap and the definition of human resources to anticipate developments in the future.

The Sustainable Nuclear Energy Technology Platform⁴⁴ (SNETP) has included in its activities a working group on **Education, Training and Knowledge Management⁴⁵ (ETKM)** that includes stakeholders from research institutions, industry and EU organisations, with essential support from ENEN. The objectives of the ETKM groups are:

- to identify a course of action to secure an adequate resource of well-educated and trained young professionals to support the research recommended in the Strategic Research Agenda (SRA),
- to identify the steps required to meet the demand of industry for new competent personnel and the need for teachers in academia,

⁴² Knowledge and Innovation Community "InnoEnergy" - <http://www.kic-innoenergy.com/homepage.html>
- initiative no 1: MSc EMINE - <http://www.kic-innoenergy.com/education/msc-programmes/msc-emine.html>
- initiative no 2: INEPT platform - <http://www.kic-innoenergy.com/innovation-projects/inept.html>

⁴³ <http://setis.ec.europa.eu>

⁴⁴ <http://www.snetp.eu/>

⁴⁵ http://www.snetp.eu/www/snetp/index.php?option=com_content&view=article&id=21&Itemid=19

- to collate the facilities, both existing and required, to develop the future human resource necessary to support the SRA.

The working group will further develop and implement a framework for nuclear education, training and knowledge management at the European level, specifically in relation to the nuclear research programmes and the associated research infrastructures, which may also serve for training and education purposes.

The **Implementing Geological Disposal of Radioactive Waste Technology Platform⁴⁶ (IGDTP)** has a special work package for **Competence Maintenance, Education and Training⁴⁷ (CMET)**. The goals of CMET are:

- The transfer of the state of the art in geological disposal, the competence analysis and needs;
- Quality assurance of training provided for new and experienced professionals in the field of nuclear waste management and especially geological disposal by developing quality assurance procedures and criteria for the voluntary accreditation of training (and education) in geological disposal;
- Develop the content of learning outcomes or more traditionally the content of training or a "Curricula" for professionals in geological disposal for the development of joint training or engaging educators and trainers into developing E&T to meet the expertise needed;
- Ensuring indirectly that providers for CMET exist i.e. ensure the sustainability of providers and infrastructures/facilities for competence maintenance and development and new personnel.

The IGDTP started the CMET in June 2011 to promote European cooperation in this area and to support IGDTP's commitment to "facilitate access to expertise and technology and maintain competences in the field of geological disposal for the benefit of Member States". The CMET is a Working Group whose work is intended to have a long lifespan.

The **Multidisciplinary European Low Dose Initiative** association (MELODI)⁴⁸ identified in 2013 "Maintaining a high level of education and training for radiation protection" as a top priority.

In recent years, many European member states have lost key competences and are no longer capable of independently retaining their current research activities in radiation sciences, with implications for effectively fulfilling operational and policy needs and obligations. Thus, specific programmes aiming at knowledge management across generations have to be designed in order to achieve sustainable continuity and development. The HLEG Report of 2009⁴⁹ recognised this problem and put the

⁴⁶ <http://www.igntp.eu/>

⁴⁷ <http://www.igntp.eu/index.php/joint-activities/competence-maintenance-education-and-training-cmet>

⁴⁸ MELODI association <http://www.melodi-online.eu/>

⁴⁹ <http://www.hleg.de/fr.pdf>

emphasis on research into the risks to humans from low-dose radiation. Support for E&T has two priority areas:

- Support for students and young scientists: Students need to be able to find places at universities and placement with research groups for project/dissertation work.
- Promotion of E&T for dissemination: Euratom research and innovation projects should dedicate a certain percentage of their budget for providing workshops or training courses to present new science/technology which is being developed in the project.

As far as coordination and collaboration of E&T providers is concerned, priority actions are:

- Continuation and extension of the MELODI Education and Training Forum: all interested parties should be regularly gathered to discuss needs and broaden the awareness of what is happening in EU member states, in synergy with other platforms (ALLIANCE, NERIS, EURADOS, EUTERP, medical groups, etc.).
- Active cooperation with other groups (EU Rays, ENEN, etc.) and EC services concerned (RTD, ENER, EAC, etc.): E&T in the radiation protection area should be further promoted and supported.

3. Nuclear E&T initiatives at national level

To ensure the highest achievable standards for nuclear education and training, a non-profit association was formed in September 2003: the **European Nuclear Education Network (ENEN)**⁵⁰. This is a legal entity, located at CEA-INSTN Paris, and is composed of 64 members (universities, research organisations, industry) from 18 EU Member States + Switzerland, South Africa, Russian Federation, Ukraine and Japan. The synergy of ENEN with national E&T networks and with the various European Technological Platforms is instrumental to the success of Euratom E&T actions. The ENEN Association is also actively engaged in the co-operation between universities, research organisations, regulatory bodies, the industry and any other organisations involved in the application of nuclear science and ionising radiation. ENEN has been central in the application of the ECTS system (higher education) in the nuclear sector.

The ENEN initiative has been well received by many Member States who have either started their own national network under ENEN or included their already existing one under ENEN umbrella. These actions contribute substantially to the work performed at the EU level and enhance the efforts in the field of harmonisation and development of nuclear expertise. In addition to the ENEN-related efforts, country-specific actions have been started in order to reinforce individual Member State's capability and competence for continuous and safe use of nuclear energy by analysing the national supply vs. need and thus ensuring the sufficient availability of expertise.

These are the relevant national nuclear education and training networks in the EU Member States: **BNEN**⁵¹ (Belgian Nuclear Higher Education Network) in Belgium, **CIRTEN**⁵² (Consorzio

⁵⁰ European Nuclear Education Network (ENEN) <http://www.enen-assoc.org>

⁵¹ <http://bnen.sckcen.be/>

⁵² <http://www.cirten.it/index.php?lang=en>

Interuniversitario per la Ricerca Tecnologica sull'Energia Nucleare) in Italy, **CNEN**⁵³ (Czech Nuclear Education Network) in the Czech Republic, **FINNEN** (Aalto University School of Science and Technology – AALTO⁵⁴) in Finland, **INSTN**⁵⁵ (Institut National des Sciences et Techniques Nucléaires) and **IZEN**⁵⁶ (International Institute of Nuclear Energy) in France, **Alliance for Competence in Nuclear Technology**⁵⁷ in Germany, **Roland Eötvös Physical Society**⁵⁸ in Hungary, **The Royal Institute of Engineers in the Netherlands**⁵⁹, **PRRS** (Polish Radiation Research Society) in Poland, **RONEN**⁶⁰ (Retea Educationala in Fizica si Ingineria Nucleara) – the Romanian Nuclear Education Network, **SNEN** (Slovak Nuclear Education Network) in Slovakia, **CEIDEN**⁶¹ (Plataforma Tecnológica de Energía Nuclear de Fisión) in Spain and **NSAN**⁶² (National Skills Academy for Nuclear) and **NTEC**⁶³ (Nuclear Technology Education Consortium) in the UK.

Several Member States have carried out national studies on the situation of human resources and the future needs in the nuclear sector or set up special committees dedicated to the issue, to form a basis for the development of their educational and training schemes to satisfy the demand and balance it with the supply in their country. For instance, Belgium made an analysis on human resources in the nuclear field⁶⁴, published in May 2012; Finland set up a committee of experts to examine the long-term competence needs of the nuclear energy sector,⁶⁵ the results were published in May 2012; France created a Co-ordination Committee for nuclear education and training in order to ensure the expansion of the French nuclear energy sector through the renewal of its workforce; UK carried out a study to analyse the future needs and supply in the area of nuclear energy – the National Skills Academy Nuclear also established a listing of UK institutions that provide the specialist education and training required by the nuclear industry. All the national reports can be found on the EHRO-N webpage⁶⁶.

4. Nuclear E&T initiatives at International level

A number of activities and projects are ongoing in international fora, namely within the International Atomic Energy Agency (IAEA), Nuclear Energy Agency (NEA)⁶⁷ of the OECD, The World Nuclear

⁵³ <http://www.cnen.gov.br/>

⁵⁴ <http://www.aalto.fi/en/>

⁵⁵ <http://www-instn.cea.fr/>

⁵⁶ <http://www.i2en.fr/en/>

⁵⁷ <http://www.grs.de/en/content/evaluation-commission>

⁵⁸ <http://www.elft.hu/>

⁵⁹ <https://www.kiviniira.net/a/PAG000007804/English-homepage.html>

⁶⁰ <http://www.ronen.ro/>

⁶¹ <http://ceiden.com/>

⁶² <https://www.nuclear.nscademy.co.uk/>

⁶³ <http://www.ntec.ac.uk/>

⁶⁴ http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/belgique_-_rapport_final_emploi_dans_le_secteur_nucleaire.pdf

⁶⁵

[http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/report_of_the_committee_for_nuclear_ene](http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/report_of_the_committee_for_nuclear_energy_competence_in_finland.pdf)
[rgy_competence_in_finland.pdf](http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/report_of_the_committee_for_nuclear_ene_rgy_competence_in_finland.pdf)

⁶⁶ <http://ehron.jrc.ec.europa.eu/public-national-reports>

⁶⁷ <http://www.oecd-neo.org/>

University⁶⁸ (WNU), the World Nuclear Association⁶⁹ (WNA), The International School of Nuclear Law⁷⁰ (ISNL), European Nuclear Society⁷¹ (ENS), FORATOM⁷² and The European Nuclear Safety Training and Tutoring Institute⁷³ (ENSTTI). These are described in the Annex.

The ENS Young Generations Network (YGN)⁷⁴ has its national nuclear societies in a number of EU Member States. These groups are involved in attracting new students to study nuclear sciences/technology and organize various activities in cooperation with national nuclear associations, nuclear operators and schools. Through different initiatives they maintain contacts with the "next generation" and disseminate information about nuclear science itself as well as about the career opportunities.

As the actions taken at the international level are of utmost importance for the future use of nuclear energy, the international aspect binds national and regional initiatives together, harmonises approaches, provides means to benchmark and compare with others and offers excellent opportunities to learn from others, share information, knowledge and experiences. It is also vital for the movement and exchange of the workforce.

5. Conclusions and perspectives

As it was already underlined in the first report on this issue, the safety of the use of nuclear energy is the utmost priority and in order to maintain the high level of nuclear safety, ensuring sufficient number of experienced and qualified staff is the key. The main recommendation of the first report was to have a "comprehensive assessment available whether the initiatives undertaken either on national or international level match fully the needs either in quantity or quality". The "European Human Resources Observatory for the Nuclear Energy Sector" (EHRO-N) has been intensively following these recommendations and with the 2012 EHRO-N study⁷⁵, the Commission and nuclear stakeholders managed to provide a more comprehensive estimate of the trend of both Supply and Demand of skilled nuclear human resources at the EU level. The study concluded that in the forthcoming years, the supply of graduates in nuclear engineering would suffer a gap of about 30% to the demand of the nuclear energy sector. More details of this study can be found in the EHRO-N report. The Commission recognises the high value of the work carried out in Member States to analyse the situation in their country and to identify areas which need improvement. At the same time, the initiatives at the EU and international levels have moved forward, focusing on increased participation of the stakeholders and fostering in particular the mobility of the available skilled resources.

