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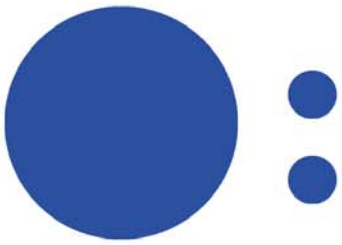

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International Developments in Nuclear Education and Training

CHALLENGES FOR EURATOM RESEARCH AND TRAINING IN THE FRAME OF THE EUROPEAN "HIGHER EDUCATION" AND "RESEARCH" AREAS

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ABSTRACT

In this key note lecture, the following questions will be addressed (see Figure 1):

1)*What are the challenges for Euratom Research and Training in the frame of the European "Higher Education" and "Research" Areas ?*
and who are the main stakeholders ? (end-users with common needs, decision makers with a common vision, institutions with implementation instruments)

2)What kind of response is offered by the Euratom RD&DD and E&T programmes in nuclear fission and radiation protection ?
and what is their scientific and societal impact ?
- RD&DD or RD3 for short = Research, technological Development, and engineering Demonstration, industrial Deployment (also called *Innovation Cycle*)
- E&T = Education and Training

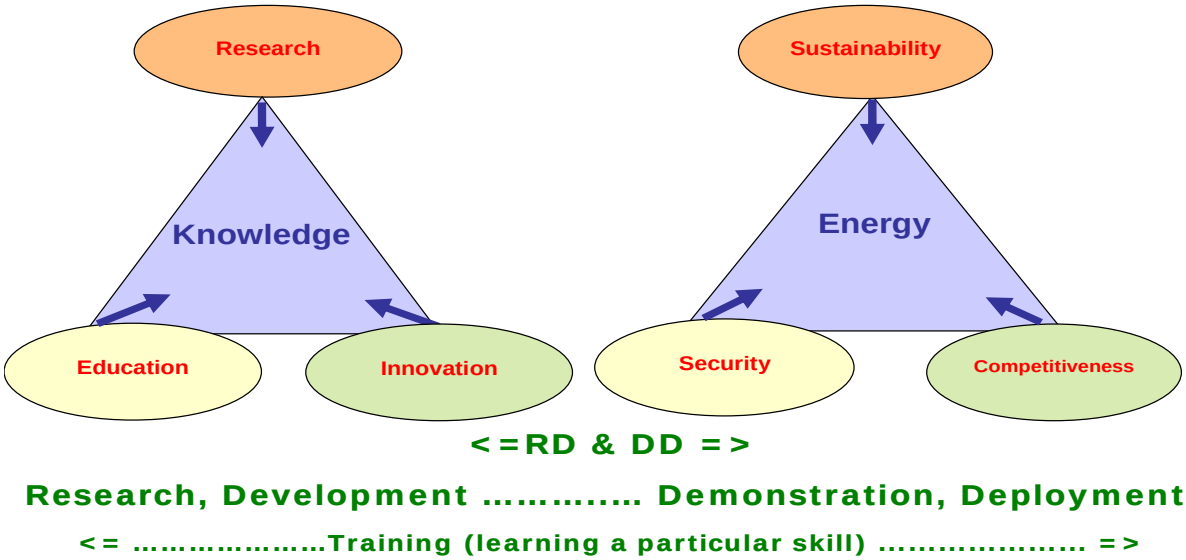

Figure 1 - “Knowledge Triangle” (*research & development*) and "Energy Triangle" (*demonstration & deployment*) + Education and Training (learning a particular skill)

1. INTRODUCTION / INNOVATION CYCLE / HOLISTIC APPROACH FOR RESEARCH-DEVELOPMENT AND DEMONSTRATION-DEPLOYMENT (RD&DD) AND EDUCATION AND TRAINING (E&T)

The globalization that has swept away the barriers to the movement of goods, ideas and people affects naturally the development of research and training. A new approach is required for programmes at both national and EU level. In this context, the concept of sustainability plays a major role. The EU definition of sustainability is very close to that of Mrs Gro Harlem Brundtland, the former Prime Minister of Norway. This definition was proposed in 1987 at the World Commission on Environment and Development (also called the *Brundtland Commission*). It describes sustainable development as: "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*.

Sustainable Development Strategies are implemented world-wide. At the EU level, it is worth recalling the recent first "*Progress Report on the Sustainable Development Strategy (SDS) 2007*" – see EC Communication COM(2007) 642 [1]. The related EU policy has identified seven key sustainability challenges, which will be the subject of annual progress assessment reports [2], namely:

1. *Climate Change and Clean Energy* (including nuclear, the main subject of this lecture)
2. Sustainable Transport
3. Sustainable Consumption and Production
4. Conservation and Management of Natural resources
5. Public Health
6. Social Inclusion, Demography and Migration
7. Global poverty.

In the general debate in the EU-27 about innovative technologies for *Climate Change and Clean Energy*, there are two types of challenges:

- scientific and technological (S/T) *challenges* related to *research* and technological *development:* the main instrument provided by the EU is the Framework Programme
- economic and political (E/P) *challenges* related to engineering *demonstration* and industrial *deployment*: the main instruments are economic and regulatory incentives.

To implement innovative technologies for *Climate Change and Clean Energy* in Europe, the governments, in collaboration with the EC and the main stakeholders, should develop, in particular, a common research and training strategy, that is:

(a) identify the end-users and their common needs (bottom up action)
(b) converge to a common vision amongst the main stakeholders (top down action)
(c) develop and apply implementation instruments at both EU and national level.

As a result, the governments and the EC are expected to act as:

- *initiator* of ambitious *research and development* programmes: e.g. to orient public funding to visionary research and training programmes (basic as well as applied) on well targeted issues with potential breakthroughs, based, in particular, on large research infrastructures of common interest

  (S/T challenges related to *research* and technological *development /RD/*)

- *financial investor* for *demonstration and deployment* programmes: e.g. to support and facilitate large financial investments, especially during the transition period between two

[1] http://ec.europa.eu/sustainable/docs/com_2007_642_en.pdf

[2] http://ec.europa.eu/environment/eussd/

technological steps (in particular, when going from the current traditional economy to the future "*clean, clever and competitive*" economy)
(E/P challenges related to engineering *demonstration* and industrial *deployment /DD/*)

- *regulator* to ensure that the *citizens' interests* are defended and that the *industrial competition* is fair (level playing field at both national and international level): e.g. establish a common European framework for the mutual recognition of best practices for safety culture, risk governance, codes and standards.

RD&DD programmes have the most chances of success if they can take advantage of a working environment that meets the following conditions (examples are given between brackets for the specific case of *innovation in nuclear fission technolog*ies):

- *objective* (i.e. clear allocation of responsibilities between industry and regulators; between promoters of innovation, RTD performers and potential customers, etc)
- *consistent* (i.e. level playing field for all nuclear actors across the Community, convergence or mutual recognition of technical and radiological safety practices, etc)
- *predictable* (i.e. no unexpected requirements from the authorities or from the market, reasonably favourable public opinion, stable international political climate, etc).

In the EU, the RD&DD programmes, tackling the above challenges, are naturally related to the policies for Research and Energy. Community Research, however, is not conducted for the sake of research for research, but as a support to EU policies, in particular, to the Energy policy. This is illustrated in Figure 1 in the form of two policy triangles:

- the "*Knowledge Triangle*" (EU policy for research, innovation and education, with emphasis on RD, that is: Research and technological Development) - see FP-7 strategy in "*Building the ERA of knowledge for growth"* [3] COM(2005) 118 and FP-7 budget in "*Financial perspectives 2007 – 2013*" [4]
(ERA = "*European Research Area*", launched in the context of the *Lisbon Strategy*, European Council of 23-24 March 2000)

- the "*Energy Triangle*" (EU policy for security of supply, sustainable development and competitiveness of energy, with emphasis on DD, that is: engineering Demonstration and industrial Deployment) - see the Energy Package announced in the EC Communication "*An Energy Policy for Europe*" [5] (EPE, 10 January 2007), subsequently endorsed by the European Council of 8-9 March 2007 .[6]

2. TOWARDS THE "EUROPEAN HIGHER EDUCATION AREA": A SINGLE UMBRELLA FOR EDUCATION AND TRAINING PROGRAMMES (2007 – 2013) / "ERASMUS" FOR HIGHER EDUCATION (DG EAC)

In the EU, education is in principle an exclusive competence of the Member States. Therefore the role of the EU is "limited" to develop the European dimension in education, in particular, by encouraging mobility of students and teachers (e.g. academic recognition of diplomas - see ERASMUS below) and by promoting co-operation between educational establishments.

Education is mentioned in a general social clause in the recent "*EU Reform Treaty*" of Lisbon (signed on 13 December 2007 by the representatives of the 27 Member States and ratified

[3] http://ec.europa.eu/research/era/index_en.html

[4] http://ec.europa.eu/financial_perspective/index_en.htm

[5] http://ec.europa.eu/energy/energy_policy/doc/01_energy_policy_for_europe_en.pdf

[6] http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/93135.pdf

by 5 Member States as of 8 February 2008, namely: Hungary, Slovenia, Malta, Romania and France). Here is an excerpt of Article 5a:
"In defining and implementing its policies and activities, the Union shall take into account requirements linked to the promotion of a high level of employment, the guarantee of adequate social protection, the fight against social exclusion, and a high level of education and training as well as protection of human health."

In this context, the EU launched in 2007 the *Lifelong Learning Programme* (LLP), as a single umbrella to integrate all educational and training initiatives that were originally organised by DG Education and Training (EAC) through the SOCRATES Programme 2000 - 2006. The budget is nearly EUR 7 billion for 2007 to 2013. This new EU programme replaces the existing education, vocational training and e-Learning programmes, which ended in 2006 [7].

