united nations
educational, scientific
and cultural
organization

international atomic
energy agency

the
abdus salam
international centre for theoretical physics

40th anniversary 1964 2004

SMR.1589 - 7

# Workshop on Managing Nuclear Knowledge

## 8 - 12 November 2004

---

# The European Nuclear Education Network Association

**- ENEN -**

**Peter DE REGGE**
**Studiocentrum voor Kernenergie**
**SCKCEN**
**Boeretang 200**
**B. Mol 2400**
**BELGIUM**

---

# THE EUROPEAN NUCLEAR EDUCATION NETWORK ASSOCIATION - ENEN -

**P. P. DE REGGE (***on behalf of ENEN*)

*Contribution to the IAEA Workshop on Managing Nuclear Knowledge, 8-12 November 2004, held at the ABDUS SALAM International Centre for Theoretical Physics, Trieste, Italy*

## 1. INTRODUCTION AND HISTORICAL BACKGROUND

The Lisbon 2000 summit proposed the strategic goal for the European Union to become the most competitive knowledge-based economy with more and better employment and social cohesion by 2010. This goal was well accepted by the main stakeholders in Europe, and in particular also by the nuclear community. The main stakeholders of this community are the suppliers and users of nuclear knowledge, respectively research organisations, the universities, the academia and the manufacturing industry on the one hand and on the other hand the utilities, the users of nuclear applications, the waste management organisations and the regulatory bodies.

Currently the production of nuclear knowledge in the European Union is fragmented and concentrated in a variety of research poles still aiming at national needs rather than community needs and receiving operational feedback essentially from within the country. There is not yet a clear common strategy how to integrate these fragments on the long term. The same situation applies to the dissemination, transfer and preservation of nuclear knowledge with a dramatic situation in several European countries. Due to lack of information on nuclear energy and disinformation on alternative energy sources, the public opinion is unsupportive towards nuclear energy and is followed by decision makers and politicians. The impact on young generations on the verge of deciding about their studies and careers leads to a shortage of students interested in nuclear disciplines, soon followed by a lack of teachers and the closing down of nuclear faculties, preventing access to nuclear education for the few that would still be interested. For the exploitation of nuclear knowledge there is an unbalance between the supply and the demand, and the impact of nuclear research on technological and societal changes is rather poor. Important developments in reactor safety are not reflected in a uniform European approach to safety issues, putting emerging new nuclear projects at a high commercial risk as a result from the lack of an objective, consistent and predictable environment in a deregulated market. Greater harmonisation is needed in radiation protection standards, particularly for low dose effects. The same applies to practices for waste management and disposal strategies, where the national geological constraints dictate the waste management policies rather than looking for optimal solutions at the level of the European Union, which might enhance public acceptance.

European Nuclear Education Network
Phone +33 1 69 08 35 33 Fax +33 1 69 08 99 50
sec.enen@cea.fr
p/a Institut National des Sciences et Techniques Nucléaires
Bldg 395, Centre CEA de Saclay, F-91191 Gif-sur-Yvette Cedex, France
peter.de.regge@sckcen.be
http://www.enen-assoc.org

Responding also to criticism that EC funding and efforts were too much devoted to fragmented knowledge production and not enough to knowledge dissemination, knowledge transfer and knowledge exploitation, the EC directed the fifth and sixth framework programme to a better knowledge management strategy in the context of a European Research Area with a stronger emphasis on the coupling of knowledge production, dissemination and exploitation.

A common durable knowledge base is now under construction as the foundation of the nuclear knowledge market. The approach relies on a full integration of EU nuclear research on the basis of the existence of common needs, the development of a common vision and strategy, and the availability of common instruments. This approach automatically calls for large integrated projects with many partners and the development of networks[1].

## 2. INCENTIVES FOR NUCLEAR KNOWLEDGE MANAGEMENT

As it has been widely recognised, nuclear science and research is not anymore at the top of the agenda in the society nowadays. In addition, many of the highly competent engineers and scientists, whose efforts created and developed the present contribution of the nuclear industry and the nuclear applications in many fields and disciplines to the benefit of this society, are approaching the retirement age[2]. The same applies to the staff of the regulatory structures.

However, nuclear energy and applications still play a very relevant role in satisfying the present society needs and, independently of the current social perceptions and political decisions, it will continue to play an unavoidable role in the next future: existing plants provide more than 30 % of Europe' s electricity and will operate for some decades more; reprocessing will continue; decommissioning of older plants will last until the second half of the century; waste management will be around at least until towards the end of the century. All of these facilities need to be managed safely, demanding high quality, technically competent personnel with specific nuclear expertise and skills for staffing the Licensees organisations, the Supporting companies and the Regulatory bodies. In addition, radiation protection specialists will be required[3].

Deregulation of the markets adds some more elements to the discussion that can be summarized as follows: an increasing pressure to reduce costs and a lack of long term planning. The first element results in the impossibility to keep operating educational and training structures only for few students or trainees, the high rate of pre-retirements in the nuclear industry and the change of the required professional profiles also by the industry. The second one has as a consequence the multiplication of fragmented “last minute”, local initiatives to palliate problems “as they arise”, which makes any particular solution inefficient and, in some cases, only partially effective. This pessimistic picture, however, would correspond to a scenario of phasing out nuclear energy and nuclear applications in industry and medicine.

On the contrary, based upon environmental and economic considerations, and on efforts to curb down the global heating according to the Kyoto protocol, there are indications that nuclear energy programmes are being reactivated. New nuclear power plant projects have been started in Finland and France and public consultations and referenda in countries like Switzerland show a more favourable general opinion towards nuclear energy. The need for adequate conservation of nuclear

1 „Towards a common knowledge base for nuclear fission: a challenge for the stakeholders' community and for the EC", G. Van Goethem, European Commission, DG Research, Directorate J: Energy.

2 "Strategic issues related to a 6th Euratom Framework Programme (2002-2006)." Scientific and Technical Committee Euratom. Euratom. EUR 19150 EN.

3 HSE. Nuclear Education And Training Forum (UK, February 2001)

knowledge and the need for new generations of nuclear engineers and scientists are all the more stringent, as an apparent scarcity of professionals would hypothecate such developments and decisions.