⁶⁸ <http://www.world-nuclear-university.org/>

⁶⁹ <http://world-nuclear.org/>

⁷⁰ <http://www.oecd-nea.org/law/isnl/>

⁷¹ <http://www.euronuclear.org/>

⁷² <http://www.foratom.org/>

⁷³ <http://www.enstti.eu/>

⁷⁴ <http://www.euronuclear.org/ygn/>

⁷⁵ http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/ehron_putting_into_perspective_report_2012_05_25_0.pdf

It has been recognised that both industry and national regulators need to play a primary role in ensuring the availability of sufficiently qualified and experienced staff for the continued use of nuclear energy. At the same time, support at political level, e.g. from governments and EU institutions would provide a much needed additional impetus.

A number of challenges remain open for the future of Education and Training (E&T) programmes in the EU (in particular via the Euratom Horizon-2020 programme):

1. Further development of scientific and technological excellence at EU level, through improved governance for E&T;
2. Better qualification and transfer of knowledge, skills and competences (KSC), with the aim to continuously improve mobility of experts and nuclear safety culture at large;
3. Contribution to the development and dissemination of the scientific basis necessary to allow a well-informed dialogue on nuclear systems and applications.

Challenge 1: Further development of scientific and technological excellence at EU level, through governance for nuclear Education and Training

The EC proposed a concept of governance in the White Paper on European Governance (2001), in which the term "European governance" refers to rules, processes and behaviour based on openness, participation, accountability, effectiveness and coherence.

The increasingly important role taken by the European Technological Platforms and associated authoritative expert associations, bringing together the main stakeholders, is aligned with the above principles of good governance. The Platforms have developed a common approach regarding needs, vision and implementation instruments in the areas covered by the Euratom research and training programmes. A further dedicated effort in the area of nuclear Education and Training will foster the search for scientific and technological excellence.

Challenge 2: Better qualification and transfer of knowledge, skills and competences (KSC), with the aim to continuously improve mobility of experts and nuclear safety culture at large

Future E&T programmes should better integrate higher education institutions (including ENEN) and "stakeholder" organisations (e.g. industry, research organisations, governmental bodies, etc.) in areas where human resources could be at risk. As a result, better qualified Continuous Professional Development schemes should be developed, preferably aligned with the ECVET (European Credit System for Vocational E&T), resulting in portfolios of learning outcomes (KSC) that can be recognised by employers across the EU, thereby improving the quality and the mobility of the nuclear safety experts. Special attention is devoted to the continuous development of a common nuclear safety culture based on the highest achievable standards, as this is also the main lesson learnt from the Fukushima accident in 2011.

Challenge 3: Contribution to the development and dissemination of the scientific basis necessary to allow a well-informed dialogue on nuclear systems and applications

Integration of policy objectives, expert knowledge and public opinion needs increasing attention in the nuclear fission and radiation protection research community (this was also a recommendation of the “2012 interdisciplinary study”). Nuclear research and training programmes need to strike a balance between scientific-technological and socio-economic approaches in order to address not only the nuclear specialists but also contribute to a well-informed dialogue on nuclear energy and applications.

In conclusion, there is a need for ensuring the necessary skills in the nuclear field and maintaining qualified experts in nuclear fission energy and radiation protection, able to address issues related to nuclear safety and security as well as health and environmental protection. The Commission, mainly via the EHRO-N, intends to continue to monitor the developments in the field of nuclear Education & Training, and the follow-up given to the challenges described above.

ACCRONYMS

BNEN	Belgian Nuclear Higher Education Network
CBRN	Chemical, Biological, Radiological and Nuclear
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
CEIDEN	Plataforma Tecnológica de Energia Nuclear de Fisión
CIRTEN	Consorzio Interuniversitario per la Ricerca Tecnologica sull' Energia Nucleare
CMET	Competence Maintenance, Education and Training
CNEN	Czech Nuclear Education Network
DoE	Department of Energy
CPD	Continuous Professional Development
DEVCO	Development and Cooperation – EuropeAid (DG)
DG	Directorate General
EAC	Education and Culture (DG)
EC	European Commission
ECTS	European Credit Transfer and accumulation System
ECVET	European Credit System for Vocational Education and Training
EDF	Électricité de France
EERA	European Energy Research Alliance
EHEA	European Higher Education Area
EHRO-N	European Human Resources Observatory for the Nuclear Energy Sector
EII	European Industrial Initiative
EIT	European Institute of Innovation and Technology
EMINE	European Master in Nuclear Energy
EMPL	Employment, Social Affairs and Inclusion (DG)
ENEF	European Nuclear Energy Forum
ENEN	European Nuclear Education Network
ENER	Energy (DG)

ENS	European Nuclear Society
ENSREG	European Nuclear Safety Regulators Group
ENSTTI	European Safety Training and Tutoring Institute
EPUE	European Platform of Universities engaged in Energy research, education and training
EQF	European Qualifications Framework
ERA	European Research Area
ESCO	European Skills, Competencies and Occupations
ESEIA	European Sustainable Energy Innovation Alliance
ESFRI	European Strategy Forum on Research Infrastructures
E&T	Education & Training
ETKM	Education, Training and Knowledge Management
EU	European Union
EUFRACT	Specific Support Action funded under the FP7
FINNEN	Aalto University School of Science and Technology - AALTO
FP7	7 th Framework Programme for Research and Technological Development
GHG	Green House Gases
H2020	Horizon 2020
HERCA	Heads of the European Radiological protection Competent Authorities
HOME	Home Affairs (DG)
I2EN	International Institute of Nuclear Energy
IAEA	International Atomic Energy Agency
ICT	Information and Communication Technology
IET	Institute for Energy and Transport
IGDTP	Implementing Geological Disposal of Radioactive Waste Technology Platform
INEPT	Innovative Nuclear Experimental Platform & Training
INSTN	L'Institut National des Sciences et Techniques Nucléaires
IRMM	Institute for Reference Materials and Measurements

ISNL	International School of Nuclear Law
ITU	Institute for Transuran Elements
JRC	Joint Research Centre (DG)
KSC	Knowledge, Skills and Competences
KTH	Royal Institute of Technology (Stockholm)
MELODI	Multidisciplinary European Low Dose Initiative
MS	Member State
OECD/NEA	The Organisation for Economic Co-operation and Development /Nuclear Energy Agency
NPP	Nuclear Power Plant
NSAN	National Skills Academy for Nuclear
NTEC	Nuclear Technology Education Consortium
PRRS	Polish Radiation Research Society
R&D	Research and Development
RM	Roadmap
RONEN	Retea Educationala in Fizica si Ingineria Nucleara
R&T	Research and Training
RTD	Research and Innovation (DG)
SEEIT	Sustainable Energy Education, Innovation and Technology
SETIS	SET-Plan Information System
SET-Plan	Strategic Energy Technology Plan
SNEN	Slovak Nuclear Education Network
SNETP	Sustainable Nuclear Energy Technology Platform
UPC	Polytechnic University of Catalonia
VET	Vocational Education and Training
WG	Working Group
WNA	World Nuclear Association

WNU

World Nuclear University

YGN

ENS Young Generations Network

ANNEX

TO THE COMMISSION STAFF WORKING DOCUMENT “2ND SITUATION REPORT ON EDUCATION AND TRAINING ON NUCLEAR ENERGY FIELD IN THE EUROPEAN UNION”

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1. EU Flagship Initiatives

1.1 Climate and Energy policies

The flagship initiative for a resource-efficient Europe under the Europe 2020 strategy supports the shift towards a resource-efficient, low-carbon economy to achieve sustainable growth. Increasing resource efficiency is key to securing growth and jobs for Europe. One of the key proposals is Energy Roadmap 2050, adopted by the European Commission on 15 December 2011, where the EU is committed to reducing greenhouse gas emissions to 80-95 % below 1990 levels by 2050. Keeping this goal in mind, different scenarios are analysed of which four are decarbonisation options. Nuclear energy is an important contributor, while ensuring the highest safety and security standards in the EU and globally. This can only happen if competence and technology leadership is maintained within the EU. The Roadmap 2050 also emphasises the importance of the social dimension connected to the transition of energy market in order to meet the targets set by the Commission in its Europe 2020 strategy. The transition will affect employment and jobs, requiring education and training to develop workers employability.

1.2 Innovation Union

As one of the flagship initiatives the Innovation Union aims to improve conditions and access to finance for research and innovation, to ensure that innovative ideas can be turned into products and services that create growth and jobs. Too few of our innovative Small and Medium sized Enterprises (SMEs) grow into large companies. Although the EU market is the largest in the world, it remains fragmented and insufficiently innovation friendly. The EU needs to confront its challenges head on and to exploit its huge scientific and innovation potential.

The EU must ensure that it has a sufficient supply of highly qualified workers, who should be offered attractive careers and easy mobility across sectors and countries. The starting point for the Innovation Union is to create an excellent, modern education system in all Member States. Although Europe has a good basic education system, significant weaknesses remain with science teaching in some Member States. Innovation is now needed in almost all walks of life: schools must ensure that all young people are ready to meet this challenge.

The EU and its Member States should strengthen their capacity to attract and train young people to become researchers and offer internationally competitive research careers.

The Innovation Union contains over thirty action points i.e. key initiatives, including strengthening Europe's knowledge base: there is a target of investing 3% of EU's GDP on R&D by 2020 – to reach this Europe would require at least one million more researchers. The Innovation Union proposes measures to complete the European Research Area by 2014. This means more coherence between European and national research policies, cutting red tape and removing obstacles to researchers' mobility.

In education, the Commission supports business-academia collaborations to develop new curricula addressing innovation skills gaps.

1.3 An Agenda for new skills and jobs – a European contribution towards full employment

This Flagship Initiative is how the Commission will help the EU reach its employment target for 2020: 75% of the working-age population (20-64 years) in work. The Agenda also contributes to achieve the EU's target to get the early school-leaving rate below 10% and more young people in higher education or equivalent vocational education (at least 40%), as well as to have at least 20 million fewer people in or at risk of poverty and social exclusion by 2020.

The Agenda focuses on four key priorities:

- Better functioning labour markets – reforms to improve flexibility and security;
- More skilled workforce – this is a considerable challenge, given the rapidly-changing skills needed, and the persistent skills mismatches in the EU labor market. Investment in education and training systems, anticipation of skills needs, matching and guidance services are the fundamentals to raise productivity, competitiveness, economic growth and ultimately employment;
- Better job quality and working conditions – high levels of job quality are associated with equally high labour productivity and employment participation;
- Stronger policies to promote job creation and demand for labour – the right conditions to create more jobs must be put in place, including in companies operating with high skills and R&D intensive business models.

The Agenda for new skills and jobs –flagship initiative set out, in 13 key actions, the possible EU contribution to this joint effort as part of the Europe 2020 Strategy.

