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

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ABSTRACT AND KEY MESSAGES

In a rapidly changing world, research and training (R&T) in Science, Technology, Engineering and Mathematics (STEM) is faced with a number of challenges that require a collective effort from all stakeholders involved. Those challenges are, for example, globalisation, climatic and demographic changes, “Sustainable, Competitive and Secure Energy” as well as lifelong learning and borderless mobility for the scientific community. Risk perception and public engagement in programmes which entail uncertainty over costs, safety, environmental protection, life cycle performance, etc. are also important issues. In this context, this lecture focuses on some key achievements of the Euratom programmes in nuclear fission and radiation protection and on future prospects in terms of contents and organisation.

An analysis is proposed of the question “who are the drivers and enablers for changes in Euratom Research and Training ?” The “end-user requirements” are an important driver: they are of scientific-technological type (e.g. the continuous improvement of a common nuclear safety culture world-wide, based on technical and organisational excellence) and of socio-economic type (e.g. the development of an interdisciplinary scientific approach to improve the EU nuclear decision making process). The enablers are the stakeholders providing human and financial resources (e.g. the European Technological platforms) and the Euratom programmes.

Faced with the above challenges, the main stakeholders share a common approach at EU level regarding needs, vision and implementation instruments for R&T in nuclear fission (especially reactor safety), in waste management (geological disposal), in radiation protection (medical applications of ionising radiations). This approach is aligned with the “Europe 2020 strategy for smart, sustainable and inclusive growth”. As a result, a number of important changes are introduced in the next Euratom R&T programme (Horizon-2020), such as:

- contribute to the creation and transfer not only of knowledge but also of skills and competences, taking advantage of instruments developed by three EU policies, namely: research and innovation (DG RTD), energy (DG ENER) and education (DG EAC)
- develop a new governance for Euratom R&T based on further improvements in accountability, participation, predictability and transparency, with a view to promote a new way of “making / teaching science”, closer to the end-users (society and industry).

Finally, this lecture is discussing the conclusion of the EC driven "2012 interdisciplinary Study": “Benefits and limitations of nuclear fission for a low-carbon economy - Defining priorities for Euratom fission research and training (Horizon 2020)”, February 2013.
1 – INTRODUCTION: DRIVERS AND ENABLERS FOR CHANGES IN EURATOM RESEARCH AND TRAINING

- **Drivers = EU policy (top down) and "end-user requirements" (bottom up) / Enablers = European Technological Platforms and Euratom R&T programmes**

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

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

1. **EU policy to improve the synergy within the Knowledge Triangle**

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

- **RESEARCH: “Innovation Union - Turning ideas into jobs, green growth and social progress”** – this Communication lays down the general objectives and Union added value of "Horizon-2020" - The Framework Programme for Research and Innovation

- **ENERGY: “Resource-efficient Europe - Towards a resource-efficient, low-carbon economy”** - this Communication is a further confirmation of the three pillars of the EU Climate and Energy Policy (namely: sustainability, security of supply, competitiveness)

- **EDUCATION: “An agenda for new skills and jobs - Improving employability in a global economy at all education levels”** - this Communication discusses, in particular, EU strategies and instruments to foster lifelong learning and borderless mobility.

As a result of the above Communications, the EC is proposing a strategy, based on a consensus on common needs, vision and instruments, for research and training related to energy. In this lecture, the emphasis is on nuclear fission energy and radiation protection (Euratom programme), and, in particular, on the way to improve the synergy within the Knowledge Triangle, i.e. between (1) research; (2) innovation, (3) (higher) education and training:

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

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

\(^2\) Europe 2020 strategy - [http://ec.europa.eu/europe2020/index_en.htm](http://ec.europa.eu/europe2020/index_en.htm)

The enablers for the changes introduced in the Euratom research and training programme are principally the European Technological Platforms (ETP) and authoritative expert bodies as well as the Euratom R&T programmes. As a result, recommendations as well as resources are provided to the Euratom programmes (FP7 /2007 – 2013/ and Horizon-2020 /2014 – 2020/).

Euratom E&T strategy: consensus on common needs, vision and instruments

Faced with the above challenges, the main stakeholders share in fact a common approach regarding needs, vision and implementation instruments in various areas of EU interest (reactor safety, radioactive waste management /geological disposal/, radiation protection /medical applications of ionising radiations/). The ETPs, in particular, are discussing the above items in a series of official guidance documents such as: “Vision Report”, “Strategic Research and Innovation Agenda” and “Deployment Strategy”. R&T in nuclear fission (with focus on reactor safety and performance), for example, is treated in the Sustainable Nuclear Energy Technology Platform (SNE-TP), comprising over 100 organizations in the EU. Focussing on nuclear education and training (E&T), the consensus can be summarized as follows:

1 – Analysis of needs of industry and society, in particular with regard to nuclear safety culture. E.g. how to better meet the above scientific-technological and socio-economic requirements?
how to define suitable training schemes in terms of "learning outcomes"? what kind of knowledge, skills and competences should be taught? what are the established standards?

2 – Convergence toward a common vision that puts the above E&T needs in a EU perspective. E.g. towards a new way of "making science" in order to better support nuclear decision making processes (aiming at robust, equitable and socially acceptable systems); towards a new governance based on improved accountability, participation, predictability and transparency.

3 – Development of common instruments that respond to the above needs and vision. E.g. ECVET partnerships aiming at mutual recognition of learners’ qualifications (towards freedom of establishment for experts); funding from “Erasmus for all” programme (DG EAC); co-funding of nuclear E&T programmes (e.g. Euratom Horizon-2020, ERC, EIT / KIC, P2P, PPP).

Euratom E&T actions are addressing primarily research and industry workers with higher education, i.e. levels 6 to 8 of the European Qualifications Framework /EQF/ (= bachelor, master and doctorate levels or equivalent, resp.). The focus here is on continuous professional development /CPD/, taking advantage of the governance and best practices for E&T that are proposed in the EU higher education policy. The aim is to continuously improve nuclear knowledge transfer and competence building, in particular by fostering lifelong learning and borderless mobility, thereby facing better the challenges of the employability at EU level.

Making lifelong learning and borderless mobility a reality is one of the objectives of the Education, Youth and Culture policy of the EU – see Council Conclusions on a strategic framework for European cooperation in education and training (“ET 2020”), Brussels, 12 May 2009 4. In this context, the European Credit System for VET (Vocational Education and Training) (= ECVET) was launched and successfully tested in a wide range of service and industrial sectors (including aeronautics and automotive). There are some similarities with the Bologna process for academic education and the associated European Credit Transfer and accumulation System (ECTS). ECVET’s objective is to promote mutual trust, transparency and recognition of learning outcomes, that refer not only to knowledge, but also to skills and competences (KSC), acquired through CPD or VET, and qualified across the 27 EU Member States and associated countries (4).

Lifelong learning requires thus a EU-wide approach for assessing and validating the learners’ qualifications by ad-hoc authorities, taking into account a variety of education and training paths (CPD programmes). Borderless mobility, in particular, implies mutual recognition of learners’ qualifications and freedom of establishment (including for regulated professions), thereby enabling the free circulation of service providers amongst the EU Member States.

Reminder. Not surprisingly, in the nuclear domain, the IAEA training programmes are based on a concept very close to the above KSC. Following the IAEA definition, competence means the ability to apply knowledge, skills and attitudes so as to perform a job in an effective and efficient manner and to an established standard (S.S.S. No. RS-G-1.4 / 2001) 5. Knowledge is usually created in higher education institutions and in (private and public) research organizations. Competences (in particular, skills and attitudes) are usually the result of specific

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training and on-the-job experience throughout professional life (e.g. internships in industry, in services or in governmental bodies). Euratom and IAEA are naturally working together in E&T.

In this context, a number of "Euratom Fission Training Schemes" (EFTS) are being launched in specific areas where a shortage of skilled professionals has been identified. The EFTS is a significant development across the EU, aimed at structuring training and career development along the above ECVET lines. Those training schemes are ambitious CPD programmes (usually 3 years, total budget of circa 1 million Euro each, modular course approach). Portfolios of “learning outcomes” (related to Europass and transcript of records) are discussed with the stakeholders and first attempts are made to develop common EU approaches for assessment and validation. The most advanced Training Schemes are planning to involve European authoritative regulatory expert bodies (e.g. ENSREG or HERCA) to discuss mutual recognition across the EU. It is clear, however, that the above mentioned "Europass" does not constitute a license or an official authorisation (in the legal national regulatory sense).

As a result, the Euratom research and training programme contributes to the creation and transfer not only of knowledge but also of skills and competences, taking advantage of instruments developed by three EU policies: research and innovation (EC Directorate General /DG/ RTD), energy (DG ENER) and education (DG EAC = Education and Culture).

Traditionally, until now, the implementation of the Euratom research and training programmes was left exclusively to the EC, principally in the form of (1) indirect actions (conducted in national laboratories, under the responsibility of EC DG RTD – see CORDIS 6) and (2) direct actions (conducted in the nuclear laboratories of EC DG JRC 7, that is, principally: ITU located in Karlsruhe (DE), and IET distributed between Petten (NL) and Ispra (IT)). The indirect actions under the current Euratom FP7 (2007–2013) are managed as a set of multi-partner projects over several years, using funding instruments such as: collaborative projects, networks of excellence or coordination / support actions. Worth mentioning are the Euratom National Contact Points 8; the NCPS are instrumental to raise information awareness about the plurality of funding opportunities, bringing specific advice to prospective participants in indirect actions.

In the future (Horizon 2020, the successor of FP7), the EU policy is aiming at “externalising” a number of indirect actions. It is generally believed that progress would be facilitated if some initiatives are implemented by the Member States or by the industries interested in them. One of the objectives of Horizon 2020 is to set up P2Ps (Public Public Partnerships) and PPPs (Private Public Partnerships), respectively, and to enable the Commission to focus on programme implementation (as opposed to project management of the FP7 type). Those new implementation instruments will replace gradually the current FP7 instruments. The “externalisation” process will require voluntary (non necessarily EC-cofunded) initiatives from public or/and private stakeholders. In the specific case of Euratom, because of the very limited available EC funding, an even stronger coordination is required regarding governance and financing in order to ensure stability and stronger commitments from the parties involved.

Detailed information about Euratom FP7 projects in reactor safety, geological disposal and radiation protection is available in the proceedings of Conferences co-organised by DG RTD:

7 "The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies" - http://ec.europa.eu/dgs/jrc/index.cfm


**Upcoming events**: Joint FISA 2013 and EURADWASTE 2013 conferences, 14-16 October 2013 - Vilnius, Lithuania. These two events are co-organised by the EC (namely: DG RTD, DG JRC, DG Energy) and the Lithuanian Ministry for Education and Science, under the auspices of the Lithuanian Presidency of the EU (second semester of 2013). Gathering together some 600 key stakeholders in the domain, joint opening and closing sessions will facilitate in-depth discussion on issues and policies in research and development programmes in both reactor systems and radioactive waste management in Europe. There will also be ample opportunity for more domain specific sessions under the separate FISA and EURADWASTE banners.

