



European Nuclear Society - Higher Scientific Council

Expert Analysis - NUCLEAR EDUCATION, TRAINING AND KNOWLEDGE MANAGEMENT IN EUROPE

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Introduction

The situation in the nuclear education today is complex as it relates to nuclear technology for both peaceful and security applications. After more than 20 years period of depression in nuclear facility construction (significant mainly in Europe and USA), there is strong renewed interest in nuclear-generated electricity. Many factors have contributed to “nuclear renaissance” including concerns about possible climate changes due to carbon emissions.

The Nuclear Energy Agency (OECD/NEA) study in 2000, “Nuclear Education and Training....Cause for Concern” [1], highlighted the necessity for a renaissance in nuclear education and training and recommended the following:

- We must act now
- Strategic Role of Governments
- The Challenges of revitalising nuclear education
- Vigorous research and maintaining high quality training
- Benefits of Collaboration and Sharing Best Practices

The world has responded. From the Americas to Europe to Asia networks have been established to respond to the necessity to maintain and perpetuate nuclear knowledge in order to provide a suitably qualified workforce for the future operation of nuclear power plants [2]. Nevertheless, the European Nuclear Energy Forum created in 2007 by European Commission identified the nuclear education as one of highest risks in nuclear industry. The nuclear renaissance depends on the increased number of engineers properly educated in wide spectrum of nuclear disciplines.

The European Nuclear Society (ENS) also responded by launching the NEST^{et} conference (Budapest, May 2008 [3]) that has been designed to facilitate the exchange of information, collaboration and the sharing of best practices in nuclear education and training in engineering science and technology as well as knowledge management in this energy sector.

The NEST^{et} conference complements the American Nuclear Society (ANS) Conference on Nuclear Training and Education (CONTE) which was held in Florida in February 2007. The European Commission/EURATOM, the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA) and the Joint Research Centre (JRC) have clearly recognised risks from missing nuclear knowledge, but conclusions and recommendations from conferences and discussion have to be implemented into the national education programs running at the universities or in trainings centres.

The quality in Education, Training and Knowledge Management (ETKM) is strongly influenced and supported by development of nuclear research, exploitation of experimental and training facilities, existence of proper education and training networks, software tools, distance and e-learning and a variety of knowledge management activities. Nuclear knowledge is required in many areas as: nuclear engineering, nuclear technology, nuclear medicine, radiological protection or waste management. The wide international collaboration in all mentioned areas is encouraged, but the basic knowledge has to be created on national level. New national and regional academic networks have been recently developed in the Americas, Asia and Europe to meet workforce requirements.

The projected global annual requirements for new nuclear engineers over the next 10 years will challenge existing academic and training institutions with respect to capacity and load factors on classrooms, laboratories and other facilities such as basic principles simulators. Additionally, the nuclear academic workforce may need to increase to meet the demand for educating/training the new industrial workforce and this will take time.

Within the European context many of the programmes will continue through private and public funding as well as private-public partnerships. The continued development of a common qualification approach, mutual recognition of institutions across Europe, increased mobility of staff and students and the creation of strategic partnerships will help to develop a well skilled and mobile workforce to support the nuclear energy renaissance.

The European Context

Within the European context, the development of the infrastructure to address nuclear ETKM has to date been largely driven by the European Commission/DG RTD Energy/Euratom and a comprehensive overview of the European actions to address nuclear related ETKM activities was given by Georges Van Goethem at NEST^{et} 2008 [3]. Within the scope of an ENS Position Paper it is appropriate to review these activities.

The Euratom Treaty (Rome, 1957) clearly recognized the importance and necessity for training and research to promote the field of nuclear energy, as given in the excerpts given below.

- Under "Provisions for the encouragement of progress in the field of nuclear energy"
CHAPTER 1 / PROMOTION OF RESEARCH / Article 4
1. The Commission shall be responsible for promoting and facilitating nuclear research in the Member States and for complementing it by carrying out a Community research and training programme.
- Under "Provisions for the initial application of this Treaty" /Article 215

1. An initial research and training programme, which is set out in Annex V to this Treaty and the cost of which shall not ...exceed ... units of account, shall be carried out within five years of the entry into force of this Treaty.

Some 50+ years on and these aspects of the treaty are as important in order to support the renaissance. However, a more integrated model has now developed as illustrated in Figure 1.