2. European Fission Training Scheme projects

CINCH (Cooperation in education in nuclear chemistry) aims to improve education and training in the nuclear chemistry field by developing a long-term Euratom Fission Training Scheme (EFTS) providing a common basis for the fragmented activities in this field.

CORONA – Establishment of a Regional Centre of Competence for VVER Technology and Nuclear Applications. The development of specific training schemes and subsequent establishment of a purpose-built structure for training personnel to operate VVER (or WWER) technology is the strategic outcome of the CORONA project. The Regional Centre of Competence will provide support and

services for preservation and transfer of VVER-related nuclear knowledge as well as know-how and capacity building.

ECNET (EU-CHINA Nuclear Education and Training Cooperation) – the project is a cooperative project carried out between partners from the EU and China with the aim of developing common ground for cooperation in nuclear education, training and knowledge management. By analyzing the current situation in both the EU and China the project consortium aims to define opportunities and barriers for cooperation, carry out pilot exercises and define a road map for long-term cooperation. The project aims to put in place postgraduate level education and training for young professionals.

ENEN III – Training scheme on nuclear engineering - covers the structuring, organisation, coordination and implementation of training schemes in cooperation with local, national and international training organisations, to provide training to professionals active in nuclear organisations or their contractors and subcontractors. The training schemes provide a portfolio of courses, training sessions, seminars and workshops for continuous learning, for upgrading knowledge and developing skills. The activities started in 1 May 2009 for the period of three years hence the project is completed.

ENEN-RU project is for cooperation between the EU and Russia that aims to develop common grounds for cooperation in nuclear education, training and knowledge management. It leads to the mutual recognition of education and training programmes that will offer nuclear research and industry a broader basis of human resources as well as foster cooperation in nuclear power development.

The overall objective **ENETRAP II** – European Network on Education and Training in Radiological Protection - of this 7th Framework Programme project was to develop European high-quality "reference standards" and good practices for education and training in radiation protection (RP), specifically with respect to the radiation protection expert (RPE) and the radiation protection officer (RPO). The project was completed end 2012.

The objective of the **PETRUS II** (Towards an European training market and professional qualification in Geological Disposal) project was to ensure the continuation, renewal and improvement of the professional skills by filling the gap between growing demand for structured E&T in geological disposal and the offering that is presently fairly limited. The programme started at the beginning of 2009 and was finished at the beginning of 2012.

The aim of the **EURECA!**-project is to establish a European-Canadian education and training programme in the field of fourth generation (GEN IV) Super Critical Water-cooled Reactors (SCWR) research. Moreover, the EURECA!-project paves the way for long-term collaboration between the EU and Canada in the field of education, training, research and development in nuclear energy generation in general.

GENTLE (Graduate and Executive Nuclear Training and Lifelong Education) focuses on two E&T domains: (a) the education of students by means of student research projects and internships in the nuclear laboratories, and intersemester courses on special topics that are generally not part of the academic curriculum, (b) the high-level training of young professionals by an Executive master course (60 ECTS) on Nuclear Energy, accredited by one of the participating academic institution. These tools

will strongly impact on the education and training quality in Europe as they broaden the scope of interest to industry and safety organisations, and give the student better opportunities to obtain hands-on experience in high level nuclear research. This will help the European industry to consolidate its leading position in the international market. In addition, to the inter-consortium collaboration, GENTLE will actively coordinate E&T efforts in the domain and will initiate a dialogue with the associated stakeholders from industry on nuclear E&T in Europe, to steer its own E&T programme but also to advice the European Commission and EU member states. GENTLE is thus a holistic approach to training and education on nuclear energy and is complementary to the ongoing efforts in Europe.

TRASNUSAFE (Training Schemes on Nuclear Safety Culture) aims to design, develop and validate two training schemes on nuclear safety culture, with a common basis: a training scheme related to the nuclear industry and a training scheme related to installations making use of ionizing radiation-based technology.

JRC Direct Actions

Nuclear knowledge management in nuclear reactor safety is addressed in a specific JRC activity, CAPTURE⁷⁶, which focuses on topics such as: Evaluation of Human Resources Trends in the Nuclear Energy Sector, Contribution to Nuclear E&T and Knowledge Preservation. The following, main activities can be reported in the reporting period.

- A European Human Resource Observatory in the Nuclear Energy Sector (EHRO-N), driven by needs of the European Nuclear Energy Forum (ENEF), was established in 2011 and is now operated by JRC. EHRO-N, guided by a Senior Advisory Group, composed of members representing more than 30 organizations, initially addressed mapping all EU nuclear stakeholders and gathering data on nuclear Human Resource supply and demand.
- The 2012 EHRON report on the nuclear workforce concluded that the supply of nuclear engineering graduates does not sufficiently respond to the demand in the nuclear energy sector (+/- 30% gap). The latest report from 2013 showed that the peak in nuclear workforce for securing the nuclear energy share in the EU European Energy Roadmap 2050 is lower than in the 1980's, and therefore is probably manageable, with the only difference being the rise of the needs, that will be steeper (i.e. a high demand within a short period). It was also underlined that a future gap analysis, based on knowledge, skills and competences can only be based on the successful implementation of ECVET in the nuclear energy sector.
- In the frame of Knowledge Preservation (NETKNOW project), two multimedia courses were developed jointly with the International Atomic Energy Agency (IAEA)⁷⁷ on "WWER⁷⁸ RPV

⁷⁶ The IET the training and education activities are available on the CAPTURE website:

<http://capture.jrc.ec.europa.eu>

⁷⁷ <http://iaea.org/>

⁷⁸ *Vodo-Vodyanoi Energetichesky Reactor; Water-Water Power Reactor*: is a pressurized water reactor design originally developed in the Soviet Union.

Embrittlement" and "WWER RPV Integrity Assessment". Two more, a "GEN IV Syllabus" and "Severe Accidents" are in phase of development.

JRC training programme on Nuclear Safety and Security

In 2011, the JRC embedded its on-going and future training and education activities into one global JRC training programme on Nuclear Safety and Security. In collaboration with relevant European and international partners, the programme is based on educational and training tracks in the fields of nuclear security and safety. Scientific and technological themes covered are e.g. nuclear safeguards, security and forensics, safety of fuel and fuel cycle technologies, nuclear decommissioning and spent fuel and radioactive waste management, nuclear data and actinide science. It contains four main components:

1. Higher Academic Education through e.g. grants for PhD students performing their thesis work at the JRC laboratories, teaching activities at universities, and preparation and implementation of training and master courses with other organisations such as for example developed in the FP7 GENTLE project⁷⁹.
2. Vocational Training: through specific JRC courses in nuclear safety and security. The training in nuclear security (detection, response, forensic, ...) has a strong relevance for Front Line Officers, Train the Trainers and experts from MS in which they are contributing to the trainings themselves, but also IAEA, DG ENER inspectors and national front line officers in case of nuclear security event (police, customs, etc.).
3. User facility (access to infrastructure): user access programme for students and young researchers as for example in the EUFRAT project.
4. Information centre: the information part should be targeting larger public audience (outreach activities).

More specifically, the main activities that contribute to the vocational training include:

- A dedicated training centre for safeguards and nuclear security (EUSECTRA⁸⁰) that has been prepared since 2009 and inaugurated in 2013 in synergy with other Commission's global security initiatives and with funding from DG HOME and DG ENER,

⁷⁹ In 2012, a consortium composed of JRC (IRMM, IET and ITU) and several EU universities and research organisations were granted a project on "Graduate and Executive Nuclear Training and Lifelong Education (GENTLE)" within the frame of the Euratom Fission Training Schemes (EFTS) in Nuclear Fission, Safety and Radiation Protection.

⁸⁰ EUSECTRA is located at the JRC sites of Karlsruhe and Ispra and offers training with real nuclear and radioactive materials as well as dedicated radiation detectors. It is composed of an outside training area for nuclear detection training, equipped with portal radiation monitors, and a laboratory area dedicated to

- The regular European Safeguards Research and Development Association (ESARDA), academically recognised nuclear safeguards and non-proliferation course,
- Summer Schools on topics such as Decommissioning and Waste Management or Actinide Science and Applications,
- Courses on nuclear data, nuclear safeguards, or nuclear fuels and fuel cycles developed and organised in collaboration with European partners on a bilateral basis or in European projects (e.g. GENTLE).

The programme focuses on the main lines of the JRC's nuclear activities, complementary and in synergy with Member States initiatives and international organisations programmes. It directly involves European entities (e.g. DG ENER, DG DEVCO's Instrument for Stability, DG HOME through the CBRN action plan, EU Member States, non EU Member States), and international bodies (e.g. IAEA, US DoE) which directly contribute to the initiative. In the international domain, the JRC is supporting the IAEA by delivering trainings e.g. in the field of mass spectrometry. In the frame of the JRC Enlargement and Integration Action, specialized workshops, conferences and training courses are organized in the field of nuclear data standards and radionuclide metrology.

In this reporting period, a transnational access scheme (FP7 EUFRAT) was also developed, providing access and experimental time for external users to JRC's research facilities. On a yearly basis, access and support was granted to users from member states and abroad numbering: 1000h per year at the GELINA facility and 400h at the Van de Graaff accelerator. PhD students as well as post-doctoral fellows were constantly involved in research and E&T, within grant holder schemes and trainee programmes and in collaboration with universities. EUFRAT, that has been recently completed, will be followed up by a new transnational access scheme, starting in June 2014. In addition to GELINA and the Van de Graaff accelerator, other facilities will now be included in the access project: the JRC laboratories for nuclear decay measurements and the low-level radioactivity laboratory in the deep-underground facility HADES.

3. Education and Training in the nuclear field in the EU Member States⁸¹

The information under this chapter can also be found in EHRO-N website and reflects the situation at the time of writing this report. To get the latest updates it is recommended to consult the EHRO-N web-page dedicated to this subject⁸² directly.

security and safeguards training. The role of EUSECTRA is to offer training to a wide auditorium, e.g., radioprotection and border control officers, police officers and safeguards inspectors from IAEA and EURATOM.

⁸¹ The list of education and training initiatives in the EU Member State is continuously evolving. An updated vision of the situation can be found on the website of the European Human Resource Observatory for the Nuclear sector: <http://ehron.jrc.ec.europa.eu/>.

3.1 Austria

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

Austrian Young Generation (AYG) gives lectures at the secondary schools on natural radiation, radiation protection and medical application. AYG organises also technical visits for children (up to 14 years old) to the TRIGA research reactor.

Bachelor studies

Upper Austria University of Applied Sciences – Fachhochschule Oberösterreich

- Radiological Technology

University of Applied Sciences Wiener Neustadt – Fachhochschule Wiener Neustadt

- Radiological Technology

Masters studies

Upper Austria University of Applied Sciences – Fachhochschule Oberösterreich

- Radiological Technology

Institute of Atomic and Subatomic Physics (Atominstitut) – TU Wien

- post-Bachelor (Master or PhD level) in the fields of
 - Nuclear Technology
 - Radiochemistry
 - Radiation Protection
 - Nuclear and Astrophysics
 - X-Ray Physics

Doctoral thesis

Any Physics Faculty of the Austrian universities and applied sciences research centres especially Atominstitut.