As far as the preparation of the upcoming Euratom Horizon-2020 is concerned, it is worth mentioning that the EU Council (meeting of 28 June 2011) requested to "organise a symposium in 2013 on the benefits and limitations of nuclear fission for a low carbon economy. The symposium will be prepared by an interdisciplinary study involving, inter alia, experts from the fields of energy, economics and social sciences".

This "2012 interdisciplinary Study" was launched in April 2012: the title is “Benefits and limitations of nuclear fission for a low-carbon economy - Defining priorities for Euratom fission research and training (Horizon 2020)”. It is composed of two parts:

- a scientific-technological part made of 10 Topics (treated by 9 experts in total): EU Energy Policy; SET Plan; Research and Development; Education and Training and Skills; EU Nuclear Safety and Security Aspects; People, quality of life and environment; Safety and Security Culture beyond EU borders; Science based policies and nuclear safety and security legislation; Ethics (separate report); Synthesis report

- a socio-economic part (treated by 16 experts in total) made of responses to 6 questions pertaining to decision making, risk governance and Euratom research (see Section 2.5).

The above 2013 Symposium is called "Nuclear Fission Research for a low carbon economy" (co-organised by EC and European Economic and Social Committee /EESC/, Brussels, 26-27 February 2013). The aim is to discuss the recommendations of the "2012 interdisciplinary Study" with the scientific community (‘hard” and “soft” sciences) and the political decision makers. The Council should then decide (during 2013) about the main orientation of the next Euratom research and training Programme 2014-2018 (as part of the Horizon 2020 package).

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2 – CHALLENGES FOR NUCLEAR EDUCATION AND TRAINING (E&T) IN THE EU

2.1 Euratom research and training: knowledge generation and competence building

It should be reminded that, in the EU, the generation of electricity through nuclear fission is a fact of life – see Annex 1. In the EU, nuclear power stations currently produce more than a quarter of the electricity and more than a seventh of the primary energy consumed in the EU. In 2013, a total of 131 units are operable in 14 Member States, representing a total installed electricity capacity of 122 GWe net and a gross electricity generation of 848 TWh. Twelve MS have given signs that nuclear remains in their longer-term low carbon energy strategy. One Member State (Poland) considers including it in its energy mix and another (Lithuania) is ready to re-introduce it. The sector represents a source of stable and reliable base load, with low carbon levels and relatively stable costs, which makes it attractive from the point of view of security of supply and fighting climate change. It is quite clear that nuclear will remain a part of the energy mix for many decades to come (EU Energy Roadmap 2050 – see Section 5.1).

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

Mankind enjoys many benefits from nuclear-related technologies, most notably electricity production. For generations to come, electrical, medical and other applications of ionising radiations will continue to require highly educated nuclear experts with very specific knowledge, skills and competences (KSC). Nuclear technology activities require in fact an interdisciplinary approach not only in engineering and science but also in policy making and communication. Hence a special effort is necessary to inform the public at large and to improve public engagement in actions related to nuclear decision making.

A key concern of industry and policy makers (in particular, of regulators) world-wide, however, is that human resources could be at risk, especially because of high retirement expectations in "old" countries (with nuclear installations) and a lack of nuclear experience in "new" countries (more than 45 Member States of the IAEA have approached the Agency with an expression of interest). Whether for power generation or for medical applications, highly qualified people are needed over a long time period to build new facilities and / or to safely operate installations, and, in particular, to manage radioactive waste and to deal with radiation protection issues. For that reason, broad and deeply rooted research and training programs, at both national and international level, are essential to the proper mastering of the many disciplines used in the nuclear domain.

Reminder: The life cycle of new nuclear power plants /NPPs/ covers a period of approximately 100 years, from design and construction to dismantling and "green field".

One of the main goals of the Euratom research and training programmes, in compliance with the Euratom Treaty (1957), is to contribute to the sustainability of nuclear energy by generating knowledge (research) and developing competences (training). This twofold objective (research and training) is recalled in every Euratom Council Decisions – see, for example, the heading of

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15 Lisbon Treaty 2007 - Article 194 ..... "Union policy on energy shall aim, in a spirit of solidarity ...:
...... Such measures shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply ".
The FP7+2 Decision. Hence Euratom contributes to the construction of both the European Research Area (ERA) and the European Higher Education Area (EHEA).

The Euratom FP7 research programme is aiming at establishing a sound scientific and technical basis for the safe operation of nuclear systems, the management of long-lived radioactive waste, and the implementation of a robust system of protection of man and environment against the effects of ionising radiation. Here is the list of the Euratom FP7 topics during the period 2007-2013 (focus on indirect actions – DG RTD), subdivided in 3 thematic and 2 cross-cutting areas:

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

The continuous improvement of safety and reliability is thus a key objective of Euratom research and training in nuclear fission, keeping in mind that safety is a process, not a state. Especially after the Fukushima accident, it is ever more necessary to ensure that the international expertise is available to further improve global nuclear safety and, in particular, strengthen emergency preparedness and response. Therefore, a special effort is made at EU level on infrastructures as well as on human resources, mobility and training.

2.2 Scientific-technological and socio-economic challenges in R&T – ENEN association

EU research and training programmes play an important role in the research – development – demonstration – deployment (RDDD) cycle of large projects (see, for example, the "European Strategy Forum on Research Infrastructures" /ESFRI/). Two types of challenges are usually discussed in this context (for nuclear, remember the “end-user requirements” in Section 1):

- Scientific-technological challenges related to applied research and technological development: the funding instrument provided so far by the EU is the RTD Framework Programme (FP) => the main stakeholders are research organisations and industry

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17 ESFRI (created in 2002) has identified 48 projects for new research infrastructures or major upgrades (referring to facilities, resources and related services) - [http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri]
Socio-economic challenges related to engineering demonstration and industrial deployment: the main instruments provided by the EU are political and regulatory incentives => stakeholders are regional / governmental bodies and the society at large.

Some scientific-technological challenges are related to socio-economic and political decisions at the EU level, especially in the area of energy and industry. Those challenges require a specific expertise and associated E&T programmes. The EU “Energy and Climate package” (2007), for example, set the "Objectives 2020/20/20 for 2020", known as the "20-20-20" targets:
- a 20% reduction in EU greenhouse gas emissions from 1990 levels;
- raising the share of energy consumption produced from renewable resources to 20%;
- a 20% improvement in the EU’s energy efficiency.

The accompanying "SET Plan" (2007) and the "Energy Roadmap 2050" (aiming at a reduction of CO₂ emissions by 80–95% of the 1990 level by 2050, with binding targets) are a further elaboration of the above "20-20-20" targets. This is also a confirmation of the three EU energy policy pillars (namely: sustainability, security of supply, competitiveness - see Section 5.1).

As a consequence of the EU energy policy (drastic decarbonisation of the overall energy sector), the energy carrier electricity is expected to become even more important than today and the electricity sector has an effectively zero carbon dioxide (CO₂) emissions objective. Moreover a number of constraints are introduced on the various parts of the electricity supply industry value chain which consists of the generation, transmission and distribution. Such constraints are, for example: taxes, levies, EU emission trading system (ETS) certificates aiming at supporting the strong penetration of (subsidized) renewables; “must run capacity” or priority dispatch of intermittent energy sources; smart distribution grids where the system has to be balanced by the residual conventional power plants (frequent load following operations have a bad impact on plant performance and maintenance costs). The resulting climate of uncertainty (due also to the current economic and financial crisis) does not provide incentives for industry to invest massively in conventional (fossil or fissile energy) power plants.

In this context, research and training actions in nuclear fission and radiation protection at EU level are discussing new priorities, as it was stressed at the above "2013 Symposium (Brussels, 26-27/02/2013)" – see e.g. "Topic 1: EU energy policy" in "2012 interdisciplinary Study" 13:

"Nuclear has ample capability to contribute to the three EU energy policy pillars simultaneously, certainly with more RD&D:
- Nuclear is CO₂ free, if using a good fuel cycle; but its safety record has received a serious dent. Waste management and proliferation controls should be further improved. Better understanding of low-dose effects of radiation could ameliorate its reputation and acceptability.
- Security of supply is offered by resource availability (possibly using fast reactors), stable but dispatchable electricity production facilities capable of load following and large turbine-generators providing inertia to the system, permitting reactive power control for voltage stability.
- Nuclear leads to cheap decarbonisation, if it can keep its investment and operational costs low. Future load following, however, must be examined as an important issue."

It is clear, for example, that work on nuclear education, training and knowledge management at EU level should be conducted not only in the scientific-technological but also in the socio-economic domain. As far as Euratom training is concerned, there are two types of initiatives:
• dedicated interdisciplinary workshops embedded in research and innovation projects, aiming at transferring the main results to the scientific community (NB-1 below)
• Euratom Fission Training Schemes (EFTS) aiming at upgrading CPD programmes, using, in particular, the ECVET instruments (see ENEN below and NB-2 below).

It is worth stressing also the increasing importance of lifelong learning and borderless mobility for students and learners (the new sociology of the workers – e.g. the Y generation - is a concern for Human Resources departments). The latter challenges are at the heart of the European Credit system for Vocational Education and Training (ECVET) 18. Practical information about ECVET and about the mobility of trainers and learners is provided in each Member State by the “ECVET support teams” 19. As a consequence, a better qualification is offered to the next generation of leading European talents, taking advantage of a variety of learning pathways, of the changing multicultural environment and of networks of competences.

The implementation of ECVET in general is monitored by the EU agency Cedefop (depending on DG EAC). At this stage, the main efforts of the ECVET policy are focussing on three issues:

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

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

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

The above mentioned EFTSs are FP7 "coordination actions", taking into account the “end user requirements” (Section 1) and using the instruments developed under the EU policy for education and training (ECTS /Bologna 1999/ and ECVET /Copenhagen 2002/ processes – Section 6). The EFTS projects are thus contributing to the definition of requirements for recognition of certain job profiles or functions. The proposed training schemes consist of portfolios of learning outcomes (made not only of knowledge, but also skills and competences /KSC/) that are needed to carry out the subject job profiles or functions.