The LLP enables individuals at all stages of their lives to pursue learning opportunities across Europe. It consists of four "sectoral" sub-programmes:

- **Comenius** addresses the teaching and learning needs of all those in pre-school and school education
- **Erasmus** addresses the teaching and learning needs of staff and students in Higher Education. It also provides support for institutions across Europe to work on shared projects, including curriculum development and other areas
- **Leonardo da Vinci** enables people who are involved in vocational education and training to benefit from work experience placements and career development opportunities in another country
- **Grundtvig** focuses on adult education and funds small-scale, community-based activities.

A transversal programme complements these four sub-programmes in order to ensure that they achieve the best results. Finally, the **Jean Monnet programme** stimulates teaching and reflection on the European integration process at higher education institutions worldwide.

As regards the four sectoral programmes, quantified targets have been set in order to ensure a significant, identifiable and measurable impact for the programme, namely:

- For **Comenius** (school education): to involve at least three million pupils in joint educational activities, over the period of the programme
- For **Erasmus** [8] (higher education): to contribute to the achievement by 2012 of three million individual participants in student mobility under the present programme and its predecessors (reminder: the first ERASMUS programme started in 1987)
- For **Leonardo da Vinci** [9] (vocational training): to increase placements in enterprises to 80 000 per year by the end of the programme
- For **Grundtvig** (adult education): to support the mobility of 7 000 individuals involved in adult education per year, by 2013.

Certain parts of the above EU's programmes are treated by *executive agencies*. The Education, Audiovisual and Culture Executive Agency (EACEA [10]) is responsible for centralised actions: *Multilateral Projects and Networks, Observation and Analysis, Operating grants, Unilateral and National Projects (Transversal Programme & Jean Monnet) and Accompanying Measures*. Fully operational from the 1st of January 2006, this Executive Agency operates under supervision from its three parent Directorates-General: *Education*

[7] http://ec.europa.eu/education/programmes/llp/index_en.html

[8] http://ec.europa.eu/education/programmes/llp/erasmus/index_en.html

[9] http://ec.europa.eu/education/programmes/llp/leonardo/index_en.html

[10] http://eacea.ec.europa.eu/index.htm

and Culture (DG EAC), *Information Society and Media* (DG INFSO) and the *EuropeAid Cooperation Office* (DG AIDCO). National agencies have also been created in 31 countries: they are responsible for decentralised actions, such as Partnerships and individual Mobility [11].

As a way of reminder, the aim of the ERASMUS programme (started in 1987, first discussions on ECTS) was to encourage transnational cooperation between universities, to boost European mobility and to improve the recognition of studies and qualifications throughout the Union. The ECTS is the "*European Credit Transfer and accumulation System*" that underlies the mutual recognition mechanism of ERASMUS: it is actually based on the student work load required to achieve the objectives of the programme. More ambitious goals were then fixed in the Bologna declaration, signed in 1999 by the Ministers of Education from 29 European countries in the Italian city of Bologna (actually the current EU-27 countries – Cyprus + Switzerland, Norway and Iceland).

The purpose of the Bologna process (or Bologna accords) is to create the *European higher education area* (EHEA) by making academic degree standards and quality assurance standards compatible throughout Europe. It has gained in popularity year on year - from a modest number (3000) of undergraduate students in 1987 to 150 000 in 2006 (cumulating in a total of more than 1.2 million students over the period 1987 – 2006). The scheme in 2006 covered 2200 higher education establishments (that is: 90 % of their total) in 31 countries. The EU budget of ERASMUS for 2000-2006 amounts to around EUR 950 Mio (of which EUR 750 Mio for students grants). As of May 2007, the ERASMUS programme is targeted at the students and staff of the higher education institutions in all 27 Member States of the European Union, Switzerland, the three countries of the European Economic Area (Iceland, Liechtenstein and Norway), as well as Turkey, Cyprus and Croatia since 2001, plus another 12 countries (including Albania, Andorra, Bosnia and Herzegovina, Holy See, Macedonia, Russia, Serbia and Montenegro since 2003).

Of particular relevance to Erasmus is the Erasmus Mundus (EM for short) programme, with more ambitious objectives, especially regarding cooperation with Third Countries. As a way of reminder, a "Third Country" means a State other than an EU Member State and other than Associated Countries to the relevant Community Programme. Both Erasmus and EM programmes contribute to the realisation of the Bologna aims, in particular by promoting student mobility and through the development of the ECTS credits system. This facilitates mobility through the accreditation and mutual recognition of study periods abroad. Erasmus can be undertaken at undergraduate, Masters and PhD levels. However, there are clear distinctions between Erasmus and EM. While Erasmus is a mass mobility programme which has supported over 1 million students since 1987, EM has been designed as an excellence programme with scholarships available on a more competitive basis. The percentage of successful applications to EM over the period 2004 – 2006 was approximately 14 %.

The Erasmus Mundus programme is actually a co-operation and mobility programme in the field of higher education which promotes the EU as a centre of excellence in learning around the world. The Erasmus Mundus programme was launched in 2004 and has since supported 80 joint master courses with over 4 000 students from approximately 60 third countries (in particular, China, Brazil and Russia), gaining a scholarship to obtain a Masters degree in Europe. A further 23 Masters Courses will become operational in 2008. The Erasmus Mundus programme provides a response to the challenges of globalisation faced by European higher education today, in particular the need to adapt education systems to the demands of the knowledge society, to enhance the attractiveness and visibility of European higher education world-wide and to stimulate the process of convergence of degree structures across Europe. These themes are central to current national reform processes in higher education taking place in Member States.

[11] http://ec.europa.eu/education/programmes/llp/national_en.html#benl

The Erasmus Mundus programme comprises four Actions:

- *Erasmus Mundus Masters Course* (that is: top-quality Masters Courses of between one and two years offered by a group of higher education institutions, leading to a master degree - selected Masters Courses must be attended by European graduate students as well as by a specific number of third-country graduate students and scholars)
- *Scholarships* (that is: funds to the selected Erasmus Mundus Masters consortia)
- *Partnerships* (that is: partnerships between Erasmus Mundus Masters consortia and third-country higher education institutions)
- *Enhancing attractiveness* (that is: dealing with the mutual recognition of qualifications with third countries).

The current Erasmus Mundus programme covers the period 2004 - 2008 and has an overall budget of EUR 230 million. After three successful academic years (2004-2006), the EC adopted in 2007 a proposal to launch the new generation of the Erasmus Mundus programme for the period 2009-2013: just over EUR 950 million will be available for European and third-country universities to join forces in joint programmes and to grant scholarships to European and third-country students for an international study experience [12]. An interim evaluation report was published in June 2007 [13]

As far as third-country assistance is concerned, the Erasmus Mundus External Co-operation Window (EM ECW) [14].should be mentioned. It is a co-operation and mobility scheme in the area of higher education co-operation launched by Europe Aid cooperation Office and implemented by the above mentioned EACEA. Its objective is to exchange persons, knowledge and skills at higher education level between the EU and third countries such as Belarus, Moldova and Ukraine.

Linkages with other EU programmes in the field of higher education

In addition to the above-mentioned Lifelong Learning Programme 2007-2013 (including Erasmus and EM), there are a number of other EU-financed programmes that seek to foster closer cooperation with third countries in the field of higher education. A summary overview of some of the most relevant programmes is provided below:

- the Atlantis (formerly known as the EU-US co-operation programme) and EU-Canada cooperation programmes in the field of higher education and vocational training as well as pilot co-operation projects in higher education with Japan and Australia, which aim to improve the quality of human resource development.
- the ALBAN programme (a programme of high-level scholarships in Europe for Latin America) provides scholarships for postgraduate studies for Latin America professionals/future decision-makers in EU institutions. Between 2003 and 2007, more than 3 300 applicants from 18 Latin American countries were selected to receive an Alban scholarship. This programme will now be merged within EM.
- ALFA (América Latina - Formación Académica) is a programme of co-operation between higher education institutions (HEI) of the EU and Latin America to develop systematic and lasting partnerships including a mobility component.
- the Asia-Link programme helps develop partnerships and sustainable links between higher education institutions in Europe and specific Asian countries to promote regional and multilateral networking.

[12] http://ec.europa.eu/education/programmes/mundus/projects/index_en.html

[13] http://ec.europa.eu/education/programmes/mundus/doc/evalreport_en.pdf

[13] http://eacea.ec.europa.eu/extcoop/call/index.htm

- the Tempus [15] programme (a Trans-European Mobility scheme for University Studies) enables universities from EU Member States to co-operate with 26 partner countries from the Western Balkans, Eastern Europe and Central Asia, and the Mediterranean partner countries in higher education modernisation projects. In the past 17 years, Tempus has funded 6 500 projects, involving 2 000 universities from the EU and its partner countries. Currently, the budget over 2007 - 2013 is EUR 50 million.
- Directorate-General for Research (DG RTD) manages various programmes which support co-operation between higher education institutions at the doctoral and research level, such as the PEOPLE programme (ex-Marie Curie) – Section 3.

Many of the above EU third country oriented programmes in the field of higher education use the new Instruments of the EU (in particular, DG Europe Aid). For example, the Tempus IV programme for the Western Balkan countries is a part of the *Instrument for Pre accession Assistance* (IPA). Countries of Eastern Europe (e.g. Russia, Ukraine), North Africa (e.g. Morocco) and the Middle East are covered by the *European Neighbourhood and Partnership Instrument* (ENPI). Countries from the Central Asian region receive assistance from the *Development and Cooperation Instrument* (DCI).

Nuclear Education and Training projects under ERASMUS (overview 2005-2007) [16]

(1) EMRP - *European Master in Radiation Protection* [17]
(Erasmus Curriculum Development project, coordinated by UJF Grenoble)
- partners = UK, CZ and FR / grant amount = EUR 180 K / approved budget = 310 K

(2) SPERANSA [18]- *Stimulation of Practical Expertise in Radiation and Nuclear Safety*
(Erasmus Intensive Programme, coordinated by Czech University in Prague)
- partners = DE, ES and BE / grant amount = EUR 18 K / approved budget = 25 K
= CHERNE "*Cooperation in Higher Education on Radiological and Nuclear Eng*."