⁸² <http://ehron.jrc.ec.europa.eu/links-member-states>

Courses and training

Atominstitut

- 80 theoretical and 10 practical courses within the nuclear scope (most of them in ENEN framework)
- Cooperation with *Dalton Institute/University of Manchester*

Stefan Mayer Institut – Stefan Mayer Institut für Subatomare Physik

- seminars

Demand of nuclear experts

Austria does not operate any Nuclear Power Plants so there is no urgent demand for skilled nuclear manpower in short term. The demand for nuclear experts in Austria focuses on the need for few experts for discussion on bilateral and international levels, which is satisfactorily fulfilled by *Atominstitut*.

3.2 Belgium

Bachelor studies

Xios Hogeschool Limburg

Masters studies

BNEN: - Ghent University – Universiteit Ghent

- Nuclear Fusion Science
- Engineering Physics
- *Katholieke Universiteit Leuven*
- *Catholic University of Louvain – Université Catholique de Louvain*
- *Free University of Brussels – Université Libre de Bruxelles*
- Master Complémentaire en Médecine Nucléaire
- *University of Liege – Université de Liège*
- the Advanced Master in Nuclear Medicine

- Free University of Brussels – Vrije Universiteit Brussel

Postgraduate studies

Ghent University – Universiteit Ghent

- Radiation Protection

Doctoral thesis

Ghent University – Universiteit Ghent

Belgian Nuclear Research Centre – Studiecentrum Voor Kernenergie – Centre d'Etude de l'Energie Nucléaire

Demand of nuclear experts

A study on human resources in nuclear field in Belgium was carried out and the report published in May 2012. According to the study the Belgian nuclear sector employs around 20 300 people. The full report (in French) can be found here:

http://www.nuclearforum.be/sites/default/files/Forum%20nucl%C3%A9aire%20-%20Cartographie%20de%20l%20emploi%20dans%20le%20secteur%20nucl%C3%A9aire%20en%20Belgique_23052012_0.pdf

3.3 Bulgaria

Bachelor studies

Sofia University St. Kliment Ohridski

- Dosimetry and Radiation Protection
- Nuclear Chemistry
- Nuclear Technology and Nuclear Power Engineering

Technical University of Sofia

- Thermal and Nuclear Power Engineering

Masters studies

Technical University of Sofia

- Nuclear Power Engineering

Sofia University St. Kliment Ohridski

- Nuclear Techniques and Technologies
- Nuclear Physics and Elementary Particles

Doctoral thesis

Sofia University St. Kliment Ohridski

- Nuclear Physics and Elementary Particles

Technical University of Sofia

- Nuclear Power Engineering

Postgraduate studies

Plodiv University Paisii Hilendarski

- Postgraduate Nuclear Physics Methods

Ruse University/Русенски университет "Ангел Кънчев"

- Atomic and Nuclear Physics
- General and Applied Physics Scientific in Nuclear Theory and Nuclear Reactions

The Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences

- Neutron Physics and Physics of Nuclear Reactors (for Doctor's Degree)
- Nuclear Physics (for Doctor's Degree)
- Physics of Elementary Particles and High Energies (for Doctor's Degree)

3.4 Croatia

The Republic of Croatia has currently no nuclear power programme in place. The training and educational opportunities in the Republic of Croatia are reflecting the limited nuclear activities in the country. There are some related academic courses available, but a comprehensive educational programme in the nuclear field is currently not offered at the national level.

Bachelor studies

The University of Rijeka

- Bachelor of Radiology Medicine

Polytechnic for Applied Health Studies in Zagreb

- Professional study of radiology technology.

Masters studies

University of Zagreb – Faculty of electrical engineering and computing

- Electrical Power engineering including
 - Nuclear engineering
 - Nuclear fuel cycle and reactor materials
 - Nuclear safety
 - Nuclear power plant safety analysis
 - Radiation effects and radiation protection

Courses

University of Zagreb

- MSc Programmes of Electrical Engineering Systems and Technology covers courses on fundamentals of nuclear physics
- Graduate Study includes courses in Nuclear Medicine

3.5 Cyprus

Bachelor studies

Cyprus does not produce nuclear power and it does not have any involvement in the nuclear industry
- no degrees are offered that specialize in the nuclear field.

Masters studies

Cyprus does not produce nuclear power and it does not have any involvement in the nuclear industry
- no degrees are offered that specialize in the nuclear field.

Courses

University of Cyprus

- courses on nuclear physics

3.6 Czech Republic

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

Education and information programme "The World of Energy of the Czech Power Company ČEZ 1992 – 2012" with the objectives to increase the level of nuclear knowledge both at children and youth and also at the wide public and increase an interest in study of nuclear fields and eventually in future employment with Czech NPPs.

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Bachelor studies

Charles University in Prague – Univerzita Karlova v Praze

- Plasma Physics and Ionized Environments

Czech Technical University in Prague/Ceské Vysoké Učení Technické

- Physics and Technology of Nuclear Fusion specialization

- Theory and Technology of Nuclear Reactors specialization

- Dosimetry and Applied Ionizing Radiation specialization

Masters studies

Czech Technical University in Prague/Ceské Vysoké Učení Technické

- Physics and Technology of Nuclear Fusion specialization (within the study branch Physical Engineering)
- Theory and Technology of Nuclear Reactors specialization (within the study branch Nuclear Engineering)
- Radiological Physics

The Brno University of Technology/Vysoké Učení Technické v Brně

- Nuclear Power Engineering Specialization within the Power Master Engineering

Doctoral thesis

Institute of Physics of the Academy of Sciences of the Czech Republic/Akademie věd ČR

- Plasma Physics and Ionization of Environment
- Subnuclear Physics

Courses

Czech Nuclear Research Institute Rez/Ústav Jaderného Výzkumu Rez a.s. (UJV) (Part of ENSTTI)

Czech Nuclear Education Network (CENEN)

3.7 Denmark

Bachelor studies

Aarhus University – Aarhus Universitet

Masters studies

Aarhus University – Aarhus Universitet

Doctoral thesis

Aarhus University – Aarhus Universitet

Courses

Aarhus University – Aarhus Universitet

- Nuclear Particle Physics

Demand of nuclear experts

Denmark does not operate any Nuclear Powerplant. Nevertheless, it participates in the Nordic Nuclear Safety Research – Nordisk Kernerikkerheds Forskning, which is a platform for Nordic cooperation and competence in nuclear issues.

3.8 Estonia

There is no high level education specialized in the nuclear scope but there are some institutions involved in the nuclear research as the Estonian Academy of Sciences - Eesti Teaduste Akadeemia, Tallinn University of Technology - Tallinna Tehnikaülikool and the University of Tartu - Tartu Ülikool.

Demand of nuclear experts

As Estonia does not have any nuclear power, there is no urgent demand for nuclear experts.

3.9 Finland

Ministry of Employment and the Economy TEM carried out a survey and a study and published a report of the finding in the Publications series Energy and Climate 14/2012 "Report of the Committee for Nuclear Energy Competence in Finland". The report provides an overview of the Finnish activities, too. The committee and its experts form now an informal national group on Competence coordinated by the Ministry TEM (contact Jorma Aurela). TEM also started in 2013 a new project YES to write a national nuclear energy research strategy.

FINNEN (Finnish universities network on nuclear education) activities are continued with the continuation of the National Training Course on Nuclear Safety (YK -course) that takes place annually. The enrolment to the course is 50-70 students each year. Also in this context a Doctoral Programme for Nuclear Engineering and Radiochemistry YTERA (2012-2015, <http://physics.aalto.fi/studies/ytera/participants/>) was started in cooperation between Aalto University, Helsinki University and Lappeenranta University of Technology (LUT). The programme provided for 7 full-time doctorate study posts and in addition 25 parttime doctoral students are enrolled into it. The YTERA is funded by public (Academy of Finland and the participating Universities) and private funding from utilities (TVO, Fortum, and Fennovoima) and Posiva.

Under the lead of TEM also a National Nuclear Waste Management training course (Kansallinen YJH -course) has been set up and run already during three years and continues with over 20 students participating each year. Like the YK-course, the implementation of this course is based on a networked implementation model including authorities, academia, research institutes, and industry (utilities, waste management organisation, and service suppliers). Both courses are based on voluntary agreements between the parties contributing to the course content, organization, and sharing the coordination costs.

Basic education in nuclear on the University level is provided by Lappeenranta University of Technology (LUT) and Aalto. LUT has in its degree program of energy technology and power engineering a major in nuclear engineering. This degree program includes 38 ECTS Master level courses on nuclear engineering subjects from reactor physics to thermal hydraulics modelling.

Aalto University's Schools provide a wide range of education on reactor physics, nuclear safety, nuclear waste, risk assessment, safety critical organizations, project management, and nuclear related ICT. These activities can be tailored into nuclear engineering modules comprising 20-60 ECTS and they can be included into a full M.Sc. degree ranging from reactor physics to fusion technology under the engineering physics and mathematics degree programme. A basic nuclear engineering education module for all B.Sc. level students will be launched in autumn 2013. Aalto is presently recruiting new tenure track professors for nuclear materials. Aalto's nuclear education strategy is based on a profound professional expertise supported by the specific requirements of the nuclear field.

Finnish radiation and nuclear safety authority (STUK) actively participates national training networks (including YTERA, YK and YJH) as well as international cooperation on the field of regulatory body's competence and capacity building. STUK also provides training courses on regulatory work on new builds area and especially on Finnish regulatory guides for all actors in the nuclear sector in Finland.

Finnuclear association (<http://www.finnuclear.fi/>) provides training for nuclear suppliers in Finland. Oulu University has set up a continuing professional education programme for the nuclear sector together with LUT and OAMK1 and some other Universities of Applied Science like SAMK and Centria have included nuclear course modules into their curriculum during the last two years.

Finnish industry, academia and research organisation are actively engaged in the two technology platforms in the field of fission: Sustainable Nuclear Energy (SNETP) and Implementing Geological Disposal of Radioactive Waste (IGD-TP). The Finnish radiation and nuclear safety authority (STUK) is engaged in the research platform Multidisciplinary European Low Dose Initiative (MELODI).

The Finnish E&T stakeholders remain also active on international level on activities related to the ENS (via Finnish Nuclear Society ATS) and ENEN associations, and in various European Fission Training Schemes and other networks.

Efficient networking between all Finnish nuclear stakeholders and European EFTS schemes are a crucial for the Finnish nuclear E&T activities.

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

TVO organises every summer "science camps" for elementary pupils. One day visits are arranged for pupils from upper level of comprehensive schools at the area of Olkiluoto site. Usually there are different topics for different class levels for example radiation & waste management for pupils from 8th grade (14 years old). Also students from secondary schools are visiting the visitor centre.

At the Loviisa site Fortum gives lectures on nuclear energy/industry for the secondary school students.

Fennovoima is actively lecturing for the Pyhäjoki's and Raahe's area secondary school students. Fennovoima also organises few day courses for teachers at a vocational schools.