To ensure the highest achievable standards for nuclear education and training, a non-profit association was formed in September 2003 (under French 1901 law): it is the European Nuclear

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18 Sources for EU policy in lifelong learning (DG Education and Culture, EAC-executive agency and Cedefop):
- EU instruments for lifelong learning and borderless mobility, and list of National Agencies (32 countries) http://ec.europa.eu/education/lifelong-learning-programme/national_en.htm
- Cedefop - The Cedefop is the "Centre européen pour le développement de la formation professionnelle" or "European Centre for the Development of Vocational Training" - http://www.cedefop.europa.eu/EN/

19 The objective of the ECVET support team is to aid in achieving objectives set by the recommendation of the European Parliament and Council for implementing the ECVET system - http://www.ecvet-team.eu/
Education Network (ENEN) \(^{20}\) - see Annex 2. This legal entity, located at CEA-INSTN Paris, is composed of 64 members (universities, research organisations, industry) from 18 EU Member States + Switzerland, South Africa, Russian Federation, Ukraine and Japan. As far as international collaboration is concerned, ENEN has signed a Memorandum of Understanding (MoU) with the Joint Research Centre (JRC) of the European Commission (EC), with the European Nuclear Society (ENS), with the International Atomic Energy Agency (IAEA), with the Nuclear Energy Agency (OECD / NEA) and with the World nuclear university (WNU). The synergy of ENEN with national E&T networks and with the various European Technological Platforms is also instrumental to the success of Euratom E&T actions.

The ENEN members play a key role in the design and implementation of the above "Euratom Fission Training Schemes" (EFTS). As of March 2013, there were 9 EFTS in total and 3 under negotiation - more are planned in the future, following the standard competitive process of EU research programmes. They are examples of Euratom responses to the need of specific competences, using the above ECVET instruments. Here is their list together with their respective "end-users" and contractual duration (see details in Annex 2):

- TRASNUSAFE - Nuclear Safety Culture: addressing mainly the health physics sector (e.g., ALARA principle in industry and medical field) (November 2010 - October 2014)
- ENEN III Training schemes - Generation III and IV engineering: addressing mainly the nuclear systems suppliers and engineering companies (May 2009 – April 2013)
- ENETRAP II - European Network on E&T in Radiological Protection: addressing mainly the nuclear regulatory authorities and TSOs (March 2009 - December 2012)
- PETRUS II - Program for Education, Training, Research on Underground Storage: addressing mainly the radwaste agencies (15 January 2009 - 14 January 2012)
- CINCH - Cooperation in education In Nuclear Chemistry: addressing mainly the sectors of the nuclear fuel cycle and site rehabilitation (February 2010 - January 2013)
- CORONA - Regional Center of Competence for VVER Technology and Nuclear Applications: focus on VVER personnel (December 2011 – November 2014)
- GENTLE - Graduate and Executive Nuclear Training and Lifelong Education: focus on synergy between industry – academia (January 2013 – December 2017)
- NUSHARE – Project for sharing and growing nuclear safety competence: focus on 3 target groups (policy makers; nuclear regulatory authorities; industry) /2013 – 2016/.

- CINCH-II - Cooperation in education and training In Nuclear Chemistry: focus on the European master's degree in nuclear and radiochemistry (NRC EuroMaster) (3 years)
- PETRUS III - Implementing sustainable E&T programmes in the field of Radioactive Waste Disposal: focus on a “Competency-Based Curriculum” for EuroMaster (3 years)

The implementation of ECVET (in particular, the KSC approach) in the nuclear sector is well advanced in a number of the above EFTS. Here is a non-exhaustive list of examples: "Fluid System Construction and Commissioning Engineers" (ENEN III), "Radiation Protection Experts" (ENETRAP II) and "Medical Physics Experts" (EUTEMPE RX) - see Annex 2.

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\(^{20}\) European Nuclear Education Network (ENEN) - [http://www.enen-assoc.org](http://www.enen-assoc.org)
As far as borderless mobility is concerned amongst experts of nuclear power plants and fuel cycle facilities, it is worth drawing the attention to a specific obstacle, namely: in some countries, a national licensing process is requested for specific safety-related jobs (usually with qualifications at higher education level). A preliminary list of those "regulated" jobs was provided in 2011 through a survey conducted in the project ENEN III (Annex 2), for example:

- **SPAIN** (CSN): reactor operator, shift supervisor, chief of radiological protection service
- **UK** (HSE / ONR): HM inspector, nuclear waste assessor (environment agency)
- **FINLAND** (STUK): manager of NPP, reactor operator, emergency response manager.

**NB-1** Dedicated interdisciplinary workshops embedded in research and innovation projects

Training workshops, open to the scientific community at large, are encouraged in all Euratom FP7 RTD projects. In this context, a number of doctoral schools were launched, such as:

- **EUROTRANS** (FP6) /2005-2010/ - "European Research Programme for the Transmutation of High Level Nuclear Waste in an Accelerator Driven System"
  (47 participants from 14 countries / total project value = euro 43 M, including EC contribution of euro 23 M): 10 internal training courses for doctoral and master students
- **HPLWR** (FP7 project) /2006 – 2010/ - "High Performance Light Water Reactor"
  (10 participants from 8 countries / total project value = euro 4.65 M, including EC contribution of euro 2.5 M): more than 20 bachelor or master theses and more than 10 doctoral theses on HPLWR (= SuperCritical Water Reactor /SCWR/) technologies – see project summaries in proceedings of FISA-2006 and FISA-2009 conferences.

**NB-2** Socio-economic challenges treated in some EFTS (e.g. GENTLE and NUSHARE)

As far as socio-economic challenges are concerned, the above GENTLE project will produce a training module called "Understanding Nuclear Power". This module will provide a general introduction to nuclear energy, both from a societal, economical and technical point of view, covering, for example, the fundamentals in the fields of economics and electricity markets. One of their partners is particularly qualified to teach in technology and economics (Lappeenranta University of Technology - in the context of the new nuclear build projects in Finland).

The above NUSHARE project is a "Training and Information programme, drawing the lessons from Fukushima". It is a “coordination action” of 4 years, under the leadership of ENEN. The main objective is to share and grow across the EU the nuclear safety culture in all nuclear installations and in all applications of ionizing radiations (in line with the conclusions of the “stress tests”). A training and information programme will be conducted in all Member States interested, targeting three groups of “learners”: (1) policy makers (including the radio-medical community); (2) nuclear regulatory safety authorities and TSOs; (3) industry (systems suppliers and energy providers). The synergy with the stakeholders will be ensured through regular contacts with the Technological Platforms and authoritative expert bodies concerned. A number of “associated stakeholders” are expected to implement the NUSHARE programme in their respective countries. Collaboration with non-EU countries is welcome – see Annex 2.

2.3 Technological Platforms to support Euratom research and training programmes

21 Excerpt of Work Programme 2013 / II.2.5 Activity: Human Resources and Training: "A significant part of the support for human resources and training will continue to be implemented by encouraging the embedding of this support within the funded projects. It is considered that 5% of the total budget of these should be dedicated to training activities." [ftp://ftp.cordis.europa.eu/pub/fp7/docs/euratom/euratom-wp-201301_en.pdf](ftp://ftp.cordis.europa.eu/pub/fp7/docs/euratom/euratom-wp-201301_en.pdf)
The European Technological Platforms and other authoritative expert bodies play an increasingly important advisory and implementation role in the Euratom research and training programmes (based on a consensus on common needs, vision and instruments – Section 1) 22. Their respective “Vision Reports” are particularly interesting to understand the objectives fixed to the scientific communities associated (reactor safety; waste management /geological disposal/; radiation protection /medical applications/) – see excerpts in Annex 3.

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

Nuclear fission in the EU is discussed most notably in the Sustainable Nuclear Energy Technology Platform (SNE-TP), launched in September 2007. The SNE-TP aims at promoting research, development and demonstration that will maintain excellence in fission technology and provide long-term waste management solutions. In May 2009, they published a Strategic Research and Innovation Agenda (SRIA) – updated in February 2013. They presented their Deployment Strategy (DS) in May 2010. The SNE-TP is composed of over 100 organizations from 21 countries (20 EU Members States and Switzerland). Members of SNE-TP have established in November 2011 an international non-profit making organisation under 1921 Belgian law: the Nuclear GENeration II & III Association (NUGENIA) 23. The aim is to provide a single framework for collaborative research and development concerning Generation II & III nuclear systems (62 members as of February 2013). The SARNET network which is drawing the lessons from Fukushima, will be integrated in NUgenIA (= “Severe Accident Research network of excellence”, coordinated by IRSN, France, in FP6 and FP7).

The Implementing Geological Disposal Technology Platform (IGD-TP) was launched in November 2009. It provides the necessary focus in the lead up to the operation of geological repositories for high-level nuclear waste in Europe (SRA in 2011, DS 2011-2016 in 2012).

The EU research strategy for radiation protection is in the hands of the Multidisciplinary European Low Dose Initiative. MELODI is actually a non-profit making association focussing on research related to the impact of low dose radiation (including the competing theories of “linear no-threshold” /LNT/ model and “hormesis”). Their SRA is under development. A number of short courses on research into radiobiological effects of exposure to low doses of

22 List of European Technological Platforms (reactor safety, radiation protection, geological disposal, etc)
- SNE-TP = “Sustainable Nuclear Energy Technology Platform” - http://www.snetp.eu/
- IGD-TP = ”Implementing Geological Disposal of Radwaste TP” - http://www.igdtp.eu/
- MELODI = ”Multidisciplinary European Low Dose Initiative” - http://www.melodi.eu/

23 NUClear GENeration II & III Association (NUGENIA) - http://www.nugenia.org/
ionising radiation are offered in the framework of FP7 research projects and EFTS. The Journal NATURE (Vol 482, 02/02/2012) 24 recognised that, through this platform, Europe is making a good start on learning about the health risks of low-dose radiation with a programme to share cold-war data and set research priorities, "but the effort needs to be global".

Another important contributor to Euratom energy policy and legislation is the European Nuclear Energy Forum, launched in November 2007 (ENEF has three Working Groups: “Opportunities”; “Risks”; “Transparency”). With regard to the need for a better understanding of the skills gaps in the nuclear industry and in research organisations, the ENEF (WG “Risks”) was active in the creation of the European Human Resources Observatory - Nuclear Energy (EHRO-N) 25: the implementing agent of the EHRO-N is EC DG JRC IET (Petten). The EHRO-N published, for example, in May 2012 an authoritative report about the shortage of nuclear skills: "Putting into Perspective the Supply of and Demand for Nuclear Experts by 2020 within the EU-27 Nuclear Energy Sector".

With regard to safety enforcement, an important role is played by the European Nuclear Safety Regulators Group (ENSREG), launched in October 2007, which is composed of senior officials from national nuclear safety authorities. This Group focuses on nuclear safety (they were also in charge of the specification of the EU “stress tests”), waste management and spent fuel, in synergy with the "Western European Nuclear Regulators Association" (WENRA) 26, the network of Chief Regulators of EU countries with nuclear power plants (+ Switzerland). Another important association is the “Heads of European Radiological protection Competent Authorities Association” (HERCA), created in 2007. Their fields of competence cover radiological protection during the design, construction, operation and decommissioning of nuclear installations, the transport, as well as the storage and use of radioactive materials and ionizing radiation for industrial, medical, veterinary and research purposes.