(3) EMNT [19]- *European Master in Nuclear Technology : Decommissioning Waste Management and Non-Power Applications*
(Erasmus Curriculum Development, coordinated by UJF Grenoble)
- partners = 2 x IT, LT and UK / grant amount = EUR 146 K / appr. budget = 220 K)

(4) FUSION-EP [20]– *European Master in Nuclear Fusion Science and Engineering Physics*
(Erasmus Mundus Masters Course by Ghent University / part of Action 1 [21])
- partners (EU + non-EU) = FR, SE, DE and 3x ES plus 2x USA, 2x Russia and China
/ Grant 2006 = 894 000 € (15 000 € consortium + 879 000 € scholarships)
/ Grant 2007 = 852 000 € (15 000 € consortium + 837 000 € scholarships)
/ Application (2008-2009) for non-EU students was open until 1st February 2008/

A list of *National Information and Contact Points* [22] exists for Erasmus Mundus.

[15] http://ec.europa.eu/tempus

[16] http://eacea.ec.europa.eu/static/en/overview/erasmus_overview.htm

[17] http://eacea.ec.europa.eu/static/en/erasmus/documents/compendium-CD-2005.pdf

[18] http://eacea.ec.europa.eu/static/en/erasmus/documents/Compendium_2005.pdf

[19] http://eacea.ec.europa.eu/static/Bots/docbots/ERASMUS/IC%202006/cd_coord_2004.pdf

[20] http://www.em-master-fusion.org

[21] http://ec.europa.eu/education/programmes/mundus/projects/index_en.html

[22] http://ec.europa.eu/education/programmes/mundus/doc/national.pdf

3. TOWARDS THE "EUROPEAN RESEARCH AREA": A SINGLE UMBRELLA FOR RESEARCH AND TRAINING PROGRAMMES (2007 – 2013) / "PEOPLE" EX – MARIE CURIE ACTIONS (DG RTD)

In the EU, the year 2000 was marked by the launch of the above mentioned *European Research Area* (ERA) [3]. The related EC Communication "*Towards a European Research Area*" proposed ways in which research in Europe could be more effectively organised and coordinated. It is generally accepted that research and training go naturally together.

The Seventh Framework Programme (FP-7, EC research over the period 2007 - 2013) has a total worth of EUR 50 521 million and includes the following specific programmes:

- *Cooperation* – fostering collaboration between industry and academia to gain leadership in key technology areas - EUR 32 413 million (64.2 %)
- *Ideas* – supporting basic research at the scientific frontiers (implemented by the *European Research Council* / ERC) - EUR 7 510 million (14.9 %)
- *People* – supporting mobility and career development for researchers both within and outside Europe (follow-up of Marie Curie actions) - EUR 4 750 million (9.1 %)
- *Capacities* – helping develop the capacities that Europe needs to be a thriving knowledge-based economy (support to infrastructures) - EUR 4 097 million (8.3 %)
- *JRC (non-nuclear)* - EUR 1 751 million (3.5 %).

The 7-th Euratom Framework Programme (FP-7, Euratom research over the period 2007 – 2011, five years duration imposed by the Euratom Treaty) consists in:

- *Nuclear research (Euratom programme)* – developing Europe's nuclear fission and fusion capabilities (RTD and JRC) - EUR 2 751 million (see Table 1 in Section 5).

The FP-7 has three major new elements, as compared with FP-6 (2003 – 2006):

(1) First, the «border» research has its own programme (*Ideas*). The *European Research Council* [23] (ERC) will fund investigator-led, frontier research. It consists of two grant schemes, the *Starting Independent Researcher Grant* and the *Advanced Investigator Grant*. A Scientific Committee was set up in 2005 and the management will be in the hands of a Commission's *executive agency* that should become operational in 2008. Projects submitted to the ERC are proposed by individual teams of researchers and evaluated according to the sole criteria of excellence by high-level panels.

There are several reasons why "basic" or frontier science (as opposed to "applied" science, as in RD&DD) is necessary. Generally, four classes of benefits can be distinguished:

- contributions to culture: e.g. from particle physics to environmental chemistry
- the possibility of discoveries of big economic and practical importance
- spin-offs of industry: e.g. ionising radiations for medical applications
- education and training: e.g. to excite the interest of the younger generations.

Focussing on nuclear fission and/or radiation protection, one could think of "basic" research at EU level, for example, in the following areas:

- basic science tools to improve experimental research (e.g. laboratory testing)
- participation in the NSF driven programme NBIC (nano-, bio-, info- and cognitive)
- basic actinide sciences to optimise the management of long-lived radioactive waste
- mathematical modelling / optimisation of electrochemical processes (radiochemistry)
- multi-scale numerical simulation of irradiation damage effects on fuels and materials
- quantification of the risks associated with low and protracted exposures of radiation.

[23] http://erc.europa.eu/

(2) Secondly, the number of *European Technology Platforms (ETP)* [24] has increased and at the end of 2007 there were 31 of them. Technology Platforms bring together stakeholders of a strategic area. Their development process is in three stages:

- stakeholders, led by industry, come together to agree on a *common vision* for the technology (over the long term)
- stakeholders define a *Strategic Research Agenda* (SRA) setting out the necessary medium- to long-term objectives for the technology (orientation towards innovation)
- stakeholders mobilise significant human and financial resources (*Deployment Strategy* - DS) to implement the above Strategic Research Agenda.

The more "mature" platforms may propose *Joint Technology Initiatives* (JTI). These are very big projects made of public-private partnership, with a great autonomy, which should be implemented through bodies created under article 171 of the Treaty (that is: requiring a Council's decision). The EU budget of such a project could reach hundreds of million EUR. The pioneering JTIs are *ARTEMIS* (embedded computing systems, budget of EUR 3 billion over 10 years) and *ENIAC* (nano-electronics, budget of EUR 2.5 billion over 10 years): both of them are supported by the DG Information Society and Media and had their first governing board meetings in Brussels on 22 February 2008. They are expected to launch their first calls for proposals by mid-2008. Two other JTIs, the *IMI* (Innovative Medicines Initiative), which will support the development of new medicines, and *Clean Sky*, which will seek to increase the competitiveness of the European aeronautics industry while reducing emissions and noise, are due to be launched soon.

(3) Thirdly, a new *Risk-sharing finance* facility is proposed with the aim to enhance backing for private investors in research projects, improving access to loans from the European Investment Bank (EIB) for large European research actions. In December 2005 a decision was taken to allocate up to EUR 10 billion to this end.

The "Marie Curie Actions", managed by DG Research (RTD), have long been one of the most popular and appreciated features of the Community Framework Programmes for Research and Technological Development. They have developed significantly in orientation over time, from a pure mobility fellowships programme to a programme dedicated to stimulating researchers' career development. The "Marie Curie Actions" have been particularly successful in responding to the needs of Europe's scientific community in terms of training, mobility and career development. This has been demonstrated by a demand in terms of highly ranked applications that in most actions extensively surpassed the available financial support.

In the Seventh Framework Programme, the "Marie Curie Actions" have been regrouped and reinforced in the "PEOPLE" Specific Programme[25]. Entirely dedicated to human resources in research, this Specific Programme has a significant overall budget of more than EUR 4.7 billion over a seven year period until 2013, which represents a 50% average annual increase over FP6. This Programme acknowledges that one of the main competitive edges in science and technology is the quantity and quality of its human resources. To support the further development and consolidation of the European Research Area, this Programme's overall objective is to make Europe more attractive for the best researchers.

The "PEOPLE" Specific Programme will be implemented through actions under five headings:

[24] http://cordis.europa.eu/technology-platforms/home_en.html

[25] http://cordis.europa.eu/fp7/people/home_en.html

- "**Initial training of researchers to improve mostly young researchers**" career perspectives in both public and private sectors, by broadening their scientific and generic skills, including those related to technology transfer and entrepreneurship.

  Funding schemes: *Initial Training Networks* (that is: grants to networks of young researchers, bringing together academia and industry, thereby facilitating the access to facilities, people and potential future employers)

- "**Life-long training and career development**" to support experienced researchers in complementing or acquiring new skills and competencies or in enhancing inter/multidisciplinarity and/or intersectoral mobility, in resuming a research career after a break and in (re)integrating into a longer term research position in Europe after a trans-national mobility experience.

  Funding schemes: *Intra-European Fellowships for Career Development; European Reintegration Grants; Co-funding of Regional, National, and International Programmes*

- "**Industry-academia partnerships and pathways** " to stimulate intersectoral mobility and increase knowledge sharing through joint research partnerships in longer term co-operation programmes between organisations from academia and industry, in particular SMEs and including traditional manufacturing industries.

  Funding scheme: *Industry-Academia Partnerships and Pathways* (that is: exchange of personnel, from post-graduate to "captains of industry", between the private and the public sector, in the context of common research projects)

- "**International dimension**", to contribute to the life-long training and career development of EU-researchers, to attract research talent from outside Europe and to foster mutually beneficial research collaboration with researchers from outside Europe.

  Funding schemes**:** *International Outgoing / Incoming / Reintegration / Fellowships for Career Development; International Staff Exchange Scheme* (that is: individual fellowships for Europeans in the EU or abroad, or for non-Europeans in the EU)

- "**Specific actions**" to support removing obstacles to mobility and enhancing the career perspectives of researchers (e.g. *Marie Curie Awards* and *National Contact Points*).

The *National Contact Points* (NCP [26]) network is the main provider of advice and individual assistance in all Member States and Associated States. As the NCPs are national structures, the type and level of services offered may differ from country to country. In general, the following basic services will be available in accordance with the Guiding Principles agreed by all countries:

- guidance on choosing thematic priorities and instruments
- advice on administrative procedures and contractual issues
- training and assistance on proposal writing
- distribution of documentation (forms, guidelines, manuals etc.)
- assistance in partner search.