The problem has been identified worldwide, although with different intrinsic timings and degrees of intensity. Several references can be found in the USA[4,5] and Canada[6,7] where, after quantifying the problem, initiatives have been put in place for integrating industry and university. International organisations like NEA[8] or IAEA[9,10] have issued several reports and studies on their member countries showing the problem, focusing on some aspects and making recommendations to the international community. So far, a specific European initiative going beyond generic recommendations is the ENEN[11] project, launched under the 5th Framework Programme with the main objective of producing a roadmap for the way ahead in nuclear engineering education in Europe and to validate the approach by organising pilot sessions.

## 3. FOUNDATION OF THE EUROPEAN NUCLEAR EDUCATION NETWORK – THE ENEN ASSOCIATION

The temporary network, established through the European 5th Framework Programme project ENEN, was given a more permanent character by the foundation of the European Nuclear Education Network Association, a non-profit-making association according to the French law of 1901, pursuing a pedagogic and scientific aim. The organisation has its legal registered office in the premises of INSTN on the site of CEA Saclay. Its Mission, objectives and structure were formulated in the Statutes, following the conclusions and recommendations of 5th FP ENEN Project, with as its main objective the preservation and the further development of higher nuclear education and expertise. This objective should be realized through the co-operation between the European universities, involved in education and research in the nuclear engineering field, the nuclear research centres and the nuclear industry.

To achieve this objective, the ENEN Association has to:

- Promote and further develop the collaboration in nuclear engineering education of engineers and researchers needed by the nuclear industry and the regulatory bodies;
- Ensure the quality of nuclear academic engineering education and training;
- Increase the attractiveness for engagement in the nuclear field for students and young academics.

The basic objectives of the ENEN Association shall be to:

- Deliver a European Master of Science Degree in Nuclear Engineering and promote PhD studies;
- Promote exchange of students and teachers participating in the frame of this network;
- Increase the number of students by providing incentives;
- Establish a framework for mutual recognition;

4 "Manpower Supply and Demand in the Nuclear Industry", (The Nuclear Engineering Department Heads Organization –NEDHO- 2000)

5 "The future of Nuclear Engineering Programs and University Research and training Reactors" (The Nuclear Energy Research Advisory Committee –NERAC/DOE-2000)

6 Candu Owners Group Report 00-204-I.

7 UNENE (University Network of Excellence in Nuclear Engineering )

8 "Nuclear Education and Training; Cause for concern?" (NEA, 1999)

9 "The Best and Brightest: Education and Training in Nuclear Fields" (IAEA Bulletin Vol 43/1, 2001)

10 IAEA World Survey on Nuclear Power Plant Personnel Training (IAEA-TECDOC-1063)

11 European Nuclear Engineering Network (www3.sckcen.be/enen/)

- Foster and strengthen the relationship with research laboratories and networks, industry and regulatory bodies, by involving them in nuclear academic education and by offering continuous training.

The ENEN association is managed by a Board of Directors, elected by the General Assembly and the work is organised through a Management Committee. The management committee will be constituted by the Secretary General, appointed by the Board of Directors, and the Chairmen of the five different working committees, which are dedicated to specific tasks in order to realise the dissemination and management of knowledge.

The strategy to be followed to achieve the aims of the ENEN Association includes:

- Discussion on educational objectives, methods and course contents among the members and with external partners, particularly national and European industries;
- Organisation of internal audits on the quality of nuclear engineering curricula;
- Awarding the label of "European Master of Science in Nuclear Engineering" to the curricula satisfying the criteria set up by the ENEN Association;
- Cooperation between the members, and with the research centres and the nuclear industry for enhancement of mobility of teachers and students, organisation of training and advanced courses, use of large research and teaching facilities or infrastructures;
- Cooperation with international and national governmental institutions, agencies and universities;
- Identification and development of solutions to specific problems and deficiencies which hinder the attainment of the aims of the Network;
- Facilitating the exchange of information between the Members of the ENEN Association - on course objectives, content, modes of presentation and other matters.

There are two types of Members in the ENEN Association, the Effective Members and the Associated Members. Effective and Associated Members are institutions or corporate bodies.

The Effective Members are academic institutions or clusters of such institutions having a legal status and meeting all following criteria:

- Provide high-level scientific education in the nuclear field -as full time teaching and providing the basis for doctorate studies- based on internationally recognized research in nuclear engineering and/or nuclear sciences, which is carried out jointly by the teaching staff, the students, and the doctoral and post-doctoral researchers in the same geographic location or in association with a nuclear research centre.
- Use selective admission criteria conforming to legal provisions and/or national practices.
- Be based in the European Union or in one of its candidate member countries.

The Associated Members are corporate bodies having a legal status, such as nuclear research centres, government institutions, nuclear companies, regulatory bodies, nuclear learning societies, who conform to the following criteria:

- commit themselves to support the ENEN Association;
- have a firmly established tradition of relations with some of the members in the fields of education, research and training;
- are based in the European Union or in one of its candidate member countries.

The activities of the ENEN Association are organised in five committees, which are described in the following paragraphs.

Teaching and Academic Affairs Committee

For each member of the ENEN association, this committee has to:
- Establish the equivalence between the curricula in nuclear engineering education and ECTS units.
- Approve the equivalence of admission criteria and define the mandatory courses depending upon the students' background.
- Provide guidance to the member institutions in order to "reach" the 300 ECTS level required.

This committee will establish a complete list of all the facilities used in affiliated institutions for their practical training. These facilities can be:

- Training reactors or research reactors used for training,
- Normal operation and post accidental type simulators,
- Nuclear physics laboratories,
- Nuclear instrumentation laboratories,
- Nuclear materials laboratories,
- Computer based training,
- Neutronics, Thermal hydraulics, mechanics design codes, etc….