The nuclear training in the country is carried out in co-operation by STUK, the Ministry of Employment and the Economy, the Lappeenranta University of Technology (LUT), Teknillinen Korkeakoulu (TKK), Technical Research Centre of Finland (VTT), Licensees Fortum and TVO, and Posiva Oy. The national nuclear training programme of five weeks has been developed on the basis of nuclear safety training of the IAEA.

Masters studies

Lappeenranta University of Technology/Lappeenrannan Teknillinen Yliopisto

- Nuclear Energy Engineering

Doctoral thesis

Graduate School in Particle and Nuclear Physics (GRASPANP) is part of the graduate school (doctoral) system launched in Finland in January 1995. GRASPANP is funded by the Ministry of Education, the Academy of Finland, the participating universities and individual research projects. The third period of the school started at the beginning of 2003. The participating universities and institutes are:

- *University of Helsinki*
- *University of Jyväskylä*

- *University of Oulu*
- *University of Turku*
- *Helsinki University of Technology*
- *Helsinki Institute of Physics (HIP).*

The main research fields of GRASPANP:

- experimental particle physics
- theoretical particle physics
- experimental nuclear physics
- theoretical nuclear physics
- accelerator technology
- nuclear and accelerator based physics applications.

The School coordinates and organizes research training, post graduate courses and workshops, invites international lecturers and supports conference participation. *The Annual International Summer School*, held in Jyväskylä, is an important part of this activity.

GRASPANP has annually over 70 postgraduate students.

Courses

Lappeenranta University of Technology - Lappeenrannan Teknillinen Yliopisto

- Nuclear Physics
- several courses in nuclear engineering inside of the Energy Technology Degree

Helsinki University of Technology - Aalto-Yliopiston Teknillinen Korkeakoulu

- special Advance Course in Nuclear engineering
- introduction to Nuclear Engineering
- introduction to Nuclear Reactors
- laboratory course in energy technologies
- Medical Physics II

- radiation physics and safety

University of Jyväskylä - Jyväskylän Yliopisto

- Applied Nuclear Physics
- Nuclear Physics I and II

Demand of nuclear experts

In October 2010, the Ministry of Employment and the Economy set up a committee to examine the long-term competence needs of the nuclear energy sector. The study was implemented by a group of experts ensuring extensive representation of the nuclear energy sector. One of the key conclusions was that comprehensive high-standard national competence is needed by nuclear sector companies and research institutes, as well as by authorities. Training of experts and sector-specific research activities call for long-term investments and cooperation, both among national actors and on an international scale.

Competence needs in Finland's nuclear energy sector are growing. The nuclear power plant units presently in operation, as well as the Olkiluoto 3 unit under construction, require a competent labour force on a continuous basis. Posiva must have readiness for commencing final disposal of spent fuel by 2020. The new nuclear power projects – TVO's Olkiluoto 4 and Fennovoima's nuclear power plant, which were given favourable decisions-in-principle by the Government in 2010 – will particularly increase the need of experts.

The full report can be found in http://www.tem.fi/files/33099/TEMjul_14_2012_web.pdf

3.10 France

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

ENS – French Young Generation are present at a secondary school job information fair (information on the different possible career) held every year close to Paris since 4 years.

In 2008, the French Minister for Higher Education and Research created a Co-ordination Committee for nuclear education and training in order to ensure the expansion of the French nuclear energy sector through the renewal of its workforce. This committee, named French Council for Education and Training in Nuclear Energy (Conseil des Formations en Energie Nucléaire – CFEN) advises the Office of Higher Education on opening new academic curricula. It also coordinates the international

recruitment of students and provides a point of contact with AFNI (the French International Nuclear Agency or Agence Française pour le Nucléaire International) for education and training. The International Institute for Nuclear Energy, I2EN, is performing nuclear trainings for the international actors in the nuclear energy area as well.

Bachelor studies

National Institute for Nuclear Science and Technology – Institut National des Sciences & Techniques Nucléaires (INSTN)

- Atomic Engineering

ENSTA Paris Tech – Ecole Nationale Supérieure de Techniques Avancées

- Nuclear Engineering specialisation withing the engineering curricula

Mines Paris Graduate School – Ecole des Mines Paris (ENSMP)

- Specialisation in Nuclear Engineering

Engineering National High School of Caen – Ecole Nationale Supérieure d'Ingénieurs de Caen (ENSICAEN)

- Specialisation in Nuclear and Instruments Engineering

Grenoble Institute of Technology – Institute Polytechnique de Grenoble

- Energy and Nuclear Engineering

Mines School of Nantes – Ecole des Mines de Nantes

- Nuclear Technology, Environmental and Safety

Chemistry Paris Tech – Chimie Paris Tech

- Specialisation in Nuclear Chemistry

National Chemistry High School of Montpellier – Ecole Nationale Supérieure de Chimie de Montpellier

- Specialisation in Environmental and Nuclear Chemistry

Mines School of Alés – Ecole des Mines d'Alés

- Nuclear Specialisation

National Mines High School of Saint-Etienne – Ecole Nationale Supérieure des Mines Saint-Etienne (in collaboration with INSTN)

- Nuclear Installations Engineering

Masters studies

Grenoble Institute of Technology - Institute Polytechnique de Grenoble (in collaboration with EDF and the National Institute for Nuclear Science and Technology - Institut National des Sciences & Techniques Nucléaires (INSTN))

- Master International Materials for Nuclear Energy (MaNuEn)
- (coordinates) ENEN European Master of Science in Nuclear Engineering (EMSNE)

University Pierre and Marie Curie-Paris VI – Université Pierre et Marie Curie-Paris VI

- Nuclear Engineering

Consortium established by the Paris Tech, the University Paris-Sud 11 - Université Paris-Sud11, the École Central Paris (ECP), the National Institute for Nuclear Science and Technology - Institut National des Sciences & Techniques Nucléaires (INSTN) and EDF

- Master International Nuclear Energy

National Institute for Nuclear Science and Technology - Institut National des Sciences & Techniques Nucléaires

- European Master in Molecular Imaging (EMMI)

University of Nancy I Henri Poincaré - Université Henri Poincaré, Nancy I collaborates in

- European Master in Nuclear Fusion Science and Engineering Physics

University Joseph Fourier – Université Joseph Fourier

- Master Professional IDTT with four specialisations
- (in collaboration with INP) Energy Physics

Blaise Pascal University Clermont-Ferrand – Université Blaise Pascal Clermont-Ferrand

- Physics Master with several courses within the nuclear field

Doctoral thesis

National Academy of Arts and Crafts – Conservatoire National des Arts et Métiers (CNAM)

- Sciences and nuclear – Sciences et Techniques Nucléaires

National Institute for Nuclear Science and Technology - Institut National des Sciences & Techniques Nucléaires in collaboration with Paris XI University

- Nuclear Energy.

National Institute for Nuclear Science and Technology - Institut National des Sciences & Techniques Nucléaires

Four European Technical Safety Organisations (TSOs) among them the French Institut de Radioprotection et de Sûreté Nucléaire (one of the founders of the European Nuclear Safety Training and Tutoring institute (ENSTTI))

CEA and IRSN

- Traineeship for master of several levels

Areva, EDF and GDF Suez

- Initial training for the operating personnel of several NPPs

Demand of nuclear experts

CFEN's estimates for the future demand for nuclear experts are that over the next ten years, domestic and international nuclear power activities in France will call for the recruitment of about 13,000 engineers with Master of Science or Ph.D. degrees, and 10,000 science technicians and operators with Bachelor of Science degrees. The chief employers will be EDF, AREVA, GDF-Suez, national agencies such as the Agence nationale pour la gestion des déchets radioactifs (ANDRA), sub-contractors, and R&D agencies such as the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), and the technical safety organization, Institut de Radioprotection et de Sûreté Nucléaire (IRSN).

As for the need for employees for the future, OPIIEC published a study in 2008 called Etude sur les métiers de l'ingénierie nucléaire.

The full report can be found here: <http://www.fafiec.fr/node/23564/node/23886/observatoire-metiers/etudes-opiiec/etude-ingenierie-nucleaire>

Study on the socioeconomic weight of nuclear power in France

The PWC carried out a study " Le poids socio-économique de l'électronucléaire en France", with a report published in May 2011. According to the study a total of 70000-150000 new employees are needed in the period of 2009-2030 in France, according to different scenarios. The report can be found in :

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/le_poids_socioeconomique_de_l_electronucleaire_en_france.pdf

3.11 Germany

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

MINT – Mathematics, Informatics, Natural Sciences and Technology – offer innovative career opportunities with great future perspectives. About 330,000 additional university and college graduates in these subjects will be needed by 2013 in Germany alone.

The National Pact for Women in MINT Careers was launched by Federal Minister Prof. Dr. Annette Schavan in June 2008 as part of the Federal Government's "Get Ahead Through Education" qualifications initiative. The aim is to build on earlier successes and, together with partners from politics, business, science and the media, combine efforts and utilise the wealth of diverse experience accumulated in encouraging young women's interest in MINT.

Steps taken to date are producing first results. For instance, the proportion of female students in the first semester of Mechanical Engineering rose from 17,5% (2005) to 18,6% (2009).

Traditionally, most of the higher level education has been provided at the University of Applied Sciences (UAS)/Fachhochschule (FH) sometimes abbreviated as Hochschule or Hochschule für angewandte Wissenschaften - HAW).

Bachelor studies

Technical University of Munich - Technische Universität München

- Nuclear Technology

Masters studies

Aachen University of Applied Sciences - Hochschule Aachen

- European Master of Science in Nuclear Applications (EMINA)

Technical University of Munich - Technische Universität München

- Nuclear Technology

RWTH Aachen University - Rheinisch-Westfälische Technische Hochschule Aachen

- Nuclear Safety Engineering.

Doctoral thesis

Courses

Aachen University of Applied Sciences

- ERASMUS Intensive Program organized jointly by the universities of the CHERNE Network called Jülich Nuclear Summer School JUNCS.

Karlsruhe Institute of Technology

Simulator Centre/Simulator Zentrum

Plant and Reactor Safety Company/Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) GmbH

- Training course for experts in the field of Nuclear Safety.

The Plants and Reactor Safety Company/Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) takes part in the European Nuclear Safety Training and Tutoring institute (ENSTTI).