4. EUROPEAN "STRATEGIC ENERGY TECHNOLOGY" (SET) PLAN AND "SUSTAINABLE NUCLEAR ENERGY TECHNOLOGY PLATFORM" (SNE-TP): KEEP THE NUCLEAR OPTION OPEN

In response to the conclusions of the European Council of March 2006 (document 7775/06), the Commission adopted the so-called *Energy Package* on 10 January 2007, as it has been already mentioned in Section 1. It was the subject of the Communication *An Energy Policy for Europe* (EPE) [5]. This Energy Package comprises the first *Strategic European Energy Review* (SEER) and a draft Action Plan for the Energy Policy for Europe. The SEER is complemented by in-depth reports on all the main issues concerning climate change and

[26] http://cordis.europa.eu/fp7/ncp_en.html

clean energy, including Renewable Energy, the Internal Gas and Electricity Market, Sustainable Power Generation from Fossil Fuels, Nuclear, Technology, and Infrastructures.

Climate Change and Clean Energy is the first of seven key sustainability challenges identified by the EU (Section 1). Climate change is discussed in the Communication "*Limiting Global Climate Change to 2° Celsius: The way ahead for 2020 and beyond*". The objective is to limit global warming to no more than 2°C (to be compared to 0.76 °C as of today) above pre-industrial temperatures. This means that global emissions of greenhouse gases will have to be stabilised by around 2020 and then reduced by up to 50% of 1990 levels by 2050. Nuclear fission (that can be considered as a "clean energy") is discussed in the PINC Communication "*Illustrative Nuclear Programme for the Community*" [27].

Of particular importance is the Communication *Towards* a *European Strategic Energy Technology Plan*, also dated 10 January 2007 (SET plan) [28] .The aim of the SET plan is to provide an objective perspective on the different energy technologies which will or might become available between now and 2050 to tackle the "energy supply issue" while respecting the environment (CO_2 and GHG free sources) and being competitive. The prospects for market penetration of a series of low carbon technologies will be analysed, be it for electricity/heat conversion or for transport technology. As a result one has a better picture of what are the real chances of the different technologies and what is needed to support their development. This will also contribute to providing the long-term framework that investors need for the deployment of new technologies in the energy market, that is: a working environment that is objective, consistent and predictable (Section 1).

The response of the European Council (in particular, all EU Energy Ministers) to the Energy Package tabled by the Commission is summarized in the conclusions of the Spring European Council of 8 – 9 March 2007 (document 7224/07 "*Europe – succeeding together"*). This new European policy contains clear commitments on GHG emissions, on energy efficiency, on renewable energies and on bio-fuels. Two key targets (of interest for this discussion) were set by the European Council - see Communication *"20 20 by 2020 / Europe's climate change opportunity*", COM(2008) 30 (dated 23 January 2008):

- a reduction of at least 20% in greenhouse gases (GHG) by 2020 – and more (30 %) if other countries go with
- a 20% share of renewable energies in overall EU energy consumption by 2020 (binding target).

At the above March 2007 European Council, the role of nuclear energy was one of the main debating points. The Presidency Conclusions reiterated the established position that it is for each EU nation to decide whether to use nuclear power. As a consequence, nuclear energy is naturally part of the SET Plan. The EU Energy Ministers actually reaffirmed that the EPE should contribute in a balanced way to the following three objectives:

- *increasing security of supply* (nicknamed "Moscow")
- *ensuring the competitiveness of European energy industry so as to provide energy at the best possible prices for citizens and companies and stimulate investments* (nicknamed "Lisbon")
- *promoting environmental sustainability (with emphasis on the objective to limit the rise in global temperatures to 2°C)* (nicknamed "Kyoto").

[27] http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0844en01.pdf

[28] http://ec.europa.eu/energy/energy_policy/doc/19_strategic_energy_technolgy_plan_en.pdf

As far as research is concerned, discussions about a long-term RD&DD strategy in nuclear fission and radiation protection started in the Euratom FP-5 (1998 – 2002) project MICANET (Michelangelo network, coordinator AREVA NP) and continued in three Euratom FP-6 (2003 – 2006) projects:

- *SNF-TP (Sustainable Nuclear Fission, 2 years, from October 2006, coordinator CEA)*
- *PATEROS (Partitioning and Transmutation European Roadmap for Sustainable nuclear energy, 2 years, from September 2006, coordinator SCK-CEN)*
- *CARD (Coordination of research, development and demonstration priorities and strategies for geological disposal, 1 year, from Sept. 2006, coordinator NIREX).*

As a result of the above Euratom FP-5 and FP-6 projects, a European Technology Platform (ETP – Section 3) was launched in 2007 to bring together all stakeholders in the area of nuclear fission, focussing on research and development (RD), namely:

(1) Sustainable Nuclear Energy Technology Platform (SNE-TP [29])
- launch event in Brussels on 21 September 2007, platform composed principally of research organisations from both the public and private sectors
- the SNE-TP consists of a General Assembly (biennial meetings), a Governing Board and an Executive Committee that supervises 3 main activities:
  * *Strategic Research Agenda* (SRA)
  * *Deployment Strategy* (DS), including policy framework
  * Knowledge Management and Education & Training (+ scientific evaluation), led by ENEN
- two additional bodies provide input and recommendations to the governing board: the mirror group, providing information to ensure the effective coordination with national programmes, and the technical safety organisations (TSO) group
- the SNE-TP will provide valuable input to the nuclear fission part of the SET Plan
- the SNE-TP could become a *Joint Technology Initiative* (Section 3) if a sufficiently strong private-public partnership is developed and if the proposed *European Research Agenda* and *Deployment Strategy* are endorsed by the main stakeholders in Europe.

In parallel, as a result of the previously discussed EU policies (*Sustainable Development Strategy* and *Energy Policy for Europe*), two other European actions were launched in nuclear fission, focussing on demonstration and deployment (DD):

(2) European Nuclear Energy Forum (ENEF [30])
- launch event in Bratislava on 26 -27 November 2007, forum composed principally of industrial stakeholders and non-governmental organisations (NGOs)
- the ENEF consists of three Working Groups:
  * Opportunities
  * Risks of nuclear energy, including education and training, which is led by EoN ("European Nuclear Trainee Academy" / ENTA proposal) in collaboration with ENEN wherever appropriate
  * Information and transparency issues.

(3) High Level Group (HLG)
- launch event in Brussels on 12 October 2007, group composed principally of senior officials from national regulatory or nuclear safety authorities.

[29] www.snetp.eu

[30] http://ec.europa.eu/energy/nuclear/forum/index_en.htm

To launch the Sustainable Nuclear Energy Technology Platform, a "*Vision Report*" (a kind of "Chart") was produced. It proposes a vision for the near, medium and long term development of nuclear fission energy technologies, with the aim of achieving a sustainable production of nuclear energy, a significant progress in economic performance and the highest level of safety as well as resistance to proliferation. Nuclear fission energy can deliver safe, sustainable, practically carbon-free and competitive energy to Europe's citizens and industries. In particular, this document proposes roadmaps for the development and deployment of potentially sustainable nuclear technologies, as well as actions to harmonize Europe's training and education, while renewing its research infrastructures. Public acceptance is also an important issue for the development of nuclear energy. Therefore, research in the fields of safety of nuclear installations, protection of workers and populations against radiations, management of all types of waste and governance methodologies with public participation will be promoted. The proposed roadmaps provide the backbone for a *Strategic Research Agenda* to maintain Europe's leadership in the nuclear energy sector, in both research and industry. By emphasizing the key role of nuclear energy within Europe's energy mix, this document also contributes to the European Commission's SET Plan, by calling on Europe to mobilise the resources needed to fulfil the vision of sustainable nuclear energy.

A number of recommendations are given in conclusion of the above Vision Report, e.g.:
"to effectively combat climate change, the cost of greenhouse-gas emissions must be taken into account at a worldwide level. Nuclear power must be included in the post-Kyoto international negotiations, as a part of clean development mechanisms, contributing to sustainable development".

5. EURATOM STRATEGY FOR RESEARCH AND TRAINING IN NUCLEAR FISSION AND RADIATION PROTECTION (COMMON NEEDS; TOWARDS ONE VISION; IMPLEMENTATION AT NATIONAL AND EU LEVEL)

As it was discussed in Section 1, the governments, in collaboration with the EC and the main stakeholders, should develop a common research and training strategy, that is:

(a) identify the end-users and their common needs (bottom up action)
(b) converge to a common vision amongst the main stakeholders (top down action)
(c) develop and apply implementation instruments at both EU and national level.

(a) Identification of end-users and common needs

As a result of the new *Energy Policy for Europe* [5] (10 January 2007), the European Commission proposed on 22 November 2007 a STRATEGIC ENERGY TECHNOLOGY (SET) Plan. For the preparation of this SET Plan, a wide consultation was organised across the EU about the need for "*European Industrial Initiatives*". On that basis, the EC proposed to launch six priority initiatives, starting in 2008, one of them being a *Sustainable nuclear fission initiative* (with focus on the development of Generation-IV). This EC proposal (based on the SET plan) was endorsed by the European Council of 13 – 14 March 2008 (Brussels) [31].

As a way of reminder, the history of nuclear fission power production is divided in four technological Generations (called I, II, III and IV), with timescales extending from around 1950 to 2040. To each of these generations, S/T and E/P challenges are associated, as follows:

- Generation II (1970 - 2000): reliability (in particular, security of supply & safety), and sustainability (in particular, waste management and resource utilization)

[31] http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/99410.pdf

- Generation III (2015): competitiveness (a.o. increased plant performances, like 60 years lifetime and 90 % plant availability), and enhanced reliability and safety

- Generation IV (2040): enhanced sustainability (a.o. better utilisation of resources and full actinide recycling) and enhanced competitiveness (a.o. cogeneration).