The above stakeholders groups are also instrumental in the design and implementation of nuclear E&T actions. For example IGDTP: they have a Cross-cutting Activity called "Competence Maintenance, Education and Training" (CMET working group). MELODI is in the process of creating a working group dedicated to E&T in low dose radiation risk (based on the latest research results). The ENEF group "Risks" has a Subgroup "Education" providing a.o. a collection of educational school material (in collaboration with the CAPTURE programme of JRC IET, Petten). Finally SNE-T/ is also active in this domain: they agreed that work on "Education, Training and Knowledge Management" should be an important cross-cutting activity (ETKM working group co-chaired by ENEN). Of particular interest is the collaboration of the latter SNE-T/ / ETKM working group with:

- the European Atomic Forum (FORATOM) 27 which is the Brussels-based trade association for the nuclear energy industry in Europe
- the European Nuclear Society (ENS) 28, also Brussels-based, which is aimed at fostering engineering E&T as well as sponsoring conferences devoted to nuclear applications.

2.4 Externalities and risk governance: best available science to support decision making

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24 Journal NATURE (Vol 482, 02/02/2012) - http://www.nature.com/nature/journal/v482/n7383/pdf/482005a.pdf
26 Western European Nuclear Regulators Association (WENRA) - http://www.wenra.org/
27 Foratom is make up of 17 national nuclear associations (nearly 800 firms in total) - http://www.foratom.org/
28 ENS is the federation of 23 nuclear societies (“from the Atlantic to the Urals”) - http://www.euronuclear.org/
Externalities: An externality is commonly defined as a cost that arises when the social or economic activities of one group of persons have an impact on another group and that impact is not fully accounted for by the first group. During the operation of a power station, there are some emissions which cause damages to human health, crops and materials among others, generating an externality because the resulting impacts are not taken into account by the generator. Externalities also arise in other stages of the fuel cycle, up and downstream, such as the mining and processing of the fuels, the construction of the plant, the waste treatment and the final decommissioning. Thus, to fully calculate the external costs, all the main impacts from all the stages have to be considered.

The above definition of externalities comes from the FP6 project EUSUSTEL (2005 - 2006) 29. They introduced the concept of total social cost of electricity generation, that is: the summary of the private and external costs of a technology based on its use of resources from an economic and environmental point of view. It can be regarded as a relative measure for sustainability. Their analysis showed that with current knowledge (2006) about technology potential and performance improvements, nuclear power seems to be the single most important option: (1) to reduce the GHG emissions of the electricity sector; (2) to alleviate the import dependence of natural gas and coal; (3) to obtain least cost effects on electricity costs under climate constraints. A new socio-economic analysis of energy externalities with updated figures and methodologies for the life cycles of all energy sources at EU level would be welcome.

The evaluation of externalities becomes increasingly important in the context of the good governance (so-called "modern" criteria of accountability, participation, predictability and transparency) that is now requested for risk-related decisions in many domains. This is a complex issue, encompassing scientific as well as non-scientific aspects (e.g. personal biases, a priori commitments, emotional involvement). The aim is to (re)build a public confidence climate in the energy mix debate. The conclusion could be that the use of nuclear energy is indeed beneficial, responsible and sustainable under certain conditions.

Risk governance: Governance refers to the actions, processes, traditions and institutions by which authority is exercised and decisions are taken and implemented. Risk governance is a systemic approach to decision making processes usually associated to natural and technological risks, based on the above "modern" criteria and the principles of mitigation and sustainability. Risk governance applies the principles of good governance to the identification, assessment, management and communication of risks.

Let us remind that risks accompany change and thus are a permanent and important part of life. The willingness and capacity to take and accept risk is crucial for achieving social and economic development. Many risks, and in particular those arising from energy generation technologies, are accompanied by potential benefits and opportunities. As a result of good governance, individuals and societies will be able to benefit from change while minimising the negative consequences of the associated risks.

If the risk is of a global, systemic nature, cohesion is necessary between countries and all stakeholders should be included (in particular, government, industry, research, academia and

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29 FP6 project EUSUSTEL ("European Sustainable Electricity; Comprehensive Analysis of Future European Demand and Generation of European Electricity and its Security of Supply", 2005 – 2006).
= complementary to project NEEDS ("New Energy Externalities Developments for Sustainability", 2004 - 2009)
civil society). Of particular interest in this context is the *International Risk Governance Council* (IRGC)\(^{30}\): their purpose is to help improve the understanding and governance of systemic risks that have impacts on human health and safety, on the environment, on the economy and on society at large. The IRGC is currently working on “Integrative Risk Management” and on “Future Resilient Systems”, in collaboration with the ETH Zurich Risk Centre.

*Best Available Science /BAS/.* The analysis of externalities and the associated debate about the pros and cons of every option in the energy mix are challenges that require a concerted effort to describe these complex issues in a language that is understandable to a knowledgeable non-specialist or, better yet, to an average person. Risk governance, in particular, is a difficult issue, not the least because it includes societal objectives, ideology, beliefs, and numerous other non-scientific issues. Some governmental and industrial organisations have an extensive science programme to support their decision making process. As accountability, participation, predictability and transparency are important issues (see above "modern criteria"), in particular, for governmental decisions, a re-visitiation might be needed of the scientific foundation, for example, of some EU policies and regulatory activities.

As a consequence, a new way of "making / teaching science" at EU level (in particular, how to select the *Best Available Science /BAS/*) might be needed in any decision making process aiming at robust, equitable and socially acceptable systems. This is valid in general for the regulators – see, for example, *"the establishment of regulatory science"*\(^{31}\) by Moghissi – and, in particular for regulatory decisions related to nuclear fission and radiation protection.

2.5 "2012 Study - Benefits and limitations of nuclear fission for a low carbon economy"

In view of their decision on the Euratom part of Horizon-2020, the EU Council (meeting of 28 June 2011) requested that the Commission *"organise a symposium in 2013 on the benefits and limitations of nuclear fission for a low carbon economy. The symposium will be prepared by an interdisciplinary study involving, inter alia, experts from the fields of energy, economics and social sciences"*.\(^{13}\)

As a consequence, as it is explained in Section 1, the "2012 Interdisciplinary Study - Benefits and limitations of nuclear fission for a low carbon economy: Defining priorities for Euratom fission research & training (Horizon 2020)" was launched (under the responsibility of DG Research and Innovation, Directorate K / Energy – Unit 4 Fission) in April 2012. This study is composed of two parts: a scientific-technological and a socio-economic part. The Terms of Reference (ToRs) of this interdisciplinary study were oriented towards answering “why – and how – continue developing research and training activities in nuclear fission and radiation protection at EU level?”.\(^{13}\)

The subject “2012 Interdisciplinary Study” has been published on the occasion of and presented at the 2013 Symposium *"Nuclear Fission Research for a low carbon economy"* (EC and EESC Brussels, 26-27 February 2013)\(^{13}\). Special attention was devoted to the 10 recommendations

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\(^{30}\) IRGC is a non-profit and independent foundation, supported by the Swiss Government and hosted by the EPFL - [http://www.irgc.org/][1] - ETH Zurich Risk Centre - [http://www.riskcenter.ethz.ch/research/projects/sec][2]

made by the experts and addressed to the EU Council. Conclusions were drawn about their implementation in the Euratom Horizon-2020 programme – see Annex 4.

- **Scientific-technological part of the “2012 Interdisciplinary Study” (9 experts + BEPA/EGE)**

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

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

A total of 9 experts were selected to treat the above Topics and to draft the synthesis report. In fact, topic "(9) Ethics" was treated separately: Mr Barroso requested on 19/12/2011 the opinion of the European Group on Ethics in Science and Technology (EGE – a team around the Bureau of European Policy Advisers /BEPA/) to contribute to the debate on a sustainable energy mix in Europe by studying the impact of research on different energy sources on human well-being.

- **Socio-economic part of the “2012 Interdisciplinary Study” (16 experts + written evidence)**

For the socio-economic part, a total of 6 Questions were asked, pertaining to three main domains, namely: (1) decision making, (2) risk governance, (3) Euratom research. A number of socio-economic scientists (16 in total) were selected. The civil society was also represented (including interest groups and NGOs) as follows: (1) by the EESC (European Economic and Social Committee) who is co-organising the "2013 Symposium" with the EC; (2) by some of the scientific-technological experts who used to be national regulatory experts (e.g. Topics 3, 5 and 8); and (3) by experts of the various Technological Platforms and authoritative expert bodies concerned as well as by non-EU experts who produced written evidence.

3 - **Political framework: "Europe 2020 strategy", Lisbon Treaty and Euratom Treaty**

3.1 "Europe 2020 strategy" for smart, sustainable and inclusive growth (March 2010)

The "Europe 2020 strategy" 2 has fixed a number of targets, related to Employment; R&D; Climate change and Energy; Education; Poverty and Social Exclusion. Its implementation goes through seven **Flagship Initiatives** 3, aiming at smart, sustainable and inclusive growth:

- **Smart growth** (Digital agenda for Europe + Innovation Union + Youth on the move)
- **Sustainable growth** (Resource efficient Europe + Industrial policy in global context)
- **Inclusive growth** (An agenda for new skills and jobs + EU platform against poverty).

The programme of Euratom research and training under Horizon-2020 is based principally on three of the above Flagship Initiatives (reflecting the Knowledge Triangle – Section 1), namely:
Many initiatives were launched to deliver on those Flagship Initiatives. For Euratom research and training, the most important initiatives are the following:

- **RESEARCH:** "Horizon 2020"[35] - The Framework Programme for Research and Innovation / Communication COM(2011) 808 (Brussels, 30.11.2011) / connected, in particular, to the above "Innovation Union" – details in Section 4

The proposed programmes and funding budgets for the "Europe 2020 strategy" are available in the "Multiannual Financial Framework", presented in 2011 by the EC to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - see "A Budget for Europe 2020"[38] / COM(2011) 500 (Brussels, 29.6.2011). This budget however is subject to changes following the European Council of 7-8 February 2013 that ended with a deal on the EU financial plan for 2014-2020 (next step: approval by the European Parliament)[39]. The deal limits the maximum possible expenditure for a European Union of 28 Member States to EUR 959.99 billion in commitments, corresponding to 1.0% of the EU’s Gross National Income. This means that the overall expenditure ceiling has been reduced by 3.4% in real terms, compared to the current MFF (2007-2013). This is to reflect the consolidation of public finances at national level. This is the first time that the overall expenditure limit of a MFF has been reduced compared to the previous MFF. The ceiling for overall payments has been set at EUR 908.40 billion, compared to EUR 942.78 billion in the MFF 2007-2013.