Advanced Courses and Research Committee

The main role of the second committee is to ensure the link between ENEN members and research laboratories in the European Community. It has also to establish exchanges with other networks in the European Union and in Eastern Europe. Its major task is to determine through tight relations with research centres, universities and industry, the different topics that might be suitable for internships, leading to the preparation of Masters' Thesis. The selected subjects should be proposed to students in affiliated institutions. This constitutes the first step to encourage and fund the mobility of students through the European countries. This committee has to establish, every year, a list of PhD topics and create incentives and facilities to candidate students willing to pursue a PhD degree.

Training and Industrial Projects Committee

The third committee has to identify the industrial needs for continued professional development (CPD). It should organize continuous training sessions and courses on different subjects of common interest for the affiliated associated members. It has also to facilitate the mobility of professors from different institutions participating as lecturers and to raise funds for this purpose. This committee is responsible for the integration of European Industrial Projects and National Projects.

One of the main tasks that have to be achieved by this committee is to create and maintain a catalogue of training sessions covering third cycle advanced courses for academia and continued professional development and support for industries. It has to establish links with the knowledge management committee and to organise and coordinate access to large nuclear infrastructures.

Quality Assurance Committee

The main responsibility of this fourth committee is to elaborate the quality assurance processes to be applied in the implementation of education and training programmes by the institutions, which are members of ENEN association. This committee has to examine as well the practices adopted in each affiliated institution concerning quality assurance. It has to collect information about rules and practices such as selection, training and certifying teachers, and to propose for validation to the ENEN management committee, a scheme and a deadline for the harmonisation of different rules. The final objective of this work is the establishment of common criteria for the organisation of education and training in affiliated institutions under a quality assurance programme.

The role of this committee also includes to:

- Manage the quality audits;

- Establish and maintain the accreditation of the European Masters in Nuclear Engineering;
- Monitor the quality of current and proposed ENEN members.

Knowledge Management Committee

The fifth committee has to identify and monitor deficiencies in scientific knowledge relevant to nuclear technology and safety. It has to prepare, maintain and implement an action plan by academia in order to ensure that valuable scientific knowledge is not lost.

To meet with this objective the Knowledge Management committee has to:

- Publish books, Edit CD-ROMs or DVDs that can be of common interest to members and associated members
- Ensure efficient use of Information and Communication Technology (ICT) to support teaching and learning e.g. supply the Web site with courses, announcements, e-classes, software for normal and accident simulators, electronic books, e-learning, etc.;
- Organise the network of knowledge and access to it (databases, industrial resources, etc.);
- Facilitate the exchange of information between committees by using the Web site.

Actually, one year after the foundation of the ENEN Association, the activities of the ENEN committees are not fully developed yet on an independent and sustainable basis. The ENEN members, the effective ones as well as the associated ones, participate to projects in the 6$^{th}$ Framework Programme of the European Community, which either address education and training as their main objective, or involve education and training components as part of their knowledge dissemination strategy. This obviously calls for coordination of the activities within the ENEN Association committees with the work packages and tasks in the EC projects. The major current project is the NEPTUNO project, the Nuclear European Platform of Training and UNiversity Organisations. With one exception, all current 27 ENEN members are participating in this project carried out by 35 partners. Another large project is the international project EUROTRANS, the EUROpean Research Programme for the TRANSmutation of High Level Nuclear Waste in an Accelerator Driven System (ADS). It is in its final preparatory phases and groups 34 partners, one of them being the ENEN Association. The ENEN association, however, is in this project actually representing 17 European Universities in charge of knowledge dissemination through education and training, and knowledge production through PhD theses. The activities of the ENEN Association in the NEPTUNO and EUROTRANS projects are described in more detail below. Before that, however, it is worthwhile to elaborate briefly on the main current product of the ENEN Association, the certificate of European Master of Science in Nuclear Engineering and the pathway for obtaining it.

## 4. THE EUROPEAN MASTER OF SCIENCE IN NUCLEAR ENGINEERING CERTIFICATE

The proposed structure of the EMSNE is compatible with the 'standard' Bologna philosophy of higher education for academic engineers in Europe (a Bachelor of Science after 6 full-time semesters, and a Master of Science after a further 4 full-time semesters). In addition, the EMSNE approach can accommodate the presently existing (variety of) educational systems in the 'Europe-30' geographical region, as well as the Bologna implementation in some countries, where Master degrees will be granted after a 2-semester program beyond the Bachelor[12].

The full curriculum leading to the degree of Master of Science in Nuclear Engineering (MSNE) is composed of course units formally recognized by ENEN and characterized by a number of ECTS credits, reflecting their load. (ECTS stands for European Credit Transfer System.) These credits can be collected from all "ENEN-recognized" institutions.

A degree is granted when the following basic set of requirements is fulfilled:

- a MSNE is in principle only be granted after having obtained a minimum of 300 ECTS credits beyond secondary level;
- a minimum of 60 ECTS credits must be obtained in strictly nuclear subjects composed of a set of core-curriculum courses complemented with nuclear electives and a project work/thesis in a nuclear domain.

As one semester of full-time study usually amounts to 30 ECTS credits; in principle, the MSNE is thus granted after a minimal full-time load of 10 semesters beyond secondary level.

Students register in one ENEN-accredited institution (further called the "home institution") and acquire the required number of ECTS credits in those ENEN-recognized institutions of their choice. In principle, students can opt to fulfil all ECTS credit requirements in their home institution, or, in the other extreme, they can "wander around" and take one or more course units in a variety of ENEN-recognized institutions. The home institution will grant the formal degree of Master of Science in Nuclear Engineering, based upon the formal recognition of the ECTS credits, very much similar to the ERASMUS philosophy. But the quality label ***European*** *Master of Science in Nuclear Engineering* will be granted by ENEN, on behalf of its members, if at least 20 ECTS credits (including project work or thesis) have been followed at an ENEN-member institution other than the home institution.

This European-exchange requirement to obtain the quality label ***European*** MS means that somebody with a MSNE from his/her home institution can only obtain the label after an additional nuclear program of 20 ECTS credits in a recognized ENEN institution other than the institution that granted the MSNE.

Typically, 1 ECTS credit amounts to a student load of 30 hours (including contact hours and study hours), and a full semester load corresponds to 30 ECTS credits or 900 load hours.