Generation IV systems are meant to be a technological breakthrough, with a major impact on the following fields (four technology goals agreed upon in 2002 – see GIF below):

- Sustainability (e.g. better fuel utilisation and waste management)
- Economics (e.g. competitive life cycle and minimum financial risk)
- Safety and reliability (e.g. plant management and investment protection)
- Proliferation Resistance and Physical Protection (e.g. safeguarding facilities).

A number of strategic studies were launched, in particular, under Euratom FP-6 (2003 – 2006), to identify the needs in all areas, that is: reactor systems (including the above GIF technology goals) and safety design (including plant modernisation), waste management (including Partitioning and Transmutation /P&T/ and geological disposal) and radiation protection (including applications of ionising radiations) – Section 7.

(b) Towards a common vision amongst the main stakeholders

Nuclear research and training requires in fact broad and extended geographical, disciplinary and time horizons, that is:

- the nuclear research community extends to all 27 EU Member States and beyond

- a variety of scientific disciplines (both applied and fundamental) are concerned

- four generations of nuclear power technologies are involved (period 1950-2040).

As far as the main stakeholders are concerned, one can distinguish 6 categories (they are usually all involved in the large Euratom research and training programmes):

- the nuclear research organisations (public and private)
- the systems suppliers (e.g. nuclear vendors, engineering companies, etc)
- the energy providers (e.g. electric utilities, heat and/or hydrogen vendors, etc)
- the regulatory bodies and associated technical safety organisations (TSO)
- the education and training (E&T) institutions, and, in particular, the universities
- the civil society and the international institutional framework (IAEA and OECD).

Regarding the development of innovative reactor systems and fuel cycles, there is a world-wide common vision amongst 12 countries and Euratom. This subject is at the heart of a large international research programme, led by the Generation IV International Forum (GIF). In July 2002, six innovative reactor systems were selected: 4 fast reactors /SFR, GFR, LFR, SCWR / and 2 thermal reactors /VHTR, MSR/. Within the EU-27, however, there is not yet a common vision on the future of nuclear fission (Generations III and IV). Actually there is consensus only on Generation II issues (e.g. "*Convergence of Technical Nuclear Safety Practices in Europe*" developed by WENRA) and on the need to maintain an adequate skills base in nuclear fission across the EU (therefore the Euratom effort on education and training).

(c) Implementation instruments at both EU and national level (such as FP-7)

At the EU level, nuclear research and training (Euratom programmes) is principally under the responsibility of two Directorates Generals (DG):

- DG Research (RTD, located in Brussels), which organises the "indirect actions", i.e. multi-partner projects undertaken by consortia made up of national laboratories, industrial groups and research organisations (both private and public) in the EU, usually on a shared cost basis, such as in the seventh Framework Programme [32].

- DG Joint Research Centre [33] (JRC, headquarters in Brussels) which carries out "direct actions" in their own research laboratories (7 scientific institutes in 5 Member States). Nuclear training actions at DG JRC focus on neutron measurements, nuclear materials and non-proliferation issues (safeguards) in collaboration with ESARDA and IAEA.

In this key note lecture, the emphasis is on the indirect actions, organised by DG Research under the 6th (FP-6 / 2003-2006) and under the 7th Euratom research framework programme (FP-7 / 2007 – 2011)[34].

Table 1 - Euratom framework programmes for fusion and fission (FP-4 till FP-7)

	FP-4 (1994-98)	FP-5 (1998-02)	FP-6 (2003-06)	FP-7 (2007-11)
Fusion Energy	**840**	**788**	**824**	**1 947**
Nuclear Fission and Radiation Protection *(indirect actions)*	**170**	**191**	**209**	**287**
JRC's EURATOM activities (*direct actions*)	**271**	**281**	**319**	**517**
Total	**1 281**	**1 260**	**1 352**	**2 751**

Euratom Budgets since 1994 are given in Table 1. As it was mentioned in Section 1, research and training should be viewed in the context of the synergy between the two Policies:

- Research ("research – development" in the context of the knowledge triangle)
- Energy ("demonstration – deployment" in the context of the energy triangle).

At the national level within the EU Member States, the largest part of nuclear research and training activities is traditionally under the responsibility of Ministries (e.g. Education, Science, Research, Industry, etc). Some States – especially those with a significant number of nuclear installations - have large programmes, associated with universities and funded by both government and industry (e.g. CEA in France, FZK in Germany, etc). Other States have developed less expensive programmes that are more appropriate to their specific needs (e.g. with emphasis on radiation protection and on applications of ionising radiations).

A number of *National Networks for Nuclear Research and Training* (most of them set up quite recently) play also an important role in the overall implementation process, such as:

- **NTEC** [35] (*Nuclear Technology Education Consortium* of 11 establishments – lead by the Dalton Nuclear Institute in the UK (of particular interest is also the UK initiative "*Keeping the Nuclear Option Open*" [36])

[32] http://cordis.europa.eu/FP-7/euratom/home_en.html

[33] http://www.jrc.cec.eu.int/

[34] http://cordis.europa.eu/fp7/euratom-fission/home_en.html

[35] http://www.ntec.ac.uk/

- **Kompetenzverbund Kerntechnik** [37] (*Alliance for Nuclear Competence*, under BMWi) in Germany

- **INSTN** [38] **(**Institut National des Sciences et Techniques Nucléaires), as a of CEA, INSTN is a higher education institution under the joint supervision of the Ministries in charge of Education and Industry in France

- BNEN [39] (Belgian Nuclear Education Network, hosted at SCK-CEN Mol), cosponsored by the national nuclear industry, containing all six "nuclear" universities of Belgium

- CIRTEN [40] ("Consorzio Interuniversitario per la Ricerca Tecnologica sull' Energia Nucleare") in Italy

- REFIN [41] (Romanian Nuclear Education Network – "Retea Educationala in Fizica si Ingineria Nucleara")

- FINNEN [42] (Finnish Nuclear Education Network, Helsinki University of Technology /TKK/)

- NKS [43] (Nordic Nuclear Safety Research = Denmark, Finland, Iceland, Norway and Sweden)

- CENEN (Czech Nuclear Education Network)

- KINT (Dutch Knowledge Infrastructure on Nuclear Technology).

Also worth mentioning is the co-operation of EU and National nuclear training programmes with international organisations, such as:

- the *World Nuclear University* (WNU[44]), an initiative of the World Nuclear Association under the umbrella of IAEA, launched in September 2003 with a secretariat in London

- the *Asian Network for Education in Nuclear Technology* / ANENT [45] (IAEA initiative in 2004), 28 participating organisations from 12 countries as of Sept 2006 (namely: Australia, China, India, Indonesia, Malaysia, Mongolia, Pakistan, Republic of Korea, Sri Lanka, Thailand, Philippines and Vietnam).

Assessment of Euratom research programmes (achievements versus objectives)

Euratom RD&DD addresses most of the above common needs and is in line with the common vision that is emerging amongst the main stakeholders. As far as Research and

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[36] www.wun.ac.uk/nuclearsci/research_themes/pubpolicy/pdfs/KNOO.pdf

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

[38] http://www-instn.cea.fr/

[39] http://www.sckcen.be/bnen/courses.html

[40] http://www.cirten.it/

[41] http://www.refin.pub.ro/

[42] http://www.tkk.fi/fi/

[43] http://www.nks.org/english/About_NKS/About_NKS.htm

[44] http://www.world-nuclear-university.org/

[45] http://www.anent-iaea.org/

Development (RD) are concerned, two new instruments were introduced under FP-6 and are further proposed under FP-7 [46] :

"*Networks of excellence" (NoE)*: the aim is to promote EU excellence while generating a process of "long term commitment" amongst the contractors. Here are the objectives of NoEs (also used as EC internal assessment criteria in programme monitoring):

- *Co-programming of research at the level of organisations :* 1. building up of strengths and shrinking of weaknesses / 2. long-term joint planning of research projects / 3. knowledge management (within and outside the Community project) / 4. horizontal integration (S/T multi-disciplinarity)
- *Vertical Integration :* 1. universities / 2. research organisations / 3. systems suppliers / 4. energy providers and waste agencies / 5. TSOs or regulators / 6. decision-makers
- *Sharing of personnel and facilities :* 1. mobility and mutual recognition of scientists / 2. sharing of equipment and (soft- and hardware) tools / 3. e-management of the project and applications of e-science / 4. "irreversible links" in the consortium (long-term vision).

"Collaborative projects" (CP): the aim is develop new knowledge, new technology, products, demonstration activities or common resources for research during the contractual period. Here are the objectives of CPs (also used as EC internal assessment criteria in monitoring):

- *Vertical Integration : see NoE above*
- *Horizontal Integration : 1. nuclear physics (nano-scale) / 2. chemistry (meso-) / 3. continuum mechanics (macro-) / 4. mathematics and informatics / 5. electronics / electricity / 6. health / environmental sciences*
- *Knowledge Management : (cf. the "Knowledge Triangle" in Figure 1) 1. research (i.e. identification, creation and development of knowledge) / 2. education (i.e. preservation, dissemination and transmission of knowledge) / 3. innovation (i.e. use and exploitation* of knowledge for research and/or industrial/regulatory purposes).

On the contractors' side, a number of external assessment exercises were conducted. Some participating organisations carried out, for example, a SWOT analysis (*Strengths – Weaknesses – Opportunities – Threats*) of their participation in Euratom research actions. Other participants went for a cost/benefit analysis (*what is the "value for money"?)* of their participation. It is worth reporting the conclusion of a large European utility: *"To give an idea of the quantitative benefits which can be obtained from sharing costs in the framework of European programmes, we can mention a few illustrative figures: in the nuclear field, in 2002, we brought about 3,5 M€ and got access to R&D results worth 36 M€. This factor of 10 is obviously a strong incentive for a utility to get actively involved in the European Research Area !"* (introductory lecture at FISA-2003 / Luxembourg, November 2003 [47]).