3.12 Greece

Masters studies

Institute of Nuclear Physics of the National Centre of Scientific Research "Demokritos"/ Εθνικό Κέντρο Έρευνας Φυσικών Επιστημών – «Δημόκριτος», in collaboration with its sister Institute of Materials Science and with the School of Applied Mathematics and Natural Science (ΣΕΜΦΕ) of the National Technical University of Athens/Εθνικό Μετσόβιο Πολυτεχνείο (NTUA/ΕΜΠ)

- Nuclear and Particle physics

Doctoral thesis

Institute of Nuclear Physics of the National Centre of Scientific Research “Demokritos”/ Εθνικό Κέντρο Έρευνας Φυσικών Επιστημών – «Δημόκριτος», in collaboration with its sister Institute of Materials Science and with the School of Applied Mathematics and Natural Science (ΣΕΜΦΕ) of the National Technical University of Athens/Εθνικό Μετσόβιο Πολυτεχνείο (NTUA/ΕΜΠ)

- Nuclear and Particle physics

Postgraduate studies

Greek Atomic Energy Commission/ Ελληνική Επιτροπή Ατομικής Ενέργειας (GAEC)

- Inter – University Postgraduate Course in Medical - Radiation Physics (Universities of Athens, Ioannina and Thrace)

3.13 Hungary

Bachelor studies

Budapest University of Technology and Economics/Budapesti Műszaki és Gazdaságtudományi Egyetem (BUTE)

- Nuclear Specialization in the 5 years Engineering Physics Program

Budapest University of Technology and Economics/Budapesti Műszaki és Gazdaságtudományi Egyetem (BUTE)

- Several nuclear related subjects within the Bachelor degrees, both in Physics and Energy Engineering

Masters studies

Eötvös Loránd University/Eötvös Loránd Tudományegyetem

- Atomic and Molecular Physics Module and a Particle Physics Module within the Master Degree in Physics

Budapest University of Technology and Economics/Budapesti Műszaki és Gazdaságtudományi Egyetem (BUTE)

- Several nuclear related subjects within the Master’s degrees, both in Physics and Energy Engineering

Doctoral thesis

University of Debrecen/Debreceni Egyetem PhD School in Physics

- Atomic and molecular physics
- Nuclear Physics
- Solid State Physics
- Interdisciplinary applications
- Particle Physics

Courses

Institute of Nuclear Techniques (BUTE)

- Continuing Education Program in Reactor Physics and Reactor Technology

Institute of Isotopes/Üdvözljük az MTA Izotópkutató Intézet Honlapján

- Lab practices for undergraduate chemist and physicist students

KFKI Atomic Energy Research Institute/KFKI Atomenergia Kutatóintézet

- Nuclear training courses

Budapest University of Technology and Economics/Budapesti Műszaki és Gazdaságtudományi Egyetem

- Nuclear training courses

3.14 Ireland

None of the higher education institutions offer a degree or carry out research in the nuclear field. There are, however, small number of courses offered in the nuclear field:

School of Physical Sciences of the Dublin City University

- Applied Spectroscopy
- Laser Physics and Medical Applications

- Medical Imaging Radiation Physics

National University of Ireland (Maynooth)

- Radiation
- Nuclear and Particle Physics

3.15 Italy

The Interuniversity National Nuclear Technology Research Association/Consorzio Interuniversitario Nazionale per la Ricerca Tecnologica Nucleare (CIRTEN), represents the Italian network institution for education and research in the nuclear field. Another association involved in the nuclear field is the Italian Nuclear Association/Associazione Italiana Nucleare (AIN).

Bachelor studies

University of Pisa - Università di Pisa

- Nuclear and Safety Engineering

Technical University of Turin - Politecnico di Torino

- Energy Engineering with a special interest in the Nuclear and Safety Engineering

University of Palermo - Università degli Studi di Palermo

- Energy Engineering and the Specialist degree in Engineering and Safety of Nuclear Technologies

University of Roma - Sapienza Università di Roma

- Energy Engineering

University of Bologna - Università di Bologna

- Nuclear specialization as a part of the degree in Energy Engineering

Milan Polytechnic - Politecnico di Milano

- Third year specialization in Nuclear Engineering within the Energy Engineering degree

Masters studies

Milan Polytechnic/Politecnico di Milano

- Nuclear Engineering

University of Bologna/Università di Bologna

- Nuclear and Sub-nuclear Physics
- Energy and Nuclear Engineering

University of Pisa/Università di Pisa

- Technology of Nuclear Installations/Tecnologie degli impianti nucleari
- Nuclear Safety and Security
- *Nuclear Engineering and Safety*

The University of Turin/Università di Torino

- Nuclear and Sub-nuclear Physics/Laurea Magistrale in Fisica. Percorso Fisica nucleare e subnucleare

The University of Roma/Sapienza Università di Roma

- Energy Engineering

Doctoral thesis

University of Roma/Sapienza Università di Roma

- PhD in the nuclear field

University of Palermo/Università degli Studi di Palermo

- Engineering of Innovative Nuclear Reactors and Fusion

Milan Polytechnic

- Energy and Nuclear Science and Technology (sponsored by the Department of Energy)

University of Bologna/Università di Bologna

- Nuclear and Sub-nuclear Physics

University of Pisa

- Nuclear and Industrial Safety nuclear/Sicurezza nucleare ed industrial

Technical University of Turin/Politecnico di Torino

- possibility of doing a thesis in the nuclear field as part of the PhD in Energy

3.16 Latvia

The Latvian Academy of Sciences - Latvijas Zinatnu Akademija is the most important association involved in the improvement of activities in the nuclear field.

Courses

Riga Technical University - Rigas Tehniska Universitate

- Molecular Spectroscopy
- Nuclear Magnetic Resonance Spectroscopy

3.17 Lithuania

The Lithuanian Nuclear Energetics Association/Lietuvos Branduolinių Energetikos Asociacija has a special interest in the consolidation of the nuclear knowledge.

Bachelor studies

Kaunas University of Technology - Kauno Technologijos Universitetas

- Nuclear Energy (Bachelor of Power Engineering)

University of Vilnius - Vilniaus Universitetas

- Physics of Nuclear Energetics

Masters studies

Kaunas University of Technology - Kauno Technologijos Universitetas

- Power Engineering

Doctoral thesis

Kaunas University of Technology - Kauno Technologijos Universitetas

- Thermal Engineering

Courses

Lithuanian Energy Institute (LEI), along with other Technical Support Organizations (TSOs) has created the European Nuclear Safety Training and Tutoring Institute (ENSTTI), which offers several training courses.

3.18 Luxembourg

Courses

University of Luxembourg/Université de Luxembourg

- Atomic and Nuclear Physics

3.19 Malta

Bachelor studies

University of Malta/L-Universita`ta' Malta

- Radiography

Masters studies

University of Malta/L-Universita`ta' Malta

- Radiography

3.20 Netherlands

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

Activities by Dutch young Generation of the Dutch Nuclear Society like Energy Week – presenting different types of energy at the secondary schools.

Bachelor studies

Currently, there is no high educational institution offering a Bachelor's degree in the nuclear field.

Masters studies

Delft University of Technology - Technische Universiteit Delft

- Chemical Engineering or Applied Physics with Specialisation Nuclear Science and Engineering

Eindhoven University of Technology - Technische Universiteit Eindhoven

- Science and Technology of Nuclear Fusion specialisation
- Science in Applied Physics/Specialization Plasma Physics & Radiation Technology

Doctoral thesis

Delft University of Technology - Technische Universiteit Delft

University of Groningen - Rijksuniversiteit Groningen, especially its Kernfysisch Versneller Instituut (KVI)

Courses

Eindhoven University of Technology - Technische Universiteit Eindhoven, especially in Radiation protection and dosimetry, by the Nuclear Nederland and by the Nuclear Research and Consultancy Group (NRG)

3.21 Poland

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

Polish Young Generation launched in 2011 an "Atomic Education". The main objective of these activities is to promote knowledge about nuclear energy through organising educational events for a broad range of target audiences. Such meetings have been organised either in schools or in the open air in the form of "scientific picnics".

Additionally since two years the Atomic Forum organises a campaign "Atomic Bus" – a bus crossing Polish cities and offering lectures and meetings to inform about the nuclear energy and radiation, dedicated also to the youngsters.

Work in the nuclear field is overseen by the Polish Nuclear Physics Network - Siec Polskiej Fizyki Jadrowej, which has been formed by thirteen Polish research and educational institutions.

Bachelor studies

AGH University of Science and Technology - Akademia Górniczo-Hutnicza Im. Stanisława Staszica w Krakowie

- Nuclear Power Engineering

Consortium Personnel for Nuclear Energy Industry and Technology in Industry and Medicine - Kadry dla Energetyki Jadrowej i Technologi Jadrowej w Przemysle i Medycynie (Maria Curie-Sklodowska University - Uniwersytet Marii Curie Skłodowskiej, Wrocław University of Technology - Politechnika Wroclawska and University of Warsaw - Uniwersytet Warszawski)

- Specialization in Design and Utilization of Energy Systems within its Energetics studies (at the Wrocław University of Technology, Faculty of Mechanical and Power Engineering)
- Specialization in Nuclear Safety and Radiological Protection within its Physics studies (at the Maria Curie-Sklodowska University, Faculty of Mathematics, Physics and Computer Science)
- Bachelor's degree in Nuclear Energetics and Chemistry (at the University of Warsaw, Faculty of Chemistry and Faculty of Physics)

Poznan University of Technology - Politechnika Poznanska (Faculty of Chemical Technology, Faculty of Civil and Environmental Engineering and Faculty of Technical Physics)

- Nuclear Energy Engineering Specialization

Silesian University of Technology - Politechnika Slask

- Nuclear Engineering specialization within its Mechanics and Machinery Design department
- Nuclear Energetics Specialization in its Energy Engineering

Wroclaw University of Technology - Politechnika Wroclawska

- specialization in Nuclear and Thermal Engineering

Masters studies

AGH University of Science and Technology - Akademia Górniczo-Hutnicza Im. Stanisława Staszica w Krakowie

- Technical Physics with a specialization in Nuclear Physics
- Energy Engineering with a specialization in Nuclear Energy Engineering

University of Warsaw - Uniwersytet Warszawski

- Nuclear Energetics and Chemistry

Doctoral thesis

AGH University of Science and Technology - Akademia Górniczo-Hutnicza Im. Stanisława Staszica w Krakowie

- Technical Nuclear Physics
- Energy Engineering

The Polish Academy of Sciences - Polska Akademia Nauk is the main educational institution offering the possibility of a Doctorate degree in the nuclear field in several of its institutes which include:

- *Andrzej Soltan Institute for Nuclear Studies - Instytut Problemów Jądrowych im. Andrzeja Soltana* together with
- *POLATOM*, the National Centre for Nuclear Research
- *Henryk Niewodniczanski Institute of Nuclear Physics - Instytut Fizyki Jądrowej im. Henryka Niewodniczanskieg* (specifically the International PhD Studies at the Institute of Nuclear Physics)
- *Institute of Molecular Physics - Instytut Fizyki Molekularnej*
- *Institute of Physics - Instytut Fizyki*
- *University of Gdansk - Uniwersytet Gdański*, which offers a Doctorate degree in Experimental Physics - Atomic and Molecular Spectroscopy and in Theoretical Physics - Atomic and Molecular Physics

3.22 Portugal

Masters studies

University of Coimbra - Universidade de Coimbra

- Physics with a specialization in Nuclear and Particles Physics

Doctoral thesis

University of Lisbon - Universidade de Lisboa

- Nuclear Physics

Courses

Porto University - Universidade de Porto

Technical University of Lisbon - Universidade Técnica de Lisboa

University of Coimbra - Universidade de Coimbra

University of Lisbon - Universidade de Lisboa

Technological and Nuclear Institute - Instituto Tecnológico e Nuclear

- Nuclear Instrumentation
- Reactors Operators
- Specialized Technicians of Laboratory
- Security and Radiological Protection

Technical University of Lisbon - Universidade Técnica de Lisboa

- Advanced Training Diploma in Radiation Safety

3.23 Romania

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

Romanian Young Generation together with Romanian Nuclear Association organise in collaboration with the secondary schools the educational seminars on topic related to radiation protection, applications of nuclear power, the operation and safety of NPPs, general information about atoms, physics, etc. for 100 pupils. Additionally every year there is organised a drawing and essay writing competitions for the pupils aged 9-19 on the topic of nuclear power – energy for the future.