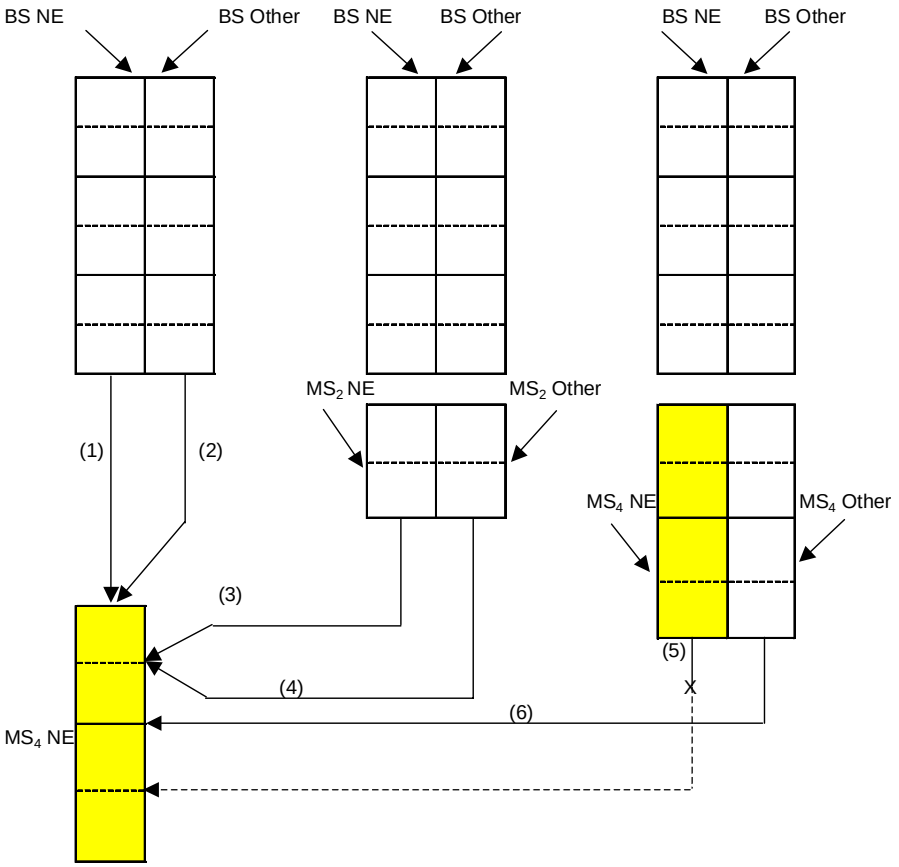
The basic concept of the EMSNE, as well as its flexible nature, is illustrated in Figure 4.1.

12 This section is taken from the 5th Framework Programme ENEN project report "European MS in Nuclear Engineering – Summary report of Work Packages 5-6-7" , G. Van Den Branden, December 2003.

**European Master of Science in Nuclear Engineering**

**Minimal Requirements for EMSNE:**

- At least 300 ECTS university-level study
- At least 60 ECTS purely nuclear engineering (NE) oriented
- At least 30 ECTS in other ENEN institution than "home institution"




(1) 48-60 ECTS non NE; 48-60 ECTS NE (partly tradeable); 12-24 ECTS Thesis (NE)
(2) 48-60 ECTS non NE; 48-60 ECTS NE; 12-24 ECTS Thesis (NE)
(3) 24-30 ECTS non NE; 48-54 ECTS NE (partly tradeable); 12-18 ECTS Thesis (NE)
(4) 24-30 ECTS non NE; 48-54 ECTS NE; 12-18 ECTS Thesis (NE)
(5) only for "European" quality label; extra 30 ECTS "abroad"
(6) 42-48 ECTS NE; 12-18 ECTS Thesis

Figure 4.1 Typical full program variations.

The full program of European Master of Science in Nuclear Engineering is indicated by the yellow (or gray) block in the lower left-hand-side corner. Each little block separated by a horizontal dashed line represents one semester; a solid line refers to a year. $MS_4NE$ refers to a 4-semester master program. Three possible routes towards the EMSNE are indicated.

The first route, indicated by numbers (1) and (2), represent the ***direct*** route, whereby the nuclear Master degree follows directly after the Bachelors' degree, or any other 6 semester / 3 year academic level engineering or sciences program. The six-semester prerequisite program need not be in nuclear engineering; all other common engineering disciplines, agricultural engineering and science disciplines are in general acceptable. If it turns out that the six-semester BS-level program is somewhat short in the basic mathematics, physics, chemistry and engineering courses, the students will be required to "correct" for that during the MS program by sacrificing some elective non-nuclear courses to those subjects (albeit possible that in some cases some additional make-up courses outside the MS program may be needed).

To fulfil the requirements of the Master degree, in principle, a minimum of 120 ECTS credits is required, of which at least 60 should be in a nuclear-engineering area. The non-nuclear ECTS credits should be preferentially in high-level engineering (fluid mechanics, heat transfer, thermodynamics, thermal hydraulics, material science, etc.) or physics, chemistry, mathematics and computer science. For students holding a BS in Nuclear Engineering before starting the MS program, the requirement of minimal 60 ECTS credits in nuclear engineering subjects refers to the combination of the BS and the MS, but whereby the nuclear ECTS credits acquired during the BS only count for 50% towards that 60 ECTS nuclear credits requirement.

The second route (in the middle of the figure) allows those who have successfully completed a 4-year academic program or those who hold a two-semester master (beyond the BS) to obtain an $MS_4NE$ (paths (3) and (4) in the figure).[13] For students following path (3), this route pursues effectively an advanced type of nuclear master, and makes only sense in the framework of the European quality label, explained above. For both paths (3) and (4), a total number of 90 ECTS credits is required, of which again a minimum of 60 ECTS must be in strictly nuclear subjects. Previously obtained ECTS credits in nuclear subjects (in case a $MS_2NE$ was obtained) can be traded for more advanced or other nuclear course units according to an "exchange rate" of 2/1 for BS courses and 1/1 for one-year MS courses for the fulfilment of the minimal 60 ECTS nuclear credits.