6. ENEN OBJECTIVES FOR EDUCATION AND TRAINING: MODULARITY AND COMMON QUALIFICATION APPROACH; MUTUAL RECOGNITION; EUROPEAN MOBILITY; FEEDBACK FROM STAKEHOLDERS

Keeping the nuclear option open means also maintaining an adequate skills base to ensure sufficient personnel in research organisations as well as in nuclear installations. This is a concern shared not only by the EU but also by OECD/NEA [48] and by IAEA [49].

[46] http://cordis.europa.eu/FP-7/what_en.html#funding

[47] http://cordis.europa.eu/fp5-euratom/src/ev-fisa2003.htm

[48] http://www.nea.fr/html/ndd/reports/2000/nea2428-education.pdf

[49] www.iaea.org/km/

In 2000 Mr. M. El Baradei, Director General of the IAEA declared in a speech:
"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."

Also in 2000, Euratom decided to fund a number of strategic studies and to strengthen training in all sectors of nuclear fission and radiation protection.

It is worth recalling that nuclear training is an obligation in the Euratom Treaty (signed in Rome in 1957) [50]. Here are two excerpts:

- 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.

For the sake of clarification, education and training (E&T) are defined as follows:

- Education is a basic or life-long learning process: education is broader than training and encompasses the need to maintain completeness and continuity of competences across generations (it is essentially a knowledge-driven process, involving academic institutions as suppliers, and students as customers).
- Training is learning a particular skill required to deliver a particular outcome: training is about schooling activities other than regular academic education schemes (it is essentially an application-driven process, involving industrial/regulatory training organisations as suppliers, and professionals as customers).

The goal of the Euratom education programme is actually to offer a number of instruments that help produce top-quality teaching modules that can be assembled into Masters programmes or higher level training packages that are jointly qualified and mutually recognised across the EU. This is done in collaboration with the DG EAC *Lifelong Learning Programme* (Section 2) and the DG RTD programme FP-7 *PEOPLE* (Section 3).

The Euratom approach is naturally in line with the Bologna process (ERASMUS). More specifically, its strategy for nuclear E&T is based on the following four objectives:

- 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, thereby getting additional funding).

[50] http://eur-lex.europa.eu/en/treaties/index.htm

In order to achieve the above objectives, a non-profit making association (*under French law of 1901*) was formed in September 2003: this is the "*European Nuclear Education Network*" (ENEN) [51], a spin-off of the homonymous FP-5 project. As of December 2007, the membership of the ENEN Association consisted of 44 members, namely: 37 universities (effective members), and 6 research centres and 1 multinational company (associated members), located in 17 European Countries. The current aim is to cover 29 countries, namely: the 27 Member States of the EU and two neighbouring countries (Switzerland and Norway). Supported by the 5th and 6th Euratom Framework Programmes, the ENEN Association developed, in particular, education and training courses in a European exchange structure, based on core curricula and optional fields of study. Of particular interest is the list of 295 ENEN courses (modules) that were produced in 25 nuclear fission disciplines. ENEN can be considered as an important step towards the harmonisation of training activities in nuclear fission and radiation protection in the EU-27.

The ENEN association consists of five Committees. The Training and Academic Affairs Committee and the Advanced Courses and Research Committee develop and implement non-overlapping schemes covering one full academic year (60 ECTS) of courses in nuclear disciplines leading to Master degrees. The latter Committee also promotes interactions between research conducted at European universities and nuclear research centres, and end users such as utilities, power plants, regulatory bodies, industries, etc. It organises exchanges and meetings between doctoral and post-doctoral students in the framework of seminars, workshops and courses on topics at the edge of current scientific research. The Training and Industrial Projects Committee facilitates interactions between training organisations and professionals in nuclear industries to provide pertinent and harmonised training programmes for continual training on new topics as well as to refresh and update capabilities and qualifications. The Knowledge Management Committee operates the ENEN web site, advertises courses and events of interest, develops and disseminates E-learning tools, courses and training packages on a variety of media, maintains data banks and communication systems. The quality of the ENEN products and the project deliverables, the reports, courses, training packages, certificates, and the reliability of the information is continuously monitored by the Quality Assurance Committee.

The central issue of the ENEN association was originally the elaboration of a concept to establish a *European Master of Science in Nuclear Engineering* (EMSNE). The concept envisaged should be compatible with the European educational road map for higher education defining Bachelors and Masters Degrees as agreed to in the Bologna declaration. Clearly, the scheme should be practicable in that it takes into account the realities of European education. The basic goal is to offer interesting programs with exciting subjects to attract bright students and to guarantee a high quality nuclear education in Europe by means of stimulating student and instructor exchanges, through mutual quality assurance checks of the courses offered, by close collaboration with renowned nuclear research groups at universities or laboratories. The nuclear master program should consist of a solid basket of basic nuclear science and engineering courses but should also contain some advanced nuclear courses.

The full curriculum leading to the original 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. These credits can be collected from all "ENEN-recognized" institutions. A minimum of 60 ECTS credits (that is: the equivalent of one academic year) are needed to be granted the degree of MSNE. The home institution will grant the formal degree of Master of Science in Nuclear Engineering, based upon the formal recognition of the ECTS credits, in line with the ERASMUS mechanism. The quality label *European Master of Science in Nuclear Engineering* (EMSNE) is granted by ENEN, on

[51] www.enen-assoc.org.

behalf of its members, only if at least 20 ECTS credits (including project work or thesis) have been followed at an ENEN-member institution other than the home institution.

Although the concept envisaged is applicable to a variety of speciality domains, in a first phase, ENEN concentrated on establishing a degree in *nuclear engineering* mainly related to nuclear electric power generation. Nowadays, the original ENEN objectives are extended. The result could be a nuclear fission *European Master* degree with different "options" like

- *waste management (including P&T and geological disposal)*
- *nuclear medicine*
- *radiation protection*
- *radiochemistry & nuclear chemistry*
- *nuclear applied sciences (including accelerators, instrumentation, etc).*

As the concept strives to offer the students the "best quality" higher education in Nuclear Engineering in Europe, ENEN has focused on a *realistic* concept that enables to interact and take courses from typical centers of excellence with a sole or major nuclear focus. The model developed does not intend to establish one single elite school that offers the degree of European Master, but rather takes advantage of exchange schemes and mutual recognition. The scheme does not intend to do away with existing programs but tries to strengthen them by offering exchange modules. The regional and national spread of the program is thought to be important to allow graduated students to interact with local safety and other authorities (language and cultural aspects). The concept is designed to fit full-time as well as part-time students. The part-time scheme is supposed to better accommodate the schedule of professionally active students.

The four above ENEN objectives apply naturally across all sectors of nuclear fission, in particular: nuclear engineering (including Generations II, III and IV), radioactive waste management (including geological storage) and radiation protection (including applications of ionising radiations). The implementation of nuclear E&T, however, can be sector specific.

7. EDUCATION AND TRAINING UNDER EURATOM FP-6 (2003 – 2006): STRATEGIC STUDIES IN ALL NUCLEAR AREAS AND TRAINING ACTIONS EMBEDDED IN LARGE RESEARCH PROJECTS

In line with the four above objectives of ENEN, Euratom FP-6 (2003 – 2006) launched a number of strategic studies in specific areas of reactor engineering and safety design, waste management (including Partitioning and Transmutation /P&T/ and geological disposal) and radiation protection (including applications of ionising radiations), namely:

*1 - Nuclear European Platform for Training and University Organisations (**NEPTUNO** [52]),* coordination action funded for 1.5 years with a total budget of 830 kEUR from EC, initiated in January 2004 and coordinated by CEA/INSTN

*2 - Coordination Action on Education and Training in Radiation Protection and Radioactive Waste Management (**CETRAD** [53]),* coordination action funded for 1.25 years with a total budget of 300 kEUR including 250 kEUR from EC, initiated in January 2004 and coordinated by University of Wales (UWC) – Cardiff School of Engineering

*3 - Securing European Radiological Protection and Radioecology Competence to meet the Future Needs of Stakeholders (**EURAC**),* coordination action funded for 1 year with a

[52] http://www.sckcen.be/neptuno/)

[53] http://www.grc.cf.ac.uk/cetrad/

total budget of 168 kEUR including 100 kEUR from EC, initiated in October 2004 and coordinated by Middlesex University (list of FP-6 Euratom projects [54])

4 - European Master of Science Course in Radiation Biology (MSCRB [55]), specific support action funded for 3 years with a total budget of 400 kEUR from EC, initiated in October 2003 and coordinated by Gray Cancer Institute / Middlesex

5 - European Network on Education and Training in Radiological Protection (ENETRAP [56]), coordination action funded for 2 years with a total budget of 450 kEUR including 400 kEUR from EC, initiated in April 2005 and coordinated by SCK-CEN Mol (Section 9)

6 – Belgian Nuclear Education Network (BNEN [57]), specific support action funded for 1.5 years with a total budget of 100 kEUR from EC, initiated in April 2005 and coordinated by SCK-CEN Mol

7 - Consolidation of European Nuclear Education, Training and Knowledge Management (ENEN II [58]), coordination action funded for 2 years with a total budget of 1240 kEUR including 1150 kEUR from EC, initiated in October 2006 and coordinated by the ENEN association – see below.

The above strategic studies (NEPTUNO, CETRAD, EURAC, MSCRB, ENETRAP, BNEN and ENEN II) dealt essentially with education (with a strong participation of academia). As far as training is concerned, it is worth mentioning the training activities "embedded" (that is: proposed as work packages) in some large FP-6 projects (with a strong participation of scientists from public and private laboratories).

In the integrated project, **PERFECT** [59], resources are assigned for training in advanced numerical simulation tools for irradiation damage. A total of 13 PhD students and as many Post Docs are funded by the project. 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.