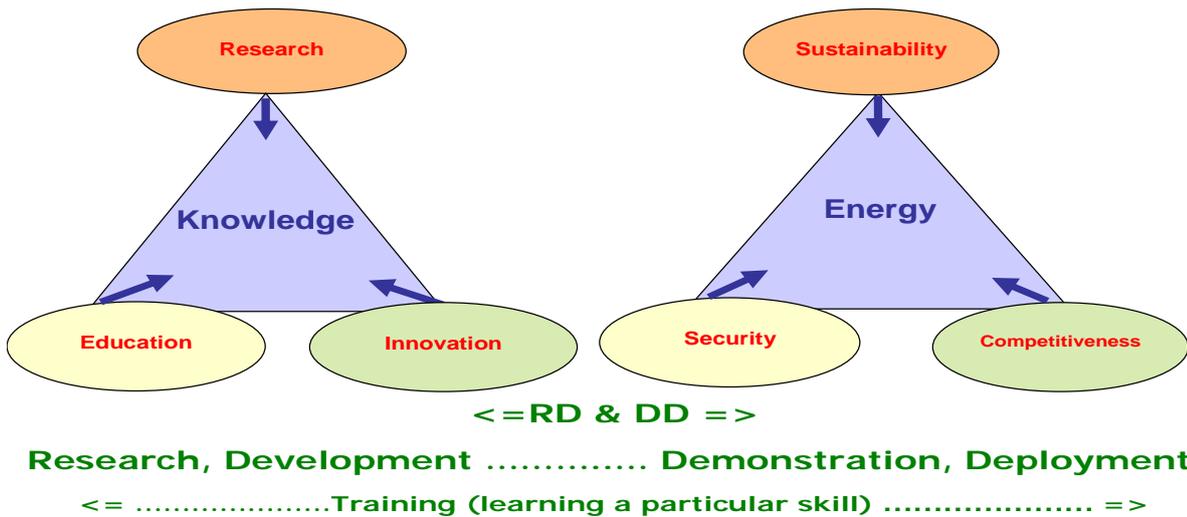


Figure 1: "Knowledge Triangle" (research & development) and "Energy Triangle" (demonstration & deployment) (G. Van Goethem [3])

The European Commission have been mindful of the integrated model illustrated above so that all key stakeholder requirements are addressed and Euratom's E&T objectives therefore focused on the following aims:

- MODULAR COURSES AND COMMON QUALIFICATION APPROACH (offer a coherent E&T framework and ensure top-quality for each module)
- ONE MUTUAL RECOGNITION SYSTEM ACROSS THE EUROPEAN UNION (e.g. European Credit Transfer and accumulation System of ERASMUS /ECTS)
- MOBILITY FOR TEACHERS AND STUDENTS ACROSS THE EU (prepare the "internal market" for free circulation of nuclear experts)
- FEEDBACK FROM "STAKEHOLDERS", BOTH SCIENTIFIC AND FINANCIAL (involve the "future employers" in the process).

An early success from this Euratom initiative was the creation of the European Nuclear Education Network (ENEN) association as a legal entity under the French Law of 1901.

Today the ENEN association is a well integrated mature pan European organization with over 40 members, as illustrated in Figure 2, delivering the objectives set out my Euratom and more details on ENEN can be found at Reference [4].