Finally, those who already hold a 4-semester Master degree, or a 5-year degree, in engineering, agricultural engineering and sciences (the extreme right hand side block in the figure), can obtain the degree of MSNE through a 2-semester "Master-after-Master" program. (See route (6) in the figure.) The minimal requirement is 60 ECTS credits in purely nuclear subjects (thesis included).

For holders of a 10-semester BS + MS in nuclear engineering (route (5) in the figure) there is only a need to fulfil an extra of 20 nuclear ECTS credits in an ENEN-recognized institution other than that where the MSNE degree was obtained, to obtain the quality label ***European*** Master of Science in Nuclear Engineering. Apart from this extra quality-label requirement[14], the two yellow (or gray) blocks in the figure are identical.

Before granting the label ***European*** MSNE, all programs are to be approved by the ENEN Steering Committee. For applicants to the EMSNE degree with different historical background than described above, the ENEN Steering Committee shall decide on a case-by-case basis.

13 For non-nuclear degrees as in path (4), the same general prerequisites as for the path (2) apply by taking some "corrective" courses during the MS5NE studies or through extra make-up courses.

14 Students having obtained their BS degree in one ENEN-accredited institution and their MS degree in a different ENEN-recognized institution satisfy the European quality label. This route is considered to be identical to route (1).

As explained above under “Boundary Conditions and Assumptions”, in a first phase, ENEN pursues the establishment of a degree in nuclear ***engineering*** mainly related to nuclear electric-power generation; extensions towards other nuclear disciplines may be envisaged in the future. Likewise, ENEN has the intention to promote future exchange of students and instructors for advanced courses in the framework of PhD programs. Depending on the future integration of obligatory advanced courses into the PhD programs in Europe suitably based on geographical exchange and collaboration on the research topic, a possible quality label ***European*** PhD in Nuclear Engineering, granted by ENEN, may be considered.

## 5. THE NEPTUNO PROJECT

The aim of the NEPTUNO project, the Nuclear European Platform of Training and University Organisations, is to continue along the roadmap defined by ENEN to enhance integration of European education and training in nuclear engineering and safety in order to combat the decline in both student numbers and teaching establishments, thereby providing the necessary competence and expertise for the continued safe use of nuclear energy and other uses of radiation in industry and medicine. The harmonised approach for education and training in nuclear engineering in Europe and its implementation goes along with the better integration of the national (governmental as well as industrial) resources and capabilities in the EU states[15].

The expected result is an operational network for academic education at the master, doctoral and post-doctoral level and for professional training and life-long learning schemes to ensure the underpinning of:

- the harmonised approach for training and education in nuclear engineering;
- the harmonised approach to safety and best practices, both operational and regulatory, at the European level within and across all Member States;
- the preservation of competence and expertise for the continued safe use of nuclear energy and other uses of radiation in industry and medicine;
- the sustainability of Europe's excellence in nuclear technology, thereby contributing to the creation of a European Nuclear Knowledge Management Strategy.

The partners of the network

- Implement the roadmap for nuclear education in Europe as developed and demonstrated in the EC 5th Framework Programme project ENEN;
- Warrant the end-user relevance of the education at all levels by recruiting part-time professors out of industry and by providing training and refreshment courses for nuclear industry personnel;
- Teach advanced courses at selected centres of excellence;
- Bridge leading edge research and new knowledge generation with teaching and education;
- Create nuclei of excellence for doctoral schools in nuclear engineering and sciences;
- Facilitate trans-national access to research infrastructure, owned by governmental as well as industrial organisations.

The final aim of the NEPTUNO initiative thus is to contribute to guarantee sufficient educated people, means and knowledge (resources) to allow continuation of the safe and efficient application of the nuclear technology to the civil industry in the medium and long term. Increased mobility of students and professors, increased accreditation and recognition of academic education schemes is part of this process. Internationalization and globalization of the nuclear industry and nuclear electricity production request mobility, accreditation and recognition of qualified licensed staff and, in a general way, all staff needing some form of education, schooling or training before operating in the nuclear industry. Within NEPTUNO, proposals will be formulated for best practices for mobility, accreditation and recognition of those staff. The latter group is presently mainly taken care of by training organizations. The ongoing trend towards cooperation between training organizations, research institutions and academia will be fostered and facilitated. Amongst others, attention is given also to re-training

15 This section is compiled from different 6th Framework Programme NEPTUNO project documents, including the Project Presentation and Description of the Work Packages, issued in 2003, 2004, F. Moons, J. Safieh, P. De Regge

of trainers and modular training schemes for staff not requiring the full academic education programme, thereby contributing to life-long learning schemes.

In the proposed scheme (Figure 5.1), the Academia will be able to preserve the European knowledge and to provide a sufficient number of postgraduates with the adequate background. A key piece of this approach is the development and subsequent pilot applications of common bases for a European Master of Science degree in nuclear engineering and safety that will find broad acceptance and use.

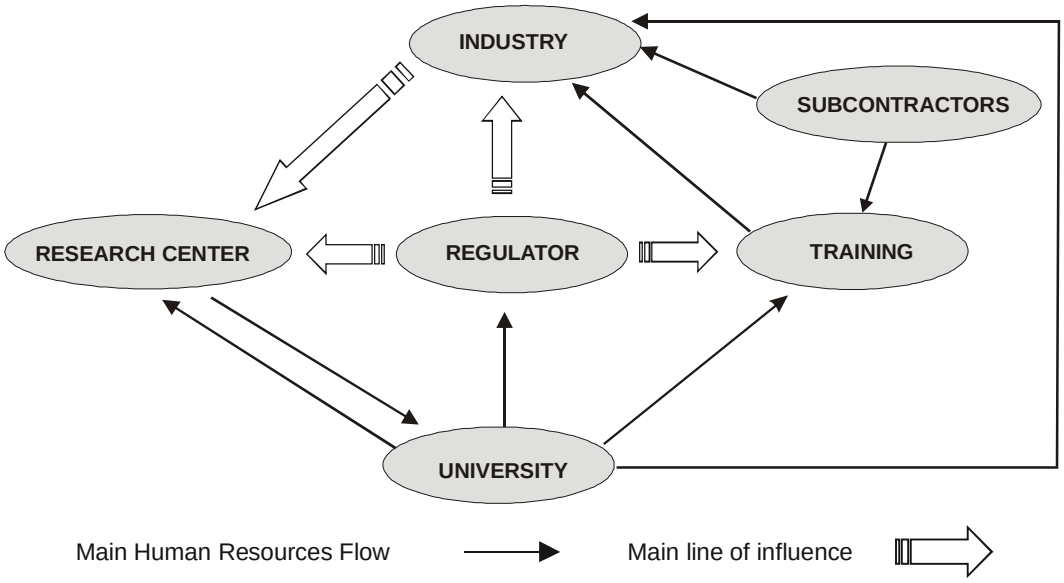



Figure 5.1 Interactions and Flow of Human resources between stakeholders in nuclear energy and applications.