In the network of excellence, **SARNET** [60], 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.

In the integrated project, **RAPHAEL** [61], 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.

[54] http://cordis.europa.eu/FP-6-euratom/projects.htm

[55] http://www.gci.ac.uk/education/index.htm

[56] http://www.sckcen.be/enetrap/

[57] www.sckcen.be/BNEN

[58] http://www.enen-assoc.org

[59] https://www.FP-6perfect.net/site/index.htm

[60] http://www.sar-net.org/

[61] http://www.raphael-project.org/index.html

In the integrated project **EUROTRANS** [62]**,** there are 17 universities, represented by the ENEN Association. At least 5% of the budget is assigned to PhD students, whereas an additional 300 k EUR is reserved for E&T (detailed course programme in www.enen-assoc.org). It is also worth mentioning the launch of a doctoral school on P&T by the ENEN association in this EUROTRANS project.

In the integrated project **ESDRED** [63] ("**E**ngineering **S**tudies and **D**emonstration of **Re**pository **D**esigns"), 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.

As far as radiation protection goes, in the integrated project **RISC-RAD**[64] (**"R**adiosensitivity of **I**ndividuals and **S**usceptibility to **C**ancer induced by ionizing **RAD**iations"), there are courses on "quantitative radiation risk modelling" and on "ethics in biological experiments".

In the integrated project **EURANOS**[65] ("**EUR**opean **A**pproach to **N**uclear and radi**O**logical emergency management and rehabilitation **S**trategies"), training is organised in connection with "real time on-line decision support (RODOS)" for emergency management and rehabilitation strategies.

FP-6 project ENEN II (covering all areas of nuclear fission and radiation protection)

This FP-6 Coordination Action (October 2006 – September 2008) consolidates and expands the achievements of the *European Nuclear Education Network* association in the previous framework programmes. The ENEN-II project is aiming at developing the ENEN Association in a sustainable way in the areas of nuclear engineering, radiation protection and waste management. Nuclear education and training networks are developed at the national level to provide a solid basis for networking at the European dimension (Section 5). Advisory groups and discussion forums are established to strengthen guidance, interaction and feedback from end-users and stakeholders regarding higher level training needs. In addition to EC funding, third-party funding will be attracted to support mobility of teachers and students at masters', doctoral and post-doctoral level. The approach (four ENEN objectives – Section 6) used so far successfully for education are developed and extended to training activities.

The ENEN II project activities are structured around the five committees of the ENEN Association in close collaboration with selected consortium partners (Section 6). The project also develops a "Think Tank" function with reviews on nuclear energy and applications in various fields, evaluating performance, achievements, expectations, potential, and costs including also public perception and social aspects.

8. EDUCATION AND TRAINING UNDER EURATOM FP-7 (2007 – 2011): TRAINING ACTIONS EMBEDDED IN LARGE RESEARCH PROJECTS AND "EURATOM FISSION TRAINING SCHEMES" (EFTS)

Similarly to what was done under Euratom FP-6, the current Euratom FP-7 programme launched nuclear E&T actions "embedded" in all large projects, that is: reactor systems, waste management (including P&T and geological disposal) and radiation protection.

[62] http://nuklear-server.ka.fzk.de/eurotrans/

[63] http://www.esdred.info/

[64] see http://www.riscrad.org/

[65] http://www.euranos.fzk.de

Here is a (non-exhaustive) list of seven training actions embedded in large FP-7 projects related to innovation in (1) reactor systems and (2) radiation protection.

Reactor systems (P&T as well as materials and fuels for Generation IV)

1 - ACSEPT / Actinide reCycling by SEParation and Transmutation
Starting date: (most likely) = 01/02/2008 (duration = 48 months)
Coordinator: Commissariat à l'Energie Atomique CEA, France (34 partners in total)
Total costs = 23 789 000, containing the EU grant of 8 999 000 EUR.

The overall goal is to advance the European integration in the fields of separation techniques, and actinide chemistry in particular, to combat the decline in student numbers, teaching establishments and young researchers. Of course strong links will be established with the direct or derived actions of the FP-6 Network of Excellence ACTINET. Summer schools will be organised at least twice during the 4 years lifetime of the project. Efforts will also be devoted to preserving, retaining, and archiving nuclear chemistry knowledge from current as well as from past Euratom RTD projects, using an ad-hoc Communication System. Funds are also foreseen to promote knowledge transfer from people retiring or already retired.

***2 - GETMAT* / Gen IV and Transmutation MATerials**
Starting date: 01/02/2008 (duration = 60 months)
Coordinator: Forschungszentrum Karlsruhe GmbH FZK, Germany (24 partners in total)
Total costs = 13 959 123, containing the EU grant of 7 500 000 EUR.

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 to workshops in collaboration with OECD/NEA and IAEA, the following training activities have been foreseen:

- Training Course 1: Correlation between the material microstructure and its mechanical integrity (inter-relationship between the microstructure and mechanical performance including modeling of microstructure evolution and mechanics)
- Training Course 2: Influence of the environment on the material performance (platform for discussion of different concept under the materials point of view).

3 - CARBOWASTE / Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste
Starting date (most likely) = 01/04/2008 (duration = 48 months)
Coordinator : Forschungszentrum Juelich GmbH, Germany (29 partners in total)
Total costs =11 500 000 EUR, containing the EU grant of 6 000 000 EUR.

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. For spreading excellence, this project will engage PhD students and/or post-doctoral fellows throughout Europe, working alongside the industrial partners. The students will get training at partner institutions so that they can make use of analytical equipments, modelling techniques and other resources of high quality. Universities working with the ECTS system will exchange information on their nuclear chemistry and physics teaching curricula, and will invite industrial partners to give lectures on waste management options.

4 - F-BRIDGE / Basic Research for Innovative Fuel Design for GEN IV
Coordinator: Commissariat à l'Energie Atomique CEA, France (20 Partners in total)
Starting date: 01/03/2008 (duration = 48 months)
Total costs =10 234 318 EUR, containing the EU grant of 5 467 808 EUR.

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. F-BRIDGE is putting together researchers from different communities: physics and chemistry, academics and nuclear organisations, modellers and experimentalists, research scientists, irradiation experiments engineers, designers, and manufacturers. Therefore, thematic workshops will be organised to ensure communication and knowledge dissemination inside the consortium.

Radiation protection (medical applications of ionising radiations)

5 - SEDENTEXCT - Safety and Efficacy of a New and Emerging Dental X-ray Modality
Starting date: 01/01/2008; duration 42 months
Coordinator: School of Dentistry, Univ. Manchester, UK (7 Partners)
Total costs: 3 070 361, containing the EU Grant of 2 449 461 EUR.

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. A dedicated WP on training and valorisation will perform a need analysis amongst the professional community (dentists, manufactures and dental suppliers,...) and public to establish an agreed list of training needs and contents. A particular priority of the website development will be a "Training on Demand" web server, with materials handled by a special Image Database and by an original user-friendly HTML shell. As a result, the user can learn directly from his/her online, without the need of external software.

6 - MADEIRA - Minimizing Activity and Dose with Enhanced Image quality by Radiopharmaceutical Administration
Starting date: 01/01/2008; duration 36 months
Coordinator: Helmholz Zentrum München (HMGU former GSF), DE (7 Partners incl. USA)
Total costs: 3 948 824, including the EU-Grant of 2 820 000 EUR.

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. A dedicated WP on training and dissemination has been set up and training courses will be organised on radiation physics (months 6), radiation protection in nuclear medicine (month 18) and imaging in nuclear medicine (month 30). Moreover it is foreseen to organise a public workshop on "Innovations in Nuclear Medicine" (months 33) targeting stakeholders in science and industry beside to set up a project web site and respective project flyers.

7 - ORAMED - Optimization of Radiation Protection of Medical Staff
Starting date: 01/02/2008; duration 36 months
Coordinator: SCK-CEN, BE (12 Partners including 1 from CH)
Total costs: 2 445285; containing the EU Grant of 1 839 999 EUR.

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). A dedicated WP on training and dissemination is set up aiming among others to develop an information package, such as presentations and e-learning modules for distribution through professional organisations and to organize a workshop where the main results of the project could be presented and disseminated among stakeholders.

Towards "*Euratom Fission Training Schemes*" involving academia and stakeholders

Nuclear training activities at higher education level do exist since long time, not only at academic but also at industrial/regulatory level. The industry (in particular, systems suppliers and energy providers) organises lifelong training activities for their staff, for example, in the framework of so-called "*training passports*". This is called CPD (*Continuing Professional Development*) and covers a variety of activities, such as: theory (e.g. advanced science and technology) and practice (e.g. internships in different departments) as well as business and communication.

To support CPD at the EU level, Euratom FP-7 in its Work Programme 2008 [66] proposed a number of "*Euratom Fission Training Schemes*" /EFTS/, to be coordinated by teams of academia and "stakeholders". The coordinating team should deliver a kind of "*European quality label*" that comes on top of any national certificate and demonstrates the top-quality of the scheme followed by the students or trainees. Stakeholders could be nuclear industry (case of reactor systems), regulators (case of radiation protection), agencies (case of waste management) or any other private or public organisation that needs new skills in the nuclear arena. The EFTS is a new scheme, leading to a significant development from a pure training and mobility programme to one dedicated rather to structuring training across the EU, taking advantage of synergies between the main stakeholders (in particular, public and private sector). The target audience consists of research workers and professional experts at least at post-graduate or equivalent level, i.e. from nuclear scientist to "captains of industry".

The proposed FP-7 funding scheme is a "*Coordination and Support Action*", that is: the duration should be several years (not a one-week spot action !). For each selected theme, the EU funding will be provided principally for the coordination and networking aspects of the EFTS, i.e. scientific secretariat, implementation of joint training programmes, organisation of training events, mobility of teachers and students, exchange of scientific staff (internships) and/or training facilities, contacts with national authorities to discuss European qualification, etc. Other funding sources should be used to pay the grants for individual fellowships, such as national programmes (both private and public) or EU programmes (e.g. *Lifelong Learning Programme* and *PEOPLE / ex – Marie Curie /* Sections 2 and 3).