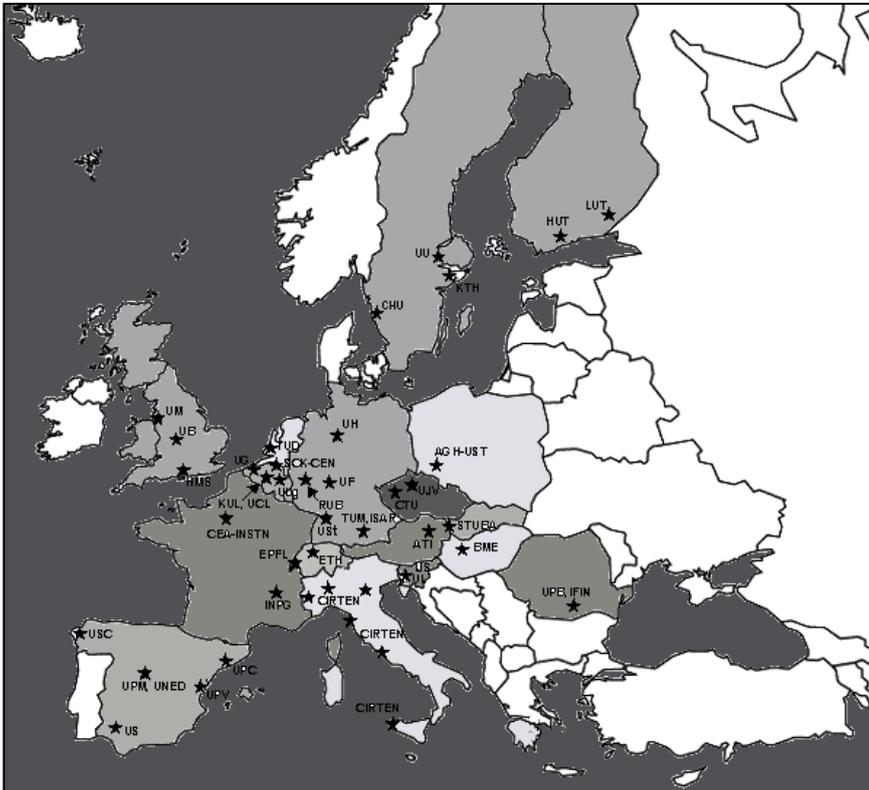


Figure 2: ENEN Association Members

In addition to ENEN, the European Network for Education and Training in Radiological Protection (ENETRAP) [5] has been developed and many EU member states have created networks of their own and a summary of these is given in Table 1. Other educational activities dealing with radioactive waste management, radioecology and radiobiology are also supported within the Euratom Framework programmes (CETRAD, EURAC, MSCRB etc) and again more details can be found in Reference [3]. As a result of these activities, many revitalised and new courses have been established, European Credit Transfer Schemes (ECTS) have been employed, student and staff mobility has been resourced and mutual recognition is apparent across the European Union. In many cases these activities have been funded by public bodies but greater emphasis is now needed on public-private partnerships in order to provide the capacity to meet the demands for the nuclear workforce for the future. New academics will also be required to meet the demands for the future and this requirement needs immediate action.

Recent activity in this area has been the transfer of senior scientists and engineers from industry into academia.

Table 1: Nuclear Education Networks in Europe	
➤	NTEC ¹ (<i>Nuclear Technology Education Consortium</i> of 11 establishments – coordinated by the Dalton Nuclear Institute in the UK (of particular interest is also the UK initiative " <i>Keeping the Nuclear Option Open</i> " ²)
➤	Kompetenzverbund Kerntechnik ³ (<i>Alliance for Nuclear Competence</i> , under BMWi) in Germany
➤	INSTN ⁴ (<i>Institut National des Sciences et Techniques Nucléaires</i>), as a part of CEA, INSTN is a higher education institution under the joint supervision of the Ministries in charge of Education and Industry in France
➤	BNEN ⁵ (<i>Belgian Nuclear Education Network</i> , hosted at SCK-CEN Mol), cosponsored by the national nuclear industry, containing all six “nuclear” universities of Belgium
➤	CIRTEN ⁶ (" <i>Consorzio Interuniversitario per la Ricerca Tecnologica sull' Energia Nucleare</i> ") in Italy
➤	REFIN ⁷ (<i>Romanian Nuclear Education Network – "Retea Educationala in Fizica si Ingineria Nucleara"</i>)
➤	FINNEN ⁸ (<i>Finnish Nuclear Education Network</i> , Helsinki University of Technology /TKK/)
➤	NKS ⁹ (<i>Nordic Nuclear Safety Research = Denmark, Finland, Iceland, Norway and Sweden</i>)
➤	CENEN (<i>Czech Nuclear Education Network</i>)
➤	KINT (<i>Dutch Knowledge Infrastructure on Nuclear Technology</i>).
➤	CHERNE (<i>network for cooperation in Higher Education on Radiological and Nuclear Engineering</i>)

¹ <http://www.ntec.ac.uk/>

² www.wun.ac.uk/nuclearsci/research_themes/pubpolicy/pdfs/KNOO.pdf

³ http://www.grs.de/products/data/3/pe_460_20_1_pe_434_20_1_kv03endg.pdf

⁴ <http://www-instn.cea.fr/>

⁵ <http://www.sckcen.be/bnen/courses.html>

⁶ <http://www.cirten.it/>

⁷ <http://www.refin.pub.ro/>

⁸ <http://www.tkk.fi/fi/>

⁹ http://www.nks.org/english/About_NKS/About_NKS.htm

With reference to Figure 1, an important part of the knowledge integration is research and training. Within the European context there have been significant activities in these areas, examples of which are given in Table 2.