Training programmes aim at developing competent personnel and at ensuring that their qualifications and competencies are maintained, after finishing their academic or other formal education, and during their further professional career. On the whole, most of the training done in European countries is covered by non-academic vocational training programmes. These programmes, usually defined by industrial companies, add value to the initial education of the personnel in nuclear installations. Those programmes have a lot of interactions with the initial education programme, which is the reason why they have to be considered by the NEPTUNO project, in order to achieve a harmonised and high level of qualifications, including skills and attitudes related to human factors.

In coordination with the European Academia and the industry, the training organisations will define a parallel European scheme allowing them to keep high performance standards. At the same time, appropriate links among universities, training organisations and the research institutions will be defined. Pilot applications and case studies will be performed that will help to validate the design options.

The project scope will be complemented with two essential elements:

- a description and analysis of the existing resources, consisting of a State of the Art Report on Education and Training and an European data base will be established;
- a knowledge dissemination action, consisting of a website and an international seminar.

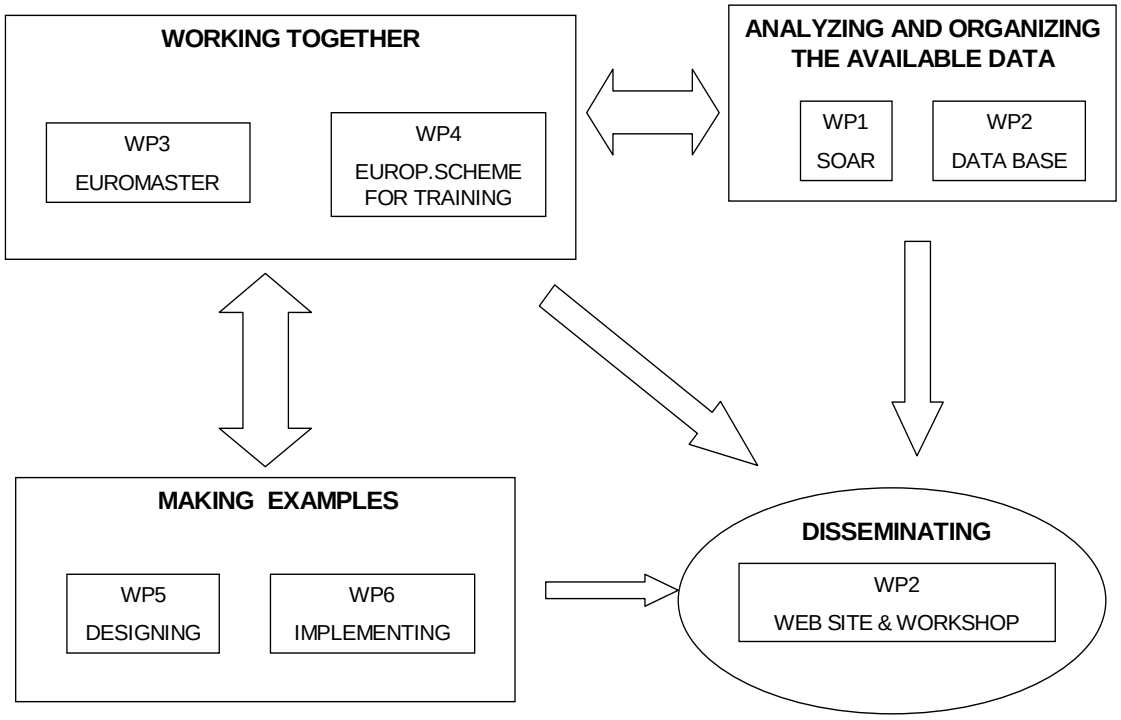



Figure 5.2. Overall structure of the NEPTUNO Project

The work to be carried out to achieve the NEPTUNO objectives is distributed over six Work Packages (WP). Each work package consists of several tasks leading to project milestones and producing deliverables. The overall structure is shown in Figure 5.2.

The six work packages are dedicated to the achievement of the following objectives.

WP1: To establish a state of the art report on education and training in the enlarged European Union (EU-25).

The state of the art report will compile previous work and, if necessary, identify further surveys or studies needed to quantify the problem. It will include recommendations for the actors involved (universities, training centres, utilities, governments).

WP2: To develop Knowledge Management, E-learning and Visibility.

This will be achieved by establishing a NEPTUNO Web site, by developing communication systems for the NEPTUNO Network including databases on the European nuclear know-how, using SINTER technology. This technology allows access to the date base through the internet and is able to integrate education and training efforts from other European research projects. WP2 also includes the integration of conventional teaching methods (CTM) and e-learning, a pilot session in e-learning.

WP3: To drive higher education and to give full implementation to the European Master of Science in Nuclear Engineering.

This includes the detailed core curriculum, the definition of course modules & ECTS identification, the recognition of courses offered by ENEN Members (establish criteria and define procedures), the admission criteria for ERASMUS exchange (background of incoming students, make up-bridge programs, language requirements), and the investigation and

definition of exchange concepts (Fund raising concepts, Marie Curie, Erasmus, Socrates, etc.). WP3 also includes the advertising and information transfer to universities, students and industry, and the promotion of PhD research and theses in the nuclear field.

WP4: To structure a harmonised European scheme for training and to enhance efficiency, to improve and monitor quality and to promote communication on nuclear training.