### 3.2 Lisbon Treaty (2007) - the EU is a community of shared values

The European Union is a community of shared values that are predominantly defined politically. According to the Treaties, the EU is founded "on the principles of liberty, democracy, respect for human rights and fundamental freedoms, and the rule of law". A number of "common ideals" were recalled in the Berlin Declaration, adopted on 25 March 2007 to mark the EU's 50th anniversary. In all EU policies, special attention is also devoted to ethical principles (and relevant legislation), such as: the principle of proportionality, the right to

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privacy, the right to the physical and mental integrity of a person, and the need to ensure high levels of human health protection as well as the exclusive focus on civil applications. EU actions should also follow the principles relating to the equality between women and men. (see TEU = Consolidated Version of the TREATY ON EU, Official Journal of the EC - C 325 - Brussels, 24.12.2002 / in particular, Articles 2, 3 and 6) 40

In a rapidly changing world, Europeans look to the EU to address issues such as globalisation, climatic and demographic changes, security and energy. The Lisbon Treaty 41 of 2007 is to some extent the EU response to some of these public expectations. It entered into force on 1 December 2009 and took over a great number of innovations proposed in the original EU Constitution (2005).

In the Treaty of Lisbon, the distribution of competences in various policy areas between Member States and the Union is explicitly stated in the following three categories (Articles 3, 4, 5 of TFEU): (1) exclusive competence; (2) shared competence; (3) supporting competence. "Supporting competence" means that "The Union can carry out actions to support, coordinate or supplement Member States' actions". (see TFEU = Consolidated Version of the TREATY ON THE FUNCTIONING OF THE EU, EC Official Journal - C 115 - Brussels, 9.5.2008) 42.

Education and vocational training fall under "supporting competences". Title XII (Arts 165 and 166) of TFEU refers explicitly to education and vocational training. For example, Art 166(2) states: “Union action shall aim to: — facilitate adaptation to industrial changes, in particular through vocational training and retraining, ...”. Education is actually one of the few competences left almost entirely to the national or regional level in the EU Member States. As a consequence of the Treaty of Lisbon, EC financial contribution to E&T actions (just like youth and sport) is authorized only if the EU added value is clearly demonstrated: for example, aiming to increasing the EU-wide coordination of E&T, by harmonising the national qualifications systems and improving the mutual recognition of learning outcomes (ECTS, EQF, ECVET, EQARF, Europass, etc).

As far as research and technological development are concerned, Article 4 of TFEU states that it is a "shared competence", notably: “3. In the areas of research, technological development and space, the Union shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs.” . Worth noting is that also energy falls under "shared competences".

3.3 Euratom Treaty - legislative framework for nuclear research and training in the EU

Energy played a key role in the construction of the European Union. Two of its founding treaties deal directly with energy: the European Coal and Steel Community (ECSC, 1951), and the European Atomic Energy Community (Euratom) 43 created in 1957 (Treaty of Rome). It is worth recalling that Euratom continues to be based on a distinct Treaty (Protocols 1 and 2 annexed to the Treaty of Lisbon, OJ 2007 C 306/165 and 199).
The purpose of the Euratom Treaty is clearly set out in its Preamble, first article: it is the peaceful development of atomic energy. The signatories of the Euratom Treaty (i.e. 6 founding States in 1957) are “RECOGNISING that nuclear energy represents an essential resource for the development and invigoration of industry and will permit the advancement of the cause of peace, and .. DESIRING to associate other countries with their work and to cooperate with international organisations concerned with the peaceful development of atomic energy.”

Of particular interest in the Euratom Treaty is the second title that contains the core of the treaty on how cooperation in the field is to take place. It sets out the provisions to encourage progress in the field of nuclear energy (promotion of research, dissemination of information, health and safety, ... joint undertakings, ... safeguards, ... external relation ...).

Article 4.1 of the Euratom Treaty reads: “The EC is in charge of promoting and facilitating nuclear research activities in the MSs and to complement them through a Community Research and Training programme”.

Article 6d of the Euratom Treaty reads: “To encourage implementation of (national) research programmes, the EC can:

- bring financial support to research contracts,
- provide to MSs, people or enterprises, facilities, equipments or expert assistance,
- stimulate joint financing (from MSs, people, enterprises)”.

Article 7 is the legal basis for the Community research and training programme (i.e. indirect actions in national laboratories under DG RTD and direct actions in DG JRC laboratories).

A number of Council “Conclusions” and “Directives” (with binding value) are regularly issued under Euratom - some are dealing with nuclear education and training, such as:

- Conclusions of the EU Competitiveness Council of 13 November 2008 44
  The Council encourages the Member States and the Commission to establish a "review of professional qualifications and skills” in the nuclear field for the European Union and invites the European Commission and the Member States to provide regular information about existing programmes devoted to basic higher education (university level or equivalent) as well as continuous professional development.

  The above-mentioned European Human Resources Observatory in the Nuclear Energy Sector (EHRO-N) 25 contributed to the drafting of this Communication. The Commission plans to report regularly on EU initiatives to improve education and training. In this context, a new EC Communication is planned by the end of 2013 in collaboration with the above EHRO-N.

  This EU Directive constitutes a major step toward achieving a common, legally binding framework and a strong nuclear safety culture in the EU. Article 7 is devoted to "expertise and skills in nuclear safety” and states the following: "Member States shall ensure that the national framework in place requires arrangements for education and training to be made by all parties

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for their staff having responsibilities relating to the nuclear safety of nuclear installations in order to maintain and to further develop expertise and skills in nuclear safety.” A new version is under preparation, drawing the lessons from the "stress tests" after the Fukushima accident.

Excerpt: Whereas (38) "Maintenance and further development of competences and skills in the management of spent fuel and radioactive waste, as an essential element to ensure high levels of safety, should be based on learning through operational experience." ……
Article 8 is devoted to "Expertise and skills - Member States shall ensure that the national framework requires all parties to make arrangements for education and training for their staff, as well as research and development activities to cover the needs of the national programme for spent fuel and radioactive waste management in order to obtain, maintain and to further develop necessary expertise and skills."

- "Basic Safety Standards" - Proposal for a COUNCIL DIRECTIVE laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation (Brussels, 29.9.2011) 48 - revised Directive to be adopted in 2013
Of particular interest is the incorporation in the revision of a new chapter specifically covering E&T, namely "Requirements for radiation Protection Education, Training and Information". Amongst other things, this chapter will require Member States to have systems in place for the education, training and recognition of "Radiation protection experts" (Article 84), of "Medical physics experts" (Article 85) and of "Radiation protection officers" (Article 86) – more information on the EUTERP website 48 and in the FP7 EFTS project EUTEMPE RX (Annex 2).

As far as future Euratom legislation is concerned, legal provisions should further enhance the role and independence of national regulators, as well as improve transparency of regulatory decisions and operating practices. New EU legislation could also define common criteria for siting, design, construction and operation of NPPs. In terms of emergency preparedness and response, EU Member States should consider expanding cross-border nuclear risk management plans to prepare better for an emergency and to coordinate their response actions. As far as waste management is concerned, the EC’s focus is on assisting Member States in drafting national waste and spent fuel management programmes. The EC is also monitoring the funding regimes in the Member States in view of properly applying the "polluter pays" principle.

3.4 “Stress Tests” and international collaboration in nuclear safety and security culture

International (non-EU) collaboration has long been at the core of EU activities in nuclear energy research and training, as it forms part of the 1957 Euratom Treaty. A remarkable international collaboration exists since decades with the IAEA and OECD/NEA.

After the 1986 Chernobyl accident, the notion of safety culture took root in the International Nuclear Safety Group (INSAG) of the IAEA. The international safety concern is summarized in the notable warning: “A (severe) nuclear accident anywhere is an accident everywhere.” INSAG maintains that the establishment of a strong safety culture within a nuclear facility is one of the fundamental management principles needed for safe operation. The INSAG-4

and “European Training and Education in Radiation Protection” (EUTERP) foundation - http://www.euterp.eu/
definition recognizes that "safety culture has two general components. The first is the necessary framework within an organization and is the responsibility of the management hierarchy. The second is the attitude of staff at all levels in responding to and benefiting from the framework." This is of course coherent with the IAEA definition of nuclear competence (see Section 1). It should be stressed that safety culture is essential not only for nuclear plant operators in industry but also for radiation physicists in hospitals or research workers in nuclear laboratories, and in many other sectors involving ionising radiations.

After the Fukushima accident (Great East Japan Earthquake, 11/03/2011), the European Council requested on 24/25 March 2011 that the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk and safety assessment ("stress tests"). These “stress tests” are defined as targeted reassessments of the safety margins of nuclear power plants, developed by ENSREG, including the EC. As security threats are not part of the mandate of ENSREG, a two-track process has been developed. The “safety track” covers extraordinary triggering events and the consequences of any other initiating events potentially leading to multiple loss of safety functions requiring severe accident management. Regarding the “security track”, COREPER (Brussels-based group made up of the heads of mission from the EU Member States) decided on the establishment of the Ad Hoc Group on Nuclear Security.

All the operators of NPPs in the EU had to review the response of their nuclear plants to those extreme situations. The operators’ reports were first reviewed by the national nuclear regulators. They then prepared summary national reports. The final national reports have been reviewed by Review Teams (peer review process set up by ENSREG). The ENSREG Summary Report was endorsed on 26 April 2012 with the 17 country specific peer review reports attached to it. As soon as the peer review process started, the public and stakeholders were provided with the opportunity to engage in the “stress tests”. A report was submitted to the European Council in October 2012. Following on from the safety reassessments’ process, ENSREG published an Action Plan in August 2012, according to which national regulators were required to prepare their national action plans by the end of 2012 in order to implement the recommendations of the safety reassessments. The action plans will be peer reviewed during an ENSREG Workshop in Brussels on 22-26 April 2013 - see Annex 5.

Actually a large international effort is being dedicated to the understanding of what happened at the Fukushima NPPs and how the subsequent response (e.g. legislative changes and research programmes) should be organised. Worth mentioning in this context is the declaration "EU Action on Nuclear Safety" of EC President Mr José Manuel Durão Barroso at the Nuclear Security Summit of Seoul, South Korea, 26-27 March 2012. Here is an excerpt:

"...... Safety, security and non-proliferation are absolute priorities for the European Union. .......
In the wake of the Fukushima tragedy, Europe has taken the lead in defining and carrying out comprehensive risk and safety assessments of all nuclear power plants in the EU. We are conducting these tough "stress tests" on the basis of an agreed methodology, which can serve as a model for our partners.

These stress tests are unique, in particular since all EU countries have agreed to subject their nuclear power plants to additional assessments, and because citizens and civil society organisations are involved in the process."

In the interest of a stronger global safety culture, the EC will actively share the results of the stress tests. And we encourage our international partners to do the same.

We should also agree that only the best available technologies will be used for nuclear construction. Power plants that will operate for the next 50 to 60 years must not use yesterday’s technology.

We offer our stress test process as a starting point. We will also give financial support through the EU Instrument for Nuclear Safety Cooperation, which currently has an overall volume of half a billion Euros.