A number of pilot sessions should be organised with the following objectives:

* address life-long learning and career development in areas of Nuclear Fission and Radiation Protection, adapting wherever possible the four ENEN principles (modularity and qualification, mutual recognition, mobility and feedback from stakeholders)

* maximise transfer of higher level knowledge and technology (preferably in close connection with research and innovation) with emphasis on multi-disciplinarity and/or inter-sectoral mobility (in particular, internships in the stakeholders' organisations) across the EU

* develop an evaluation methodology, for example, following the IAEA *Systematic Approach to higher level Training* /SAT/ ("*Systematic Approach to Human Performance Improvement in Nuclear Power Plants: Training Solutions*", IAEA-TECDOC-1204, March 2001) [67]

* ultimate objective = develop *European passports for Continuous Professional Development* that will enable high-level nuclear experts to perform their job across Europe, without any administrative or other barrier, and will be a quality label for potential employers.

[66] http://cordis.europa.eu/fp7/dc/index.cfm?fuseaction=UserSite.EuratomDetailsCallPage&call_id=88

[67] http://www-pub.iaea.org/MTCD/publications/PDF/te_1204_prn.pdf

9. TOWARDS A COMMON VISION OF NUCLEAR TRAINING BEYOND ERASMUS: EU INSTRUMENTS FOR MUTUAL RECOGNITION OF CERTIFICATES AND QUALIFICATIONS AMONGST STAKEHOLDERS

Besides the scientific contents of academic curricula, the FP-6 strategic studies (Section 7) discussed also practical problems related to mutual recognition and accreditation across the EU Member States. In the area of education (in particular, universities), ERASMUS provides a series of well tested tools (based on "Bologna"). In the area of training (in particular, continuous professional development), where a great variety of stakeholders are involved, the problem is more complex, because there is no such mechanism as "Bologna". The Radiation Protection community, in particular, examined the problem of mutual recognition of *Qualified Experts* in *Radiation Protection,* in connection with the Euratom *Basic Safety Standards* (ENETRAP project). The appropriate EU instruments could be the European Qualifications Framework (EQF) or/and the Community Directive 2005/36/EC (see below).

Mutual recognition of certificates for lifelong learning in the EHEA

If mobility between EU countries is to be promoted, a European Qualifications Framework [68] is needed for higher education as well as for lifelong learning. This is the scope of the European Qualifications Framework (EQF), adopted by the EP in October 2007 (to be formally adopted by the Council in 2008). The EQF will provide a common language to describe qualifications which will help Member States, employers and individuals compare qualifications across the EU's diverse education and training systems. It is foreseen that Member States relate their national qualifications systems to the EQF by 2010, and that individual certificates or diplomas should bear an EQF reference by 2012 .

Mutual recognition of professional qualifications in the Internal Market

The rights of EU citizens to establish themselves or to provide services anywhere in the EU are fundamental freedoms in the Single Market. National regulations which only recognise professional qualifications of a particular jurisdiction present obstacles to these fundamental freedoms[69]. This fact was recognised by the Internal Market Commissioner who proposed the Community Directive 2005/36/EC, which came into effect on 20 October 2007. In line with the Lisbon strategy of 2000 (Section 1), the purpose of this Directive is to ensure the free movement of qualified persons, thereby contributing to the development of the knowledge-based economy, the flexibility of labour markets and improved public services.

This Directive lays down mechanisms according to which fully qualified professionals in one Member State (MS) will benefit from the recognition of their professional qualifications when willing to exercise the same regulated profession in another Member State. The Directive replaces fifteen existing Directives in the field of the recognition of professional qualifications. A number of changes are proposed compared with the existing rules, including greater liberalisation of the provision of services, more automatic recognition of qualifications and increased flexibility in the procedures for updating the directive.

Automatic recognition is possible only in "Specific Sectors" (mainly in the health sector) where there is clear agreement on harmonised minimum training requirements or on professional experience. Otherwise, the "General System" applies, that is: the host MS compares the qualifications held by the migrant with the qualifications required in the host MS. This Directive applies whenever the profession at stake is regulated in the host MS, which is the case, in particular, of the *"qualified experts" in radiation protection* (see below).

[68] http://ec.europa.eu/education/policies/educ/eqf/index_en.html

[69] http://ec.europa.eu/internal_market/qualifications/index_en.htm.

A practical example: mutual recognition of "qualified experts" in radiation protection

In the Euratom legislation on *Basic Safety Standards*, the Council Directive "96/29/EURATOM" of 13 May 1996 is of particular interest for nuclear training actions. It layed down *basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation* (OJ L-159 of 29/06/96). Two years later in the same context, a European syllabus was proposed concerning the training requirements for the recognition of *"qualified experts" in radiation protection*. This syllabus was laid down in Annex I of Communication 98/C 133/03 (OJ L-133 of 30/04/98) from the Commission concerning the implementation of the above Council Directive 96/29/Euratom. Once the International Commission on Radiological Protection (ICRP) will have issued new recommendations, the above Directive 96/29/Euratom will be revised taking into account operational experience and consolidating the existing *acquis*. This revision of the basic safety standards, however, will not affect the definition of *qualified experts*.

As a consequence, the CEA-INSTN (Saclay, France), in collaboration with other European partners, launched in 2000 the *European Radiation Protection Course* (ERPC) to deliver the theoretical knowledge needed to be recognised as a *qualified expert* on the basis of the above Euratom legislation and of the related IAEA Standard Syllabus. There were, however, strong barriers for the attendance of this ERPC course: in particular, the lack of recognition by the national competent authorities across the EU, the use of rather traditional educational tools and the total costs for participants. This is actually the challenge facing the above mentioned DG RTD project *European Network on Education and Training in Radiological Protection* (FP-6 / ENETRAP, consisting mainly of research organisations – Section 7) in collaboration with the DG TREN platform *European Training and Education in Radiation Protection* (EUTERP, consisting of representatives of the national safety authorities). One of the objectives of the EUTERP Platform is to gather knowledge of the different national criteria for recognition of radiation protection experts and to come to agreement on these criteria, thereby facilitating the free movement of these experts in the EU.

10. CONCLUSION / SCIENTIFIC AND SOCIETAL IMPACT OF EURATOM PROGRAMMES FOR RD&DD AND E&T (DIRECT AND INDIRECT ACTIONS)

In this key note lecture, the following questions were addressed (see also Figure 1):

1) *What are the challenges for Euratom Research and Training in the frame of the European "Higher Education" and "Research" Areas ?*
   and who are the main stakeholders ? (end-users with common needs, decision makers with a common vision, institutions with implementation instruments)

2) *What kind of response is offered by the Euratom RD&DD and E&T programmes in nuclear fission and radiation protection ?*
   and what is their scientific and societal impact ?
   - RD&DD or RD3 for short = Research, technological Development, and engineering Demonstration, industrial Deployment (also called *Innovation Cycle*)
   - E&T = Education and Training

The following categories of stakeholders were identified (actually, most of them are present in the large Euratom research and training programmes):

- the nuclear research organisations (public and private)
- the systems suppliers (e.g. nuclear vendors, engineering companies, etc)
- the energy providers (e.g. electric utilities, heat and/or hydrogen vendors, etc)
- the regulatory bodies and associated technical safety organisations (TSO)
- the education and training (E&T) institutions, and, in particular, the universities
- the civil society and the international institutional framework (IAEA and OECD).

Actually, Euratom research and training should be considered in the wider context of EU Policies, in particular those related to sustainability. *Climate Change and Clean Energy* is the first of seven key sustainability challenges identified by the EU. Nuclear fission is part of the solution and is discussed in various European platforms (SNE-TP, ENEF and HLG).

The Euratom strategy developed by the EU and the main stakeholders is based on an analysis of the common needs (end-users' point of view) and a possible consensus on a European vision (decision makers' point of view). Implementation instruments should then be developed and applied at both EU and national level. At the EU level, the implementation is usually carried out through "indirect Euratom actions" (organised by DG RTD) in synergy with "direct Euratom actions" (conducted by DG JRC). At the national level, the nuclear laboratories and a number of *National Networks for Nuclear Research and Training* are working towards the same objectives (naturally with national nuances).

The following preliminary conclusions can be drawn regarding, in particular, the nuclear training strategy of Euratom:

(a) Identification of end-users and common needs

- to make nuclear (again) attractive amongst the younger generation, training should be maintained as close as possible to RD&DD (*Innovation Cycle*) – Section 1
- to set up lifelong learning programmes at EU level, while optimising international cooperation (third countries), the ERASMUS approach should be followed – Section 2
- to strengthen the synergy between private and public sectors, exchanges of staff across the stakeholders' organisations should be promoted (inter/multi-disciplinarity) – Section 3

(b) Towards a common vision amongst the main stakeholders

- contribute to the Energy Policy for Europe by providing valuable input to the European Strategic Energy Technology (SET) Plan through participation in SNE-TP – Section 4
- optimise Euratom research and training actions by better integration (both vertically and horizontally), sharing of facilities, and policy for knowledge management – Section 5
- develop the European Nuclear Education Network (ENEN) towards all areas of nuclear fission and radiation protection ("young" students and "old" professionals) – Section 6

(c) Implementation instruments at both EU and national level (such as FP-7)

- promote training actions to be embedded in large research projects in all areas, thereby satisfying the needs of research organisations and universities – Section 7
- promote training actions through the synergy between stakeholders' organisations (e.g. EFTS), thereby satisfying the needs of industry as well as regulators – Sections 8 and 9.

Challenges for Euratom Research and Training in the frame of the European "Higher Education" and "Research" Areas

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