As a correlated task WP4 will propose key professional positions and functions in industry, and the best practices for mobility, accreditation and recognition of training programmes for those functions. It will further design the organization of such training programmes and the connections with other players (universities, regulators, research centres).

WP5: To develop common approaches for training, by the evaluation of existing training programmes.

WP5 will select an existing or design a new training program on Improved Professional Performance for subcontractors, capture the experience from seminars on "Interchange of Operative Experience (IOE)" and evaluate and upgrade a course on nuclear safety.

WP6: To implement and evaluate pilot experiments.

The pilot experiments will include the Implementation of a Euromasters course, the organization of a seminar on the nuclear fuel cycle, the organization of Improved Professional Performance (IPP) courses for subcontractors, and the performance of an advanced training course on nuclear safety.

## 6. THE IP EUROTRANS PROJECT

IP EUROTRANS, the EUROpean Research Programme for the TRANSmutation of High Level Nuclear Waste in an Accelerator Driven System (ADS) is devoted to transmutation of high-level waste from nuclear power plants, which make up for about 35% of the European electricity production. The work is focused on transmutation in an Accelerator Driven System (ADS)[16].

Due to the fact that the strategy of partitioning and transmutation (P&T) could reduce the radiotoxicity of high-level wastes and thus ease the discussion about the long-term safety assessment of a final repository, any step towards the technological realisation of transmutation in Europe could have a positive influence on the improvement of public acceptance of nuclear electricity production. An increasing acceptance of nuclear by society could lead to a nuclear revival in Europe, which in turn would reduce Europe's steadily increasing dependency on energy imports.

The objective of IP EUROTRANS is the design and the feasibility assessment of an industrial ADS prototype dedicated to transmutation, together with the definition of a design backup solution. IP EUROTRANS benefits from the scientific results and technological achievements of FP5 and is fully coherent with the project IP EUROPART dealing with partitioning and the project STREP RedImpact studying the impact of P&T on waste management. The necessary R&D results in the areas of fuel, technology and nuclear data will be made available, together with the experimental demonstration of the ADS component coupling. The outcome of this work will allow to provide a reasonably reliable assessment of feasibility and an estimate of cost for an ADS based transmutation, and to possibly decide on the detailed design of an ADS and its further construction.

IP EUROTRANS will strengthen and consolidate the competitiveness and international leadership of Europe in transmutation. The involvement of universities strengthens the training and education activities in nuclear technologies. The involvement of industries assures a market-oriented and economic design development and an effective dissemination of the results.

IP EUROTRANS is integrating critical masses of resources and activities, including education and training (E&T) efforts, within the industry, the national research centres, including the Joint Research Centres (JRC)and the universities in Europe.

The importance of IP EUROTRANS is underlined by the fact that waste management and disposal is the responsibility of the present generation and has to be dealt with now.

Structure and Objectives of the Domains

The structure of IP EUROTRANS divides the IP Management and the R&D work into six Domains (DMs), shown in Figure 6.1.

The major objectives of the six Domains are:

- DM0 Management: Management of the IP by the IP Co-ordinator, supported by the Project Office. In DM0 the integrating activities including problem solving, the dissemination of knowledge between the Domains and to the outside nuclear community, and the organisation of workshops are performed.

16 This section is compiled from excerpts of the 6th Framework Programme project IP EUROTRANS "Annex I - Description of Work", J. Knebel, September 29, 2004

- DM1 DESIGN: Development of a reference design for a Generic European Transmutation Demonstrator (Generic ETD) with a power of up to several 100s MW(th), as basis for a cost estimate for an ADS based transmutation.
- DM2 TRADE-PLUS: Design, realisation and operation of the experimental facility TRADE to demonstrate the coupling between a proton accelerator, a spallation target and sub-critical blanket at sizeable power (several 100 kW) in presence of thermal reactor feedback effects.
- DM3 AFTRA: Design, development and qualification in representative conditions of a U-free fuel concept for the Generic ETD, compatible with the reference design studied in DM1 DESIGN.
- DM4 DEMETRA: Improvement and assessment of the Heavy Liquid Metal (HLM) technologies and thermal-hydraulics for application in ADS, and in particular to Generic ETD and XT-ADS, where the HLM is both the spallation material and the primary coolant.
- DM5 NUDATRA: Improvement and assessment of the simulation tools and associated uncertainties for ADS transmuter core, the shielding design and its associated fuel cycle.

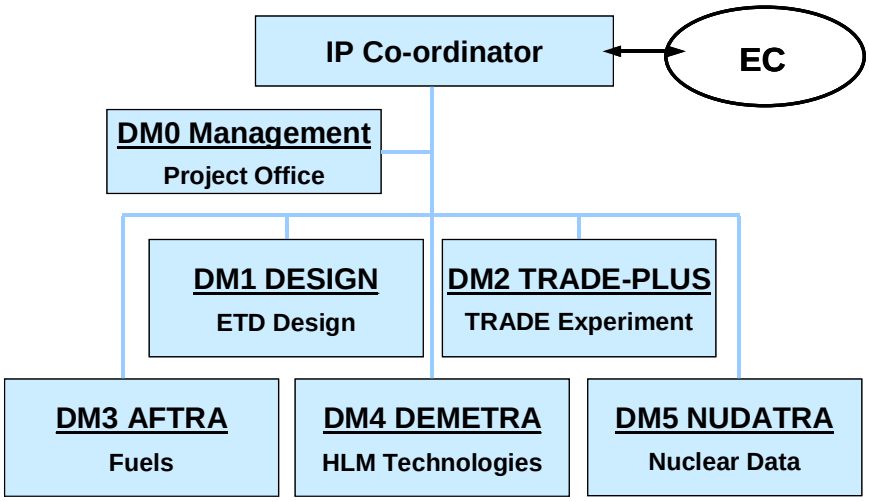



Figure 6.1: IP EUROTRANS - Structure of Domains.