Table 2: Research/Training Programmes
PERFECT¹⁰ : resources are assigned for training in advanced numerical simulation tools for irradiation damage. The proposed numerical tools allow students to perform “virtual irradiations” on “virtual reactors”, with the aim to analyse the resulting evolution of mechanical properties and microstructure.
SARNET¹¹ : an education and training programme is foreseen directed at young scientists. The aim is to consolidate European excellence in the long-term in the areas of experimental and numerical simulation as well as in level 2 probabilistic safety assessment methods and in mitigation techniques related to severe accident management.
RAPHAEL¹² : a number of major industrial issues are discussed in connection with future industrial needs and energy policies (e.g. high temperature heat and electricity supply, natural resource preservation). Special attention is paid to education in innovative nuclear hydrogen production technologies and in communication.
EUROTRANS¹³ : there are 17 universities, represented by the ENEN Association. At least 5% of the budget is assigned to PhD students, with additional funding reserved for E&T (detailed course programme in www.enen-assoc.org). It is also worth mentioning the launch of a doctoral school on E&T by the ENEN association in this EUROTRANS project.
ESDRED¹⁴ : (“Engineering Studies and Demonstration of Repository Designs”), the partners (waste management agencies and technological R&D organisations) organise training sessions of broad interest. One of their general aims is to fabricate and test prototypes of technologies for deep geological disposal of high level radioactive waste (such as spent fuel or vitrified waste), for backfilling and for sealing disposal cells or drifts.
RISC-RAD¹⁵ : (“Radiosensitivity of Individuals and Susceptibility to Cancer induced by ionizing RADiations”), there are courses on “quantitative radiation risk modelling” and on “ethics in biological experiments”.
EURANOS¹⁶ : (“EUROpean Approach to Nuclear and radiOlogical emergency management and rehabilitation Strategies”), training is organised in connection with “real time on-line decision support (RODOS)” for emergency management and rehabilitation strategies.

¹⁰ <https://www.FP-6perfect.net/site/index.htm>

¹¹ <http://www.sar-net.org/>

¹² <http://www.raphael-project.org/index.html>

¹³ <http://nuklear-server.ka.fzk.de/eurotrans/>

¹⁴ <http://www.esdred.info/>

¹⁵ see <http://www.riscrad.org/>

¹⁶ <http://www.euranos.fzk.de>

Some activities are embedded in large infrastructure programmes and a selection of those proposed for the Framework 7 programme are given in Table 3.

Table 3: Embedded Programmes Covering Research/Training	
1 - ACSEPT / Actinide reCycling by SEPARation and Transmutation:	The overall goal is to advance the European integration in the fields of separation techniques, and actinide chemistry. Strong links will be established with the direct or derived actions of the FP-6 Network of Excellence ACTINET.
2 - GETMAT / Gen IV and Transmutation MATerials:	The overall goal is to motivate a new generation of material scientists to study and deepen the open challenges in the materials science for nuclear applications. In addition workshops in collaboration with OECD/NEA and IAEA will be organized.
3 - CARBOWASTE / Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste:	The overall goal is to develop the scientific competence and human capacity that will guarantee the availability of suitably qualified researchers, engineers and employees in this specific field of legacy waste management.
4 - F-BRIDGE / Basic Research for Innovative Fuel Design for GEN IV:	The overall goal is to share the modelling and experimental methodologies in fuel materials sciences that will be developed during the project. The project will organise two summer schools demonstrating to young scientists and engineers how basic research in material science can contribute to the understanding of fuel behaviour under irradiation and to the selection and development of advanced fuels.
5 - SEDENTEXCT - Safety and Efficacy of a New and Emerging Dental X-ray Modality:	The aim is the acquisition of key information for sound & scientifically based clinical use of Cone Beam Computed Tomography (CBCT) & to use them to develop guidelines dealing with justification, optimisation & referral criteria and to conduct dissemination and training for users of CBCT.
6 - MADEIRA - Minimizing Activity and Dose with Enhanced Image quality by Radiopharmaceutical Administration:	The goal is to improve 3D nuclear medicine and molecular imaging technologies and with this the quality of the diagnostic information obtained & to reduce the amount of radioactive material to be administered.
7 - ORAMED - Optimization of Radiation Protection of Medical Staff:	The goal is to improve standards of protection for medical staff for procedures resulting in potentially high exposures and to develop methodologies for better assessing and reducing exposures to medical staff in interventional radiology (IR).