In short: The EU is totally committed to boosting nuclear safety and I urge the strongest possible, common and truly global approach. We all stand to benefit from such progress.

It is indeed worth recalling that the EU cooperates beyond its neighbourhood towards nuclear safety and security at global level. Under the Instrument for Nuclear Safety Cooperation, the EU has established cooperation with some 15 countries worldwide, aimed at the promotion of a high level of nuclear safety, radiation protection and the application of efficient and effective safeguards of nuclear material. In this framework, several joint projects are developed with the IAEA. For example, DG DEVCO (Development and Cooperation - EuropeAid) is working with EU neighbourhood and Russia on nuclear training 52.

The Euratom education and training programmes (including the above mentioned Euratom Fission Training Schemes under FP7 – Section 2.2) take into account, wherever appropriate, the guidance proposed by international organisations, such as:

- **IAEA – International Atomic Energy Agency** 53: for example, the IAEA has many projects concerning knowledge management in nuclear energy. They offer a selection of world-wide information and manage an Internet Directory of Nuclear Resources. In 2000, the IAEA published, in particular, guidance about the development, implementation and evaluation of training programmes covering both technical and non-technical skills of NPP personnel (IAEA Systematic Approach to higher level Training - SAT in short). Typically, SAT is organized into five distinct phases of Analysis, Design, Development, Implementation, and Evaluation, and relies on Feedback as a process for continuous improvement. In 2012, the IAEA has updated their strategies and policies for nuclear knowledge management, taking into account five main characteristics: Complexity; Cost; Timescale; Cooperation; and Education. This knowledge will be needed by several generations of the workforce during the lifetime of the nuclear energy programme. IAEA is also active in organising workshops addressing specifically the emerging countries interested in nuclear (item 3 of Annex 1).

- **OECD/NEA / Nuclear Energy Agency of the OECD**: for example, the NEA established an ad-hoc expert group on Education and Knowledge Management at the end of 2009, involving 23 experts representing 15 countries, EC and IAEA. The group produced a

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- **WNU – World Nuclear University** 55: it is a global partnership committed to enhancing international education and leadership in the peaceful applications of nuclear science and technology. The central elements of the WNU partnership are: the global organizations of the nuclear industry, the inter-governmental nuclear agencies (IAEA and OECD/NEA) and leading institutions of nuclear learning in some third countries. The WNU was inaugurated in 2003. ENEN has signed a MoU with WNU in 2005.

- **ISNL - Montpellier International School on Nuclear Law** 56: the ISNL was established in 2001 by the OECD/NEA and the University of Montpellier (France) and benefits from the support of the IAEA. Its objective is to provide a high quality, intensive course in international nuclear law to law students at doctoral or master level and to young professionals in the nuclear sector who wish to develop their knowledge.

- **G8 "Nuclear Safety and Security Group"** (NSSG, created at the G8 Kananaskis Summit, Alberta, Canada, June 2002): in July 2009, at the G8 summit of L’Aquila, Italy, the emphasis was put on "Nuclear Education and Training – Institutional Capacity Building" 57, focused on safety and security in countries embarking on or expanding nuclear programmes. As a result, the IAEA and the EC are organising joint E&T actions.

4 – "**INNOVATION UNION**" - TURNING IDEAS INTO JOBS, GREEN GROWTH AND SOCIAL PROGRESS

4.1 Excellent science, Industrial leadership and Societal challenges under Horizon 2020

The above mentioned communication "**Horizon 2020 - The Framework Programme for Research and Innovation**" (COM(2011) 808 Brussels, 30.11.2011) 35 is aligned with the **Innovation Union** strategy. **Horizon 2020** is the follow-up of FP7 (2007 – 2013): it is the Commission proposal for a Euro 80 billion funding programme for research and innovation ("**Common Strategic Framework for Research and Innovation (CSF)**" 2014 - 2020), including the Euratom programme. **Horizon 2020** is a part of the MFF (actually under item no 1 **Smart and Inclusive Growth**) 38. Following the revision of the EU financial plan for 2014-2020 (European summit of 7-8 February 2013 39), a budget reduction however might be expected. DG RTD is the main responsible for the implementation of “Horizon 2020”.

**Horizon 2020**: Two proposed priorities (no 1 and no 3) are of direct interest to Euratom R&T:

- **Priority 1** - Excellent science: emphasis on two initiatives:
  - **European Research Council** or **ERC** 58: the focus is on frontier research by the best individual teams with a proposed funding of Euro 13 268 million.
  The ERC is the independent body that funds investigator-driven frontier research by individual teams in the EU. Created (in 2007 - it was already part of FP7) to provide a new source and philosophy for competitive funding, based on peer-reviewed excellence as the sole criterion for

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57 G8 Summit - [http://www.g8italia2009.it/static/G8_Allegato/NSSG_ET-ICB_Final_28May_OK%5B1%5D.0.pdf](http://www.g8italia2009.it/static/G8_Allegato/NSSG_ET-ICB_Final_28May_OK%5B1%5D.0.pdf)
success, the ERC is aiming to set new standards and create a level playing field for research of a multi- and inter-disciplinary nature across a diverse continent of more than 500 million people in 39 countries. National Contact Points 59 are set up across Europe to provide information about ERC and personalised support to applicants in their native language.

The ERC covers a.o. the domains of "Physical Sciences & Engineering" and "Life Sciences". Topics of potential interest to the nuclear fission basic research community are, for example, "Fundamental constituents of matter" (PE2), "Materials and synthesis" (PE5), and "Molecular and Structural Biology and Biochemistry" (LS1). For example, the UNCLE project ("Uranium in non-conventional ligand environments") in the category PE5 is developing a uranium nitride complex of a very advanced type 60. Also interesting in this context is the Future and emerging technologies (FET) programme 61, launched by DG CONNECT (ICT).

- "Marie (Sklodowska) Curie actions" 62 (MSCA) and COFUND: the objective of MSCA is to provide opportunities for training and career development with a proposed funding of Euro 5 572 million.

It is worth mentioning the COFUND scheme ("Co-funding of regional, national and international programmes") of the "Life-long training and career development" programme. The aim of COFUND within MSCA is to increase transnational mobility and career development opportunities, by using the EU contribution to leverage national, regional and international funds. It seeks to link fellowship programs to the mobility objectives of the Marie Curie Actions.

- Priority 3 - Societal challenges: (containing, in particular, health, clean energy and transport)

The proposed funding for item no 3 “Secure, clean and efficient energy” under Horizon 2020 is Euro 5 782 million. A separate but complementary programme has been added to this item for nuclear energy activities (safety and security) adopted under the Euratom Treaty (Article 7) for the period 2014-2018. The additional amount proposed (without ITER /International Thermonuclear Experimental Reactor/) is Euro 1788 million (in constant 2011 prices), distributed as follows: nuclear fission, safety and radiation protection under DG RTD (Euro 355 million) 63, fusion research and development programme (Euro 709 million) to be restructured under DG RTD, nuclear safety and safeguards (Euro 724 million) under DG JRC.

As far as ITER is concerned, in 2010, the Council decided to limit the EU’s contribution to Euro 6.6 billion (including the contribution for 2014 – 2018). By Decision of the Council of Ministers held on 7-8 February 2013, it was decided that ITER will be incorporated in the Multiannual Financial Framework (MFF) and will be financed with an amount of maximum euro 2707 million. Reminder: The agreement on the establishment of the ITER International Fusion Energy Organisation was signed on 21 November 2006 by the European Atomic Energy Community (Euratom), China, India, Japan, Korea, Russia and the United States. As the host party and largest contributor during the construction phase (five elevenths, around 45% of the total), Euratom has responsibilities and special obligations. The EU’s contribution is financed 64.

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61 Future and emerging technologies - FET is the incubator and pathfinder (originally focusing on ICT) for new ideas for long-term research. Its mission is to promote high risk research, off-set by potential breakthrough with high technological or societal impact - http://cordis.europa.eu/fp7/ict/programme/fet_en.html
63 Conversion in annual budget for indirect actions: approximately Euro 60 Million under Horizon 2020 (= 15 times less than non-nuclear energy), compared to 52 Million under FP7 (= 5 times less than non-nuclear energy)
by Euratom (at the level of 80%) and by the host country, France (the remaining 20%), and covers construction and running costs, as well as contingency costs.

Knowledge Alliances for higher education: This initiative is in collaboration with the Commission proposal “Erasmus for All”, discussed further down in Section 6.2. The objective is to improve the synergy between the world of education and the world of work, while helping universities modernise and enhance quality and innovation. Structured partnerships are being set up between higher education institutions and businesses, which develop innovative ways of producing and sharing knowledge, foster creativity and entrepreneurship and design and deliver new curricula and qualifications.

European Institute of Innovation and Technology: The EIT, established in 2008 by the European Parliament and the Council, aims to becoming a flagship for excellence in European innovation. Business creation activities are coupled with Research & Innovation Projects as well as with Education & Training. The EIT consists of a number of “Knowledge and Innovation Communities” (KIC) in all sectors of industry and society, with a proposed funding of euro million 1360 (+ conditional 1440 million) under Horizon 2020. Furthermore the EIT provides enhanced opportunities for links and concrete connections with the EU Cohesion policy, since its KICs use the co-location and co-creation concepts where KICs stakeholders share together physical space to spark more innovation through cluster-like interactions.

Of particular interest for nuclear fission research and training is the current KIC InnoEnergy 64, a company, with all its implications: built upon an industrial plan, results and output oriented, commitment from shareholders for a first period of 7 years, financially sustainable in the medium term. The KIC InnoEnergy covers all the SET Plan thematics, shared amongst 6 Co-location Centers: one of them is "Sustainable nuclear & renewable energy convergence" (coordinated by the French node Colocation Centre Alps Valley; core members = AREVA, CEA, Grenoble INP and Ecole de Management). For example, one of the Innovation projects deals with innovative sensors for material ageing and radiation testing - see item 5 of Annex 2.

In conclusion, referring to the Knowledge Triangle (research, innovation, education – see Section 1), one can say the following:

- “Horizon 2020”: promotes stronger links between research and innovation (without covering education activities – Euratom research and training is in fact an exception)
- “Knowledge Alliances”: promotes enhanced cooperation between education and innovation (under “Horizon 2020” and “Erasmus for all”)
- “European Institute of Innovation and Technology” (EIT) under “Horizon 2020”: integrates fully the Knowledge Triangle (research, innovation and education).

4.2 A common strategic framework for research and innovation (funding instruments)

The funding instruments of Horizon 2020 will be a combination of existing and new instruments proposed by DG RTD (e.g. collaborative projects as in FP7) and by other DGs (e.g. European Investment Bank, Funds related to the EU Cohesion Policy – see NB below).