A Knowledge Management (KM) Portal will be developed to facilitate and to support the external and internal transfer and dissemination of results of the whole IP EUROTRANS. Given the wide scope and the broad range of disciplines and R&D activities included in IP EUROTRANS, it is of the prime importance that - already from the start of the project - a system is built up to organise and to structure the transfer of the knowledge generated between the different disciplines and Domains. For that reason, a knowledge management tool will be developed and implemented by the Project Office at the initial stage of the Integrated Project. The knowledge management system will be built up in such a way that it can be used as a permanent information tool and a special information system for these training sessions.

The role of the ENEN Association in IP EUROTRANS

Besides the simple introduction of the project deliverables into the KM system the co-ordinator and the Project Office together with the Domain coordinators will develop a set of procedures to assure that the information of one Domain of high relevance to other Domains

is passed on. ENEN with the assistance of the Project Office will be in charge of introducing the outcomes (e.g. summaries, proceedings) of the training courses and of organising the introduction in the KM system of other training course materials specifically developed for external trainings. Multidisciplinary and crosscutting internal training courses will be organised by ENEN with the aim to foster the exchange of information between the Domains and experts in view of establishing consensus views on the key issues to be investigated, as well as to fine-tune research as a function of requirements and priorities defined by the Project Co-ordination Committee.

IP EUROTRANS has proposed to gather all R&D activities performed by the 17 participating Universities under the umbrella of the Legal Entity European Nuclear Education Network (ENEN) Association. The Universities contributing to IP EUROTRANS and represented by ENEN are:

- Party P13.1: AGH Cracow, University of Science and Technology, Poland,
- Party P13.2: TUW, Vienna University of Technology, Austria,
- Party P13.3: CIRTEN, Inter University Consortium for Nuclear Technological Research, Italy,
- Party P13.4: IAP-FU Frankfurt, J.W. Goethe-Universität, Germany,
- Party P13.5: IQS, Institut Quimic de Sarria, Spain,
- Party P13.6: KTH Stockholm, Kungl Tekniska Högskolan, Sweden,
- Party P13.7: RUB-LEE Ruhr-Universität Bochum, Germany,
- Party P13.8: TU Delft, Delft University of Technology, The Netherlands,
- Party P13.9: UCL, Université Catholique de Louvain, Belgium,
- Party P13.10: ULG, University of Liège, Belgium,
- Party P13.11: UNED Madrid, Universidad Nacional de Educación a Distancia, Spain,
- Party P13.12: UPM, Universidad Politecnica De Madrid, Spain,
- Party P13.13: UPV, Universida Politécnica de Valencia - Instituto de Ingeniería Energética, Spain,
- Party P13.14: USDC, Universidade de Santiago de Compostela, Spain,
- Party P13.15: USE, Universidad de Sevilla, Spain,
- Party P13.16: UU, Uppsala University, Sweden,
- Party P13.17: ZSR, Zentrum für Strahlenschutz und Radioökologie, Universität Hannover, Germany.

Clearly, ENEN is providing the link between the students in the Universities and the scientists working at the partners of IP EUROTRANS. ENEN is thereby connecting the students already during their stay at the universities with ongoing research work and with their potential future employers, i.e. the industry, the national research centres, and the JRCs.

Organised and focused by ENEN and the participating Universities, a considerable part of the scientific work of IP EUROTRANS is performed by young students and researchers in the universities.

In addition, special educational efforts are performed by ENEN and the IP EUROTRANS partners. Of special importance are lectures at universities, workshops, short courses, and summer schools dedicated to transmutation.

ENEN is thereby responsible for:

- contacting the tutors and hosting organisation,
- obtaining the training materials in electronic format (to be made available on the IP EUROTRANS file server),

- inviting people from outside the consortium,
- managing the budget allocated to:
  - the trainees from the new member countries for their travel and subsistence costs,
  - the tutors for preparing the courses and their travel cost, and
  - the hosting organisation (fees).

The proposed common organisation of PhD theses at the universities through ENEN will enable to maintain a strong link between the research carried out in the project, and the education of a significant group of young scientists. In this respect, the series of 10 internal courses prepared by ENEN, as well as the Frederic Joliot / Otto Hahn Summer School are part of the doctoral programme of all PhD students, as a formal mandatory requirement.

Training and education (E&T) of students on the job, e.g. via a diploma thesis and/or a PhD thesis, is also an important mission of IP EUROTRANS, as these young students and researchers shall gradually be recruited as post doctoral students and junior staff. The interdisciplinary character of IP EUROTRANS research (e.g. reactor physics, materials science, radiochemistry, thermal-hydraulics, instrumentation, engineering design) makes it particularly well adapted for the training of PhD students and researchers. This approach explicitly helps to attenuate the critical issue of alternation of generations and efficient know-how transfer in the nuclear field.

A proper Training and education (E&T) programme is especially needed for nuclear phase-out countries which urgently need skilled nuclear experts as there are at least twenty years of operational time for their nuclear power reactors still to come (e.g. Germany).

## 7. THE FUTURE OF THE ENEN ASSOCIATION

The European Nuclear Education Network Association emerged as a non-profit organisation legal entity out of the 5th Framework Programme of the European Community. The legal entity is open for academic institutions and corporate bodies committing themselves to support the ENEN association and having a firmly established tradition of relations with members in the fields of education, research and training. Within ENEN, a consensus has been reached on the qualification of common curricula, an accreditation mechanism inspired by the Bologna declaration and a mobility scheme for students and teachers. Although the present working field of the ENEN Association is mainly nuclear engineering education, the scope of the NEPTUNO project will expand the activities into the definition, harmonisation and trans-national recognition of professional training for key functions in nuclear industries and regulatory bodies. The involvement in the EUROTRANS project will further enlarge its field of activities into the realm of nuclear disciplines. With the support of its members and the strong endorsement of its activities by the European Commission, future extensions towards nuclear medicine, radiation protection, nuclear and radiochemistry, nuclear applied sciences, instrumentation, accelerators, measurements may be envisaged and expected. It will be up to the ENEN association, its structural bodies, committees and their members to take up this challenging task, which will significantly contribute to the management of nuclear knowledge within the European Union as well as on a world-wide level, through ENEN's international contacts, for example with its sister Network ANENT in Asia, and by its participation to the World Nuclear University.