In addition, under Framework 7, ENEN-III has been funded to develop Euratom Fission Training Schemes (EFTS). Members of the ENEN Association will work on a selected number of nuclear sector skills profiles, develop training profiles and establish pilot schemes whereby the concept of a *Passport for Continuous Professional Development* may be created to meet industry requirements.

A review of the European context for ETKM would not be complete without considering the framework in which it will sit for the future. This framework exists at the higher level within *European Strategic Energy Technology Plan* (SET plan)¹⁷ and specifically with respect to the nuclear option, in the *Sustainable Nuclear Energy Technology Platform* (SNE-TP)¹⁸ with a detailed Strategic Research Agenda (SRA) addressing Generation II, III and IV

¹⁷ http://ec.europa.eu/energy/energy_policy/doc/19_strategic_energy_technolgy_plan_en.pdf

¹⁸ www.snetp.eu

reactor systems. The SRA will be supported by cross-cutting activities in the deployment strategy and education, training and knowledge management areas. In parallel other initiatives that will influence the context for ETKM are the *European Nuclear Energy Forum* (ENEF¹⁹) and the *High Level Group* (HLG). Amongst other activities, ENEF will consider on-line sources for nuclear education, possibly a schools curriculum for basic nuclear technology understanding and the concept for creating a European *nuclear observatory*. The HLG is composed primarily of senior officials from national nuclear regulatory or nuclear safety authorities. It will be important for ETKM providers to address future developments by this group in order to support a common integrated approach to nuclear safety culture.

Endorsement of ETKM activities within the European Union is of the utmost importance and this has been given by the Council of the European Union in their Conclusions on the Need for Skills in the Nuclear Field [6]. Of particular note is the importance the Council places on an integrated nuclear skills framework within Europe as given in the quote from [6] below.

*In particular, THE COUNCIL INSISTS that the appropriate conditions must be created for mutual recognition of nuclear professional qualifications throughout the European Union; ENCOURAGES the Member States and the Commission to establish a "review of professional qualifications and skills" in the nuclear field for the European Union, which would give an overall picture of the current situation and enable appropriate solutions to be identified and implemented. Such a review could pave the way for drawing up a pan-European **chart of skills and knowledge** relating to occupations in the nuclear field; acceptance of this could lead to the production of a **European handbook of skills, experience and professional qualifications**, which would facilitate the mobility of employees within the EU.*

Other influential organizations that are contributing significantly to the ETKM area are the Nuclear Energy Agency (OECD/NEA) and Joint Research Centre (JRC) and most importantly, the International Atomic Energy Agency (IAEA). A quote from the IAEA is therefore appropriate.

"As the nuclear workforce ages and retires, and support decreases for university programmes in nuclear science and engineering, knowledge management is becoming critical to ensuring safety and security, encouraging innovation, and making certain that the benefits of nuclear energy - related to human health, food and agriculture, water management, electricity supply, and a host of other applications - remain available for future generations."

Mr. M. El Baradei, Director General of the IAEA, 2000

The Present Position

Within nine years of the OECD/NEA report, *Nuclear Education and Training..... cause for concern*, an enormous amount of activity has been undertaken in the area of ETKM as

¹⁹ http://ec.europa.eu/energy/nuclear/forum/index_en.htm

summerised above. It may seem as though nuclear ETKM is in its renaissance period but we must not be complacent. Indications are that the “cliff edge” of nuclear workforce

retirements is drawing ever closer and when this impact is taken together with the growth needed in the workforce to meet the global demand for nuclear power, the challenges facing the ETKM sector remain, but at least we are heading in the right direction. While this paper has focused on the European context, there are international ETKM developments under progress by Euratom and the IAEA in all global sectors.

References

- [1] Nuclear Education and Training....Cause for Concern, OECD study, 2000
- [2] Nuclear Human's Element, American Nuclear Society Report, 2007
- [3] Proceedings from ENS conference NESTet, 2008
- [4] ENEN Association (www.enen-assoc.org)
- [5] ENETRAP (www.sckcen.be/enetrapp/)
- [6] Skills in the Nuclear Field, EU Council, 2 December 2008, st 15406.