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64 Knowledge and Innovation Community "InnoEnergy" - http://www.kic-innoenergy.com/homepage.html
The EC will also be calling for partnerships (public-public and public-private) – Annex 6. Here is an excerpt of the above communication COM(2011) 808 on Horizon-2020:

"Executive Summary

2.3. Focusing EU funding instruments on Innovation Union priorities

Moreover, the integration of the research and innovation dimensions should be reflected in EU funding programmes, including the Framework Programme, the Competitiveness and Innovation Framework Programme (CIP) and the Cohesion Funds. They also need to be better coordinated in design and implementation so as to maximise impact, user-friendliness and EU added value. The expertise and market standing of the European Investment Bank (EIB) Group in managing these financial instruments has been a major factor in their success."

"4. Maximising social and territorial cohesion

The Structural Funds have a critical role and already provide substantial investments in research and innovation. The European Social Funds could be deployed more effectively to train and retrain people with the skills needed for the Innovation Union."

NB - Reformed Cohesion policy – possible applications for Euratom research infrastructures

The Commission adopted in October 2011 its proposals on a reformed Cohesion policy (2014 - 2020) that put emphasis on capacity building in research, technology and innovation through "smart specialisation", setting the foundations for a “staircase to excellence” for those Member States that are on a “catch-up” path with the rest of their European counterparts. "Smart Specialisation" is a strategic approach to economic development through targeted support to Research and Innovation (R&I). The Structural funds are at the core of the structural changes that are necessary in a number of EU regions. Research initiatives that contribute to the low carbon economy (including R&I in nuclear fission) could be covered by the European Regional Development Fund (ERDF) provided that they also cover the basic goals of the Cohesion policy. Training initiatives of researchers and technical personnel could be covered by the European Social Fund (ESF).

The "cohesion" instruments of the above ERDF are being applied in the nuclear RTD domain for the first time: this is the Czech Sustainable Energy Project (SUSTainable ENergy, SUSEN) which is implemented as a regional R&D centre, located at the CVR (UJV Rez site). The objective is to create a robust infrastructure for sustainable R&D activities to support Czech participation in EU programmes for safe and efficient energy generation with emphasis on the preparation of Gen IV and fusion technologies and on the continuous improvement of safety in Gen III and Gen II. This large-scale project was approved by the EC in November 2011 (the maximal rate would be 85% and it would apply to an amount of euro 100 million).

5 – “RESOURCE EFFICIENT EUROPE” - TOWARDS A RESOURCE-EFFICIENT, LOW-CARBON ECONOMY

5.1 Energy Policy for Europe: from Green Paper 2006 to EU Energy Roadmap 2050

66 JRC / IPTS (Ispra) website for S3 (smart specialization strategy) - http://s3platform.jrc.ec.europa.eu/home
The facts about nuclear, recalled in Annex 1, show that energy problems in general cannot be taken for granted in the EU, and demand a Community-wide approach. Energy in the EU falls under "shared competences" (Section 3.2). The EC has been mandated to create the political and financial framework to deal with these challenges. It is worth recalling that EC DG ENER is monitoring the EU actions in energy policy (e.g. delivering the EU's decarbonisation objective while at the same time ensuring security of energy supply and competitiveness).

As a reminder, in March 2006, the Commission published a Green Paper (COM 2006 105, Brussels, 8.3.2006) entitled "A European strategy for sustainable, competitive and secure energy". The proposed strategy should lead to a low-carbon economy, based on a balance between sustainable development, industrial competitiveness and security of supply.

One year after, in the Energy Policy for Europe (EPE) – (COM(2007) 1, Brussels 10.1.2007), the EU Energy Ministers reaffirmed the three objectives of sustainability, security of supply and competitiveness:
- promoting environmental sustainability with emphasis on the objective to limit the rise in global temperatures to 2°C (nicknamed "Kyoto")
- increasing security of supply (nicknamed "Moscow")
- ensuring the competitiveness of EU energy industry so as to provide energy at the best possible prices for citizens and companies (nicknamed "Lisbon").

The EU Council of March 2007 recalled that nuclear fission is an integral part of the energy mix policy and that the EPE will fully respect Member States' choice of energy mix. The European Council also suggested that broad discussion takes place among all relevant stakeholders on the opportunities and risks of nuclear energy. As a result, the European Nuclear Forum Energy (ENEF) was launched in November 2007.

The above mentioned Flagship Initiative "Resource efficient Europe" (COM(2011) 21 (Brussels, 26.1.2011)) is a further strengthening of the main objectives of the “Energy Policy for Europe” in the short to medium term, that is: explore possible paths towards a low-carbon, resource-efficient EU energy system and the policy challenges related to that goal.

As far as future scenarios for the EU energy system in the long term are concerned, the EC issued the EU Energy Roadmap 2050 (COM(2011) 885 (Brussels, 15.12.2011)), based on different energy mix scenarios. Council conclusions were issued in May 2012. As a result, the EU is committed to reducing greenhouse gas emissions to at least 80% below 1990 levels by 2050 in the context of necessary reductions by developed countries as a group, while at the same time ensuring security of energy supply and competitiveness. A total of 7 scenarios are proposed, as basis for policy action – see Impact Assessment study of the EU Energy Roadmap 2050 and summary of the 7 scenarios below (NFIEG = 2050 estimates of nuclear fuel in electricity generation in % from 2005 / ECO = equivalent capacity operating in GWe):

1. Business as usual (Common Reference Scenario – pre-Fukushima)
   - NFIEG = 26.4% / ECO = 161 GWe

1bis. Current Policy Initiatives (CPI) scenario (post-Fukushima)
   - NFIEG = 20.6% / ECO = 117 GWe

2. High Energy Efficiency
   - NFIEG = 14.2% (= average for nuclear energy) / ECO = 79 GWe

3 Diversified supply technologies
   - NFiEG = 16.1 % (= average for nuclear energy) / ECO = 102 GWe
4 High Renewables (RES)
   - NFiEG = 3.6 % / ECO = 41 GWe
5 Delayed CCS
   - NFiEG = 19.2 % (= maximum for nuclear energy) / ECO = 127 GWe
6 Low Nuclear
   - NFiEG = 2.5 % (= minimum for nuclear energy) / ECO = 16 GWe.

The reference "Business as Usual" scenarios (above 1 and 1bis) would lead to a 40% reduction of greenhouse gas emissions in 2050 (compared to 1990). This is far from the EU objective of 80 to 95% reduction. Therefore, five "decarbonisation scenarios" have been developed (above scenarios no 2 to 6), all reaching the 80% greenhouse gas emission reduction. Three of these decarbonisation scenarios (no 2, 3 and 5) show an important role for nuclear energy in the low carbon electricity generation in 2050, with shares between 14 and 20%. The cumulative time-integrated cost over the period 2011–50 of all seven scenarios varies between 14.06% and 14.58% of the expected cumulative GDP of 2011–50. The most expensive routes would lead to an overall cumulative cost spread of Euro 3 600 billion (3.6 trillion), which is still only 0.5% of the cumulative EU GDP in 2011–50. However, this extra cost comes on top of the cost of the cheapest envisaged energy system in 2050, which will already absorb about 14% of EU GDP compared to about 10% in 2010 (reminder: European GDP 2011 = Euro 12 650 trillion). The cheapest EU energy policy scenarios have the largest nuclear fraction:

- "delayed CCS": above 14.06%, that is: in absolute numbers, - Euro 57 billion / year over the period 2011–50, compared to the reference (which has a total cost of €2 582 billion at 2008 values)
- "diversified supply technologies": above 14.11%, that is: - Euro 47 billion / year.

One of the main conclusions of the decarbonisation of the energy system by 2050 is that electricity will play a greater role in energy supplies (20% of final energy demand today, almost 40% by 2050) and in areas such as transport and heating: an estimated 4800 TWh per year in 2050 (almost 4000 TWh today). If longer-term operation (LTO) of NPPs is conducted between 2015 and 2035, new build should take place between 2025 and 2045. If 20 % of the electricity in 2050 is produced by nuclear (Delayed CCS scenario), that means 960 TWh or 137 GWe (assuming 7000 hours / year), that is: new build of approximately 100 units of 1400 MWe.

Interesting studies have been published by other authoritative bodies, such as the French "Cour des Comptes" report "The costs of the nuclear power sector", January 2012 69. Their investigation covers exclusively the past, current and future cost of producing nuclear energy in France (excluding both transport and distribution of electricity): due account is taken of internal and external costs over the entire life cycle of the generation chain, including the fuel cycle.

5.2 European Strategic Energy Technology Plan (SET Plan - 2007) and E&T initiatives

The above EU Council of March 2007 approved the integrated policy package on "Climate Change and Energy". It proposed a sustainable, low-carbon, energy-efficient economy, in particular, through the “Objectives 20/20/20 for 2020”. As a follow-up, the EC published in

69 Cour des comptes - http://www.ccomptes.fr/Publications/Publications/Les-couts-de-la-filiere-electro-nucleaire
November 2007 a European Strategic Energy Technology Plan (SET Plan)\(^{70}\), which was endorsed by the EU Energy Council in February 2008 (“Investing in the Development of Low Carbon Technologies (SET-Plan)”) - COM(2009) 519 - Brussels, 7.10.2009. In the meantime, the “climate and energy package” (agreed by the European Parliament and Council in December 2008,) which became law in June 2009, proposed binding legislation to implement the 20/20/20 targets.

Under the SET Plan, a strong technology push is undertaken by the EU and the Member States to address the main bottlenecks. Breakthrough energy solutions are proposed from the creation stage to first-of-a-kind deployment and system integration stages. The SET Plan has changed the way energy research is performed in Europe. National Energy Research Strategies are clearly aligned to the objectives of the SET Plan. For instance, the German government prioritized the SET Plan in its Energy Concept and allocated a dedicated budget line. Based on wide consultation across the Member States, the EU then proposed to launch a number of European Industrial Initiatives (EIIs) that cover both energy efficiency and clean applications of primary energy sources.

Progress made in the implementation of the SET-Plan is reported in the Strategic Energy Technologies Information System (SETIS)\(^{71}\) developed by DG JRC IET Petten. The next SET-Plan Conference will be organised by the Irish Presidency (Dublin, 7-8 May 2013)\(^{72}\): a broad range of stakeholders including the research community, industry, financial community, policymakers and international partners will discuss the main achievements and the future.

As far as Euratom research and training programmes are concerned, two items of the SET-Plan are particularly interesting (EII and EERA – elaborated hereafter in Sections 5.2.1 and 5.2.2).

5.2.1 "European Industrial Initiatives" (EII) aiming at closing the RDDD cycle

The focus is on key challenges and bottlenecks. A number of concrete actions (six EIIs in total – see below) are proposed for the period 2010-2020, with detailed implementation plans and Technology Roadmaps, taking into account priorities and available resources.