The Romanian Nuclear Higher Education Network (RONEN) is a joint initiative of the Romanian Universities, Nuclear Research Institutes, SMEs, NGOs and the Regulatory body.

Bachelor studies

Polytechnical University of Bucharest - Universitatea Politehnica din Bucuresti

- Nuclear Power Engineering and Nuclear Technologies

Ovidius University of Constanta - Universitatea Ovidius Constanta

- specialization in Industrial Energetics within the Energy Engineering oriented towards the nuclear field

Masters studies

Polytechnic University of Bucharest - Universitatea Politehnica din Bucuresti

- Radiation Protection and Nuclear Security
- Nuclear Engineering

University of Bucharest - Universitatea din Bucuresti

- Physics specialising in Photons, Spectroscopy, Plasma and Laser

Doctoral thesis

Horia Hulubei National Institute of Physics and Nuclear Engineering

University of Bucharest/Universitatea din Bucuresti

- Atomic Physics

- Nuclear Physics
- Elementary Particle Physics

University Babes-Bolyai Cluj - Universitatea Babeş-Bolyai

Courses

Romanian National Consortium (RNC) for Training and Education in Nuclear Sciences Platform (TENSP)

Demand of nuclear experts

In the nuclear field, all the activities are deployed in accordance with the provisions of the National Strategy for the Development of the Nuclear Field (SNDDN) and of the National Nuclear Programme (PNN), approved through the Governmental Decision No. 1259/2002. These documents state the main directions for nuclear power and non-power development in Romania and establish the strategy and the ways to ensure the needed human resources.

3.24 Slovakia

European Decommissioning Academy

The European Decommissioning Academy is organised by the Institute of Nuclear and Physical Engineering of Slovak University of Technology in Bratislava in collaboration with the IAEA. They organize post-gradual courses focused on decommissioning.

The first run in 2014 will be focusing on VVER decommissioning.

General idea:

According to analyses presented at EC meeting focused on decommissioning organized at 11.9.2012 in Brussels, it was stated that about 7.000 new experts for decommissioning will be needed in Europe up to 2025.

Having in mind the actual EHRO-N report from 2013 focused on operation of nuclear facilities and an assumption that the ratio between nuclear experts, nuclearized and nuclear aware people is comparable also for decommissioning, as well as the fact that the special study branch for decommissioning in the European countries almost does not exist, these European Decommissioning Academy (EDA) could be helpful in the overbridging these gap.

The main goal is – from about 74% of nuclearized experts (graduated at different technical Universities and increased their nuclear knowledge and skills mostly via on-job training and often in the area of NPP operation) to create nuclear expert for decommissioning via our post-gradual course organized in two semester study at our Academy, which will include the lessons, practical exercises in our laboratories, on-site training at NPP V-1 in Jaslovské Bohunice, Slovakia as well as 3 days technical tour to NAGRA a Zwiilag in Swiss.

Beside the exams in selected topics, the final thesis written under supervision of recognized expert will be precondition for graduation and certification of participants.

For the first run of the EDA scheduled on 2014 we would like to focus on VVER decommissioning issues because this reactor type is the most distributed design in the world and many of these units are actually in decommissioning process or will be decommissioned in the near future in the Europe.

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

The Slovak Nuclear Society organises the presentations directly on secondary schools about the different aspects of nuclear energy (power engineering, accidents, radiation monitoring, nuclear medicine, etc.).

Students of secondary schools are invited also to Open Days in different institutes or companies e.g. Slovak Hydro-meteorological Institute, Institute of Nuclear and Physical Engineering at Slovak University of Technology, etc.

Slovak Young Generation participates on the biggest open-air summer music festival. The objective is to communicate with young people on all aspects of using nuclear energy and ionising radiation, the name of Slovak YG exhibition is "Radiation is around us and in us".

Masters studies

the Institute of Nuclear and Physical Engineering - Ústav jadrového a fyzikálneho inžinierstva at the Faculty of Electrical Engineering and Information Technology - Fakulta elektrotechniky a informatiky (FEI) of the Slovak University of Technology in Bratislava - Slovenska Technická Univerzita v Bratislave (STU)

- Nuclear Power Engineering

Doctoral thesis

the Institute of Nuclear and Physical Engineering - Ústav jadrového a fyzikálneho inžinierstva at the Faculty of Electrical Engineering and Information Technology - Fakulta elektrotechniky a informatiky

(FEI) of the Slovak University of Technology in Bratislava - Slovenska Technická Univerzita v Bratislave (STU)

- Nuclear Power Engineering

Courses

VUJE (established in 1977 as a research institute, today an engineering joint stock company) is the authorised contractor for theoretical and simulator training, and organizes other training, as well as regional and international courses.

Demand of nuclear experts

The Young Generation of the Slovak Nuclear Society - Mladá generácia Slovenskej nukleárnej spoločnosti and the Slovak Nuclear Society - Slovenská nukleárna spoločnosť (SNUS) are highly involved in the preservation of the nuclear knowledge and other activities in the nuclear human resource area in Slovakia.

3.25 Slovenia

The process of restructuring the education programmes at universities and faculties according to the Bologna system is being gradually completed at all three public universities (University of Ljubljana, established in 1919, University of Maribor, established in 1975, and University of Primorska, established in 2003) and at the private university of Nova Gorica (established in 1995). New programmes under the Bologna process have been developed also for nuclear engineering.

Educational efforts of Slovenian universities and institutes are closely connected with European ENEN (European Nuclear Education Network) activities. Both the Jožef Stefan Institute and the University of Ljubljana are founding and active members of the ENEN Association.

The Nuclear Society of Slovenia/Društvo Jedrskih Strokovnjakov Slovenije is highly involved in the dissemination of knowledge in the nuclear field.

Masters studies

University of Maribor - Univerza v Mariboru

- Nuclear energy
- Nuclear power engineering

Doctoral thesis

University of Ljubljana - Univerza v Ljubljani

- Mathematics and Physics with a specialization in the nuclear field, the Nuclear Physics Module

Courses

Technical High School in Krško

- basic knowledge of nuclear engineering for mechanical and electrical engineers

Nuclear Training Centre

- Training courses for future Krško nuclear power plant operators

Nuclear Training Centre (ICJT) within the Jožef Stefan Institute

- Theory of Nuclear Technology is the initial training of future control room operators
- Basics of Nuclear Technology is intended for non-control room personnel of Krško NPP and for the staff of some other organizations
- Specific courses mainly for the regulatory body and for the NPP

For training in radiological protection, two institutions are authorized in Slovenia: the *Nuclear Training Centre (ICJT)* and the *Institute for Occupational Safety*. About 20-25 courses yearly are organized for people from medicine, industry and science about open, closed and industrial sources of ionizing radiation, including the training of Krško NPP personnel in that area.

3.26 Spain

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

The Spanish Nuclear Industry Forum has a wide experience in programmes dedicated to the secondary schools (courses, round table, congress, etc.) and also in preparing educational material, for teachers and students, on issues related to energy, including nuclear energy, ionising radiation and radiological protection:

- Webpage about energy and environmental for educational sector (Elementary, Middle and High School students and teachers), "Rincón Educativo". On this website you can find videos,

activities for the secondary school educational levels, courses, questions and answers, installations to visit, etc.

It includes also different didactic/educational materials about:

- Ionising radiation: "Despeja la X" for Elementary school and "@radiación" for Middle and High school,
- Energy: "ponte al Día en Energía". Also for both education levels you can find sheets with information about all types of energy, advantages and disadvantages of each ones, installations, photos, complementary information, etc.,
- Interactive Periodic Table of Chemical Elements, where you can compare different properties of the elements,
- Didactic units about Energy for Elementary school,
- Papers presented on the "National Congress about Energy and Society" over 29 years.

The materials are prepared by the Spanish "Training Committee on Energy and Education". This Committee was founded by Foro Nuclear 6 years ago and it is formed by teachers of different educational levels (Elementary, Middle and High, Teacher Training Centers, School of Education and University) and the Spanish Nuclear Foro staff.

In 2011 the material about ionising radiation for Middle and High School was prepared. In 2010 the same material for Elementary School was written.

Several associations are working to improve the education in the nuclear field: the Nuclear Forum - Foro Nuclear, Sociedad Nuclear Española, Plataforma Tecnológica de Energía Nuclear de Fisión (CEIDEN) , the Spanish Society for Nuclear Medicine - Sociedad Española De Medicina Nuclear, and Asociación Española de la Industria Eléctrica (UNESA) which had been established as a negotiation forum between all the participants in the nuclear activities.

Masters studies

Independent University of Madrid - Universidad Autónoma de Madrid in collaboration with the Research Centre for Energy, Environment and Technology - Centro de Investigaciones Energéticas Medio Ambientales y Tecnológicas (CIEMAT)

- Nuclear Engineering and Applications

Carlos III University of Madrid - Universidad Carlos III de Madrid, Complutense University of Madrid - Universidad Complutense de Madrid, and the Polytechnic University of Madrid - Universidad Politécnica de Madrid are partners in the European Master's degree in Nuclear Fusion Science and Engineering Physics (Erasmus Mundus)

Polytechnic University of Madrid/Universidad Politécnica de Madrid

- Nuclear Science and Technology
- Technologies of Electrical Energy Generation with a Specialization Course in Technologies of Nuclear Generation (in collaboration with *Tecnatom*)

University of Huelva - Universidad de Huelva

- Nuclear Technology and Instrumentation

Polytechnic University of Catalonia - Universidad Politécnica de Cataluña

- Synchrotron Radiation and Particle Accelerators
- Inter-university Master's degree in Energy Engineering with a Nuclear Specialization

Doctoral thesis

Carlos III University of Madrid - Universidad Carlos III de Madrid

- Plasma Physics and Nuclear Fusion

Polytechnical University of Catalunya - Universidad Politécnica de Cataluña

- Nuclear and Ionizing Radiations Engineering

University of Castilla La Mancha - Universidad de Castilla La Mancha

- Lasers and Advanced Spectroscopy in Chemistry

Polytechnic University of Madrid/Universidad Politécnica de Madrid

- Science and Nuclear Technology
- Fusion Nuclear Institute

Courses

The Nuclear Forum/Foro Nuclear in the Training Department of *Tecnatom* provides training for teachers and media professionals.

Demand of nuclear experts

A study "Training Capabilities Analysis of the Spanish Nuclear Industry" was carried out by CEIDEN (Plataforma Tecnológica de Energía Nuclear de Fisión), with an objective of creating a catalogue of

training capabilities in the Spanish nuclear industry as well as identify potential weaknesses and strengths of those.

The results of the analysis are in the report:

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/training_capabilities_analysis_of_the_spanish_nuclear_industry.pdf

3.27 Sweden

Masters studies

Chalmers University

- Nuclear engineering

KTH Royal Institute of Technology - Kungliga Tekniska Högskolan Universitet

- Nuclear energy engineering

Doctoral thesis

KTH Royal Institute of Technology - Kungliga Tekniska Högskolan Universitet

Uppsala University - Uppsala Universitet

- Nuclear and Particle Physics

3.28 United Kingdom

Initiatives and activities to attract more students to study Science, Technology, Engineering and Mathematics:

Nuclear Skills Academy:

The Skills Academy has developed an interactive game aimed at secondary school and college students to provide an interactive look at the Energy Mix needed to power the UK.

STEMNET:

STEMNET creates opportunities to inspire young people in Science, Technology, Engineering and Mathematics (STEM).

STEMNET purpose: to be a recognised leader in enabling all young people to achieve their potential in STEM by:

- Ensuring that all young people, regardless of background, are encouraged to understand the excitement and importance of science, technology, engineering and mathematics in their lives, and the career opportunities to which the STEM subjects can lead;
- Helping all schools and colleges across the UK understand the range of STEM Enhancement & Enrichment opportunities available to them and the benefits these can bring to everyone involved;
- Encouraging businesses, organisations and individuals wanting to support young people in STEM to target their efforts and resources in a way that will deliver the best results for them and young people.

The most important associations involved in the nuclear education are the National Skills Academy and the Nuclear Industry Association.

University of Central Lancashire (UCLan⁸³):

UCLan Nuclear provides regulatory and operational know-how in academia, consisting of Masters-levels courses for those looking to join the nuclear industry and for those in the nuclear industry looking to extend their competence. The courses are a product of the nuclear industry and regulatory expertise available through staff at UCLan Nuclear.

The list of courses available:

- Nuclear Safety, Security and Safeguards
 - MSc
 - PG Diploma
 - PG Certificate in Nuclear Safety
 - PG Certificate in Nuclear Security and Safeguards
- Nuclear Safety Case
 - MSc in Nuclear Safety
 - PG Diploma in Nuclear Safety
 - PG Certificate in Safety Case Authorship

⁸³ <http://www.uclan.ac.uk/>

- Nuclear Law
 - PG Certificate in Nuclear Law and Regulation
- Training and CPD
 - A range of industry-focused training and CPD courses is also available:
 - Engineering Substantiation
 - Fissile Materials
 - NTEC N02 Nuclear Fuel Cycle
 - NTEC N04 Decommissioning, Waste and Environmental Management
 - NTEC N21 Geological Disposal of Radioactive Waste
 - NSAN Certificate of Nuclear Professionalism

Bachelor studies

Imperial College London

University of Leeds

University of Liverpool

Lancaster University

Masters studies

University of Birmingham

- Physics and Technology of Nuclear Reactors

University of Leeds

- Chemical and Nuclear Engineering

University of Liverpool

- Nuclear Science and Technology

University of Sheffield

- Nuclear Environmental Science and Technology

- Nuclear Science and Technology

City University London

- Nuclear Medicine

University of Cambridge

- Nuclear Energy

Nuclear Technology Education Consortium

- distance learning degree in Nuclear Science and Technology

Doctoral thesis

University of Liverpool

- Nuclear Physics

University of Manchester

- Nuclear Engineering

University of Sheffield

- Nuclear Engineering

Courses

United Kingdom Atomic Energy Authority has a number of training courses, among which are

- Successful Nuclear Safety Case Production
- Radiological HAZAN Production

Demand of nuclear experts

It has been several decades since there was a major nuclear construction programme in the UK and important specialist skills needed for building new nuclear plants have been lost in the generation gap, according to the report "Building Britain's nuclear future - will the UK construction industry deliver?", compiled by law firm Berwin Leighton Paisner (BLP) and supported by the UK's Nuclear Industry Association. The report says that the industry needs to invest not only to fill this gap, but also to ensure there are sufficient resources to withstand the poaching of UK skills by those economies that want to fill their skills gap quickly and are able to pay to do it.

Among the report's key findings are:

- The UK has the civil engineering skills to deliver 70 per cent of a nuclear plant, but vital specialist skills have been lost because of the generation gap since the UK's last nuclear programme.
- There is a shortage of home grown "major programme management skills" in the UK, with foreign consortia now delivering the biggest projects.
- Regulators must not "move the goalposts" once the framework to construct the new power stations has been agreed.
- Contracts will have to spread risks between parties – both domestic and international – to prevent investors in nuclear new build from being deterred from participation.

There are plans or proposals to build 10 new nuclear power plants in the UK and the report notes that there is little or no reason for concern about the readiness of British civil engineering and construction. Furthermore, "(t)here will be time to learn from foreign expertise, and to develop skills which UK businesses can later export to other countries".

Cogent is the Sector Skills Council for chemicals, pharmaceuticals, nuclear, oil and gas, polymer and petroleum businesses. It has a key role in meeting the skills needs of emerging technologies.

Cogent – SSC regularly publishes reports on nuclear skills and the needs of the UK nuclear industry.

UK Nuclear Education, Skills & Training Directory

The UK has developed a UK Nuclear Education, Skills & Training Directory, which is the first listing of UK institutions that provide the specialist education and training required by the nuclear industry. Education and training is carried out with full regard to the UK's international non-proliferation obligations. The directory can be found here:

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/uk_international_directory_nuclear.pdf

Capability Report

The study "Capability Report" – published in December 2012 – had an objective to assess the capability and capacity of UK industry to deliver a programme of new nuclear power stations in the UK over the next 15 to 20 years while continuing to support the existing, operating UK nuclear stations and to execute the UK Nuclear Decommissioning Authority's decommissioning programme.

The report is intended to inform of the current situation and to indicate where action should be taken to strengthen the UK nuclear supply chain and to enhance the prospects for successful delivery of the nuclear new build programme.

The report:

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/nia_capability_2012_small.pdf

Next Generation – Skills for New Build Nuclear

This report was produced in response to the request of the Nuclear Development Forum, as facilitated by the Office for Nuclear Development. The objective was to research skills capacity, capability and timeline to secure a new build nuclear programme up to 2025.

The report:

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/next_generation_skills_for_new_build_nuclear.pdf

UK Nuclear Industry HR Challenges: Knowledge Retention and Transfer

This dissertation was prepared by Olga Zavatskaya, a student of Human Resource Management at the University of Strathclyde.

The aim of this dissertation was to look at the HR challenges that the UK nuclear industry is currently facing and to analyse in depth one of them – knowledge retention and transfer¹ (KRT).

The full text can be found here:

http://ehron.jrc.ec.europa.eu/sites/ehron/files/documents/public/current_dissertation_last_edition_olga.pdf

4. Initiatives at international level

Addressing the challenges in the area of nuclear knowledge management identified by the **IAEA** General Conference in 2006, the IAEA is implementing a special sub-programme on Nuclear Knowledge Management which focuses on developing methodologies and guidance documents for NKM, facilitating nuclear education, training and information exchange and assisting Member States in maintaining and preserving nuclear knowledge. They have several projects in the NKM area:

- Cyber Learning Platform (CLP4NET) – to help MSs to ensure high standards for nuclear E&T and establishing a framework for e-learning capacity through information technology in web based education
- The IAEA Schools:
 - Nuclear Energy Management for young professionals – 2-3 weeks

- Nuclear Knowledge Management for young professionals – 1-2 weeks
- Networking nuclear education – regional and interregional cooperation: ANENT (Asia), AFRA-NEST (Africa) and LANENT (Latin America)
- Materials and publications

A decade after publishing "Nuclear Education and Training: Cause for Concern?" (2010) and the follow-up report "Nuclear Competence Building" (2004) the **OECD/NEA** assesses the current state of nuclear education and training for the development of nuclear skills, the remaining gaps and the actions that are now required to address corresponding development need across NEA member countries. The report presents 12 recommendations to Governments, industry, universities and R&D organisations to avert the risk of human resource shortages and to maintain the stock of skilled and competent workers.

The **World Nuclear University (WNU)** is a global partnership committed to enhancing international education and leaderships in the peaceful applications of nuclear science and technology. WNU activities are organised and led by the London-based WNU Coordinating Centre (WNUCC), which is supported administratively by the **World Nuclear Association (WNA)**. The programmes are intended to complement the work of existing institutions of nuclear learning by filling unmet educational and training needs on the international level. As of December 2012, 3,500 nuclear professionals and students from over 60 countries have participated in such programmes.

The **International School of Nuclear Law (ISNL)**, established in 2001 by the OECD/NEA in cooperation with the University of Montpellier 1 and supported by the IAEA, has been designed to provide participants with a comprehensive understanding of the various interrelated legal issues relating to the safe, efficient and secure use of nuclear energy. To date, the ISNL has provided a unique educational opportunity to more than 600 graduate students and professionals from around the world.

European Nuclear Society (ENS) is the largest nuclear society for science and industry. In 2011 ENS established an Education, Training and Career Platform provides an overview of available university courses, as well as the training and education programs offered by industry and other institutions. The E&T Platform places special emphasis on collaboration with Young Generation Network, to develop the platform after the needs of young professionals, who start their career in nuclear sector and have to gain additional skills to work in this field. Moreover ENS is organizing two conferences dedicated to education and training issues, one in radiation protection and the second across the fields of engineering, science and technology.

FORATOM is the Brussels-based trade association for the nuclear energy industry in Europe. Its main purpose is to promote the use of nuclear energy by representing the interests of this important and multi-faceted industrial sector. Foratom acts as the voice of the industry in energy policy discussions involving the EU institutions and provide a "bridge" between the industry and the institutions. In 2010 FORATOM established together with ENS a joint Education, Training and Knowledge Management Task Force to provide a platform for discussion and exchange needs and best examples between industry and research/academics institutes on nuclear education and training.

The European Nuclear Safety Training and Tutoring Institute (ENSTTI) was established in 2010 as an initiative of the European Technical Safety Organizations Network-ETSON. ENSTTI is a center specialized in meeting the growing need for highly qualified personnel with adequate knowledge and skills in nuclear safety and security at nuclear regulatory authorities and technical safety organizations. The institute provides vocational training and tutoring in methods and practices required to perform assessments in nuclear safety, nuclear security and radiation protection calling merely on senior experts from European TSOs for its implementation. In addition to training, ENSTTI offers tutoring for duration ranging from weeks to months inside operational units of its TSOs' Members. ENSTTI is involved in several training activities supported by The European Commission or the IAEA, to share and transfer the European TSOs knowledge and know-how to the global nuclear safety and security communities Since 2013, ENSTTI is also coordinating the development of a harmonized Basic Training Scheme for new entrants at NRAs and TSOs under the umbrella of the EC project for "Sharing & Growing Nuclear Safety Competences" (NUSHARE project).