This European research, development and demonstration programme on low carbon energy technologies has been estimated by the Commission together with the industry to cost between Euro 58 and 72 billion over the next 10 years, divided between the EIIs (Euro 48 – 60 billion) and the Smart Cities Initiative (Euro 10 to 12 billion). This should be shared between industry, the Member States and the European Commission. The partition of the cost for each EII may vary as well as for the activities within each EII. Typically, research and development programmes should have a prominent public and EU investment component, the demonstration programmes should have a strong industrial drive, accompanied by public support, both EU and national; and the deployment programme should have a large participation from industry.

Here is the list of the six proposed EIIs and their cost estimates:

1. **Wind energy** (total public and private investment needed in Europe over the next 10 years is estimated as Euro 6 billion + creation of 250 000 skilled jobs)

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\(^{70}\) Strategic Energy Technology Plan (SET Plan) - [http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm](http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm)


2 - Solar energy, including photovoltaics (PV) and concentrated solar power (CSP) (total investment needed is estimated as Euro 16 billion + creation of 200 000 skilled jobs)

3 - Electricity networks (creating a real internal market; integrating a massive increase of intermittent energy sources; and managing complex interactions between suppliers and customers – total investment needed is estimated as Euro 2 billion)

4 – Sustainable bio-energy (total is estimated as Euro 9 billion + creation of 200 000 jobs)

5 - CO₂ capture, transport and storage /CCS/ (total investment Euro 10.5 to 16.5 billion)

6 - Sustainable nuclear energy

Nuclear fission has to move towards long-term sustainability with a new generation of reactor type – Generation-IV. They will be designed to maximise inherent safety, increase efficiency, produce less radioactive waste and minimise proliferation risks. Commercial deployment of these reactors is foreseen for 2040, but to achieve that target, work has to start now.

The bulk of this EII no 6 up to 2020 (actions to be carried out by the Member States) will be the design and construction of prototypes and demonstrators, fuel fabrication workshops and experimental facilities and a research programme to develop new materials and components to improve the industrial and economic viability of the reactors. This effort will build upon a solid basis of competences and experience in current nuclear technology which is contributing to meeting the 2020 SET-Plan objectives. The total public and private investment needed in Europe over the next 10 years is estimated as Euro 5 to 10 billion. By 2020, the first Generation-IV prototypes should be in operation. The first cogeneration reactors could also appear within the next decade as demonstration projects to test the technology for coupling with industrial processes.

The subject EII is called the European Sustainable Nuclear Industrial Initiative (ESNII). It is an outcome of the SNE-TP 22 and was launched on 15 November 2010 at the SET Plan Conference in Brussels. The ESNII addresses, in particular, the need for demonstration of Generation-IV fast neutron technologies, together with the supporting research infrastructures, fuel facilities and research work. The ESNII addresses also a part of the Euratom contribution under the intergovernmental GIF agreement (Generation IV International Forum 73). The three types of fast reactor (using, respectively, sodium, lead or gas as coolant) have a comparable potential for making efficient use of uranium and minimising the production of high level radioactive waste. When it comes to priorities, the previous work in the EU on sodium technology gives this option a strong starting position. As an alternative to sodium, however, the lead and gas fast reactors offer also a number of interesting features.

5.2.2 "European Energy Research Alliance" (EERA) and E&T initiatives

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73 The GIF has ten active members, i.e. members who have signed the Charter and signed, ratified or acceded to the Framework Agreement and are effectively contributing to GIF work, namely: USA, Canada, France, Japan, South Africa, the Republic of South Korea, Switzerland, Euratom (since 2003), China and the Russian Federation. The OECD/NEA (Paris) is in charge of the GIF Technical Secretariat tasks - [http://www.gen-4.org/](http://www.gen-4.org/)
The European Energy Research Alliance (EERA) under the SET-Plan has been established as a partnership between research organisations in October 2008 (EERA is not a legal entity). The key objective of the EERA is to integrate European research capacities to advance the SET Plan long-term Agenda. As a consequence, new knowledge and technologies or proofs of concepts are generated, that individual MS research programmes cannot address alone and/or for which working at European level brings in economies of scale and raises significantly the level of excellence. A total of 13 Joint Research Programmes (JP) were conceived on their own resources, to accelerate the development of new energy technologies in support of the SET Plan. This represents more than 2000 researchers from over 150 research organisations. In this way, the cooperation between national research institutes is being elevated to a new level: from an ad-hoc participation in uncoordinated joint projects to collectively devising and implementing joint programmes, combining national and Community sources of funding and maximising complementarities and synergies.

Three priorities are retained in the above Alliance:

(1) taking ideas out of the laboratory and developing them to the point where they can be taken up by industry is a step that needs to be shortened considerably

(2) launch and implementation of 13 Joint Programmes (strong links with the European Industrial Initiatives to ensure industrial relevance)

Four JPs were launched in June 2010, Madrid (Photovoltaic; Wind Energy; Smart Grids; Geothermal), three in November 2010, Brussels (Carbon Capture and Storage; Materials for Nuclear; Bioenergy), six in November 2011, Warsaw (Concentrated Solar Power; Ocean Energy; Smart Cities; Advanced Materials and Processes for Energy Applications; Energy Storage; Fuel Cells and Hydrogen)

NB: the above JP on "Materials for Nuclear" (coordinator = KIT, Karlsruhe) groups together 16 participants: CIEMAT (ES), CEA (FR), CNR (IT), CNRS (FR), ENEA (IT), HZDR (DE), JRC (EU), KIT (DE), KTH (SE), NRG (NL), IRN (RO), PSI (CH), RCR Ltd. (CZ), SCK CEN (BE), University Oxford (UK), VTT (FI) and 8 Associates (EDF, IET, MPA, KIT, POLITO, UA, ULB, UPC). More associates are expected.

(3) involvement of universities to ensure that the best brains are mobilised.

The European Strategic Energy Technology Plan (SET-Plan) launched an "Energy Education and Training" initiative, made of 13 Working Groups:

- Horizontal Groups (2 in total): (12) System Integration / (13) Coordination of Education and Training Systems /

This Energy E&T initiative included the platform created by the "European University Association". The kick-off meeting of the Core Group was held in 2011 with the 13 Working Groups (final report expected at SET Plan Conference, Dublin, 7–8 May 2013). The Group no 8 "Nuclear Energy" was coordinated by the nuclear E&T partner of KIC InnoEnergy.

6 – “AN AGENDA FOR NEW SKILLS AND JOBS” - IMPROVING EMPLOYABILITY IN A GLOBAL ECONOMY

The main objective of the Flagship Initiative "An agenda for new skills and jobs" (COM(2010) 682, Strasbourg, 23.11.2010) is to contribute towards full employment. DG EAC and DG EMPL are in charge of monitoring a number of actions under this Initiative in the context of the Education, Youth and Culture policy. Four key priorities are proposed: better functioning labour markets; a more skilled workforce; better job quality and working conditions; stronger policies to promote job creation and demand for labour.

“Comprehensive lifelong learning” is quoted as a “considerable challenge”. The emphasis is on the improved access to lifelong learning, thereby helping people move to high-value added sectors and expanding occupations. The modularisation of learning programmes is mentioned as a way to facilitate transitions between the phases of work and learning. A number of flexible pathways should allow for the validation of formal, non-formal and informal learning and be based on learning outcomes, as well as the integration of career guidance systems. The stakeholders should be better involved in the implementation of lifelong learning. Effective incentives and cost sharing arrangements should be established to enhance public and private investment in the continuing training of the workforce.

6.1 EU governance for education and training (Bologna 1999 and Copenhagen 2002)

A new governance for education and training in the EU is under development through the "Open Method of Coordination". For this purpose, two processes were set up by the Member States (Bologna and Copenhagen, each with their own Agenda and Roadmap), namely:

- **Bologna** Declaration on the European space for higher education (June 1999):
  (in 1999, this Declaration had 29 signatory States; meanwhile, their number has risen to 40)
  =>$> "European Credit Transfer and accumulation System" /ECTS/

- **Copenhagen** Declaration on enhanced European cooperation in VET (Nov. 2002):
  (signature by all EU Member States + two countries of the European Economic Area (Liechtenstein and Norway) and two candidate countries (FYRM and Turkey))
  =>$> "European Credit system for Vocational Education and Training" /ECVET/

ECVET's objective (as it is being pioneered in large industrial sectors, e.g. aeronautics and automotive) is to promote the assessment, validation, transfer, recognition and accumulation of individuals’ learning outcomes in Europe. "Learning outcomes" (defined in terms of knowledge, skills and competences /KSC/) are a key factor in the common language that is needed between the world of education and the world of work. They should be discussed by all parties interested in the design and implementation of ECVET partnerships. They are usually defined in terms of "action verbs", using, for example, the Bloom's taxonomy for learning objectives.

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35 The European University Association (EUA) launched the "European Platform of Universities Engaged in Energy Research, Education and Training" (EPUE) in Delft in February 2012. The EPUE comprises almost 170 universities who have demonstrated research and training capacity in the energy field - [http://www.eua.be/epue](http://www.eua.be/epue)
Following the ECVET definition, "learning outcomes" means "statements of what a learner knows, understands and is able to do on completion of a learning process and which are defined in terms of knowledge, skills and competences that can be assessed and validated".

The three components of learning outcomes can be further defined as follows:

- **Knowledge** (Learning to know: for example in the nuclear domain, knowledge needed to support operational and technical decisions in NPPs) – "cognitive domain"
  - ECVET definition: Knowledge is the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study (loosely described as knowing / head)

- **Skills** (Learning to do /cognitive ability and practical intelligence/: for example, translation of nuclear safety culture into practical terms) – "psychomotor domain"
  - ECVET definition: skills are the ability to apply knowledge and use know-how to complete tasks and solve problems (loosely described as doing / hands)

- **Competences or attitudes** (Learning to live together: e.g. communicating efficiently / Learning to lead a team: e.g. nuclear safety values and beliefs) – "affective domain"
  - ECVET definition: Competence is the proven ability to use knowledge, skills and personal, social and/or methodological abilities in work or study situations and in professional and personal development (loosely described as feeling / attitudes).

In the ECVET context, "Personal Transcripts" (containing the records of learning achievements) are proposed. They contain information on assessed learning outcomes that the learner has achieved by attending training and information sessions. A document (e.g. inspired from the "Europass" concept for recording skills and competences) is proposed for certain job profiles, as a portfolio of learning outcomes, usually in the context of an ECVET partnership or MoU. This includes a learning agreement between competent institutions and learners on a common qualification approach and a common taxonomy. The aim is to describe the qualifications prepared by the learners who are to undergo mobility. In every country (EU and European Economic Area), a National Europass Centre coordinates all activities related to the Europass: the Europass includes several documents, developed at EU level in the late 1990s (e.g. European CV; Diploma Supplement; Europass Language Passport; Europass Mobility) 76.

A number of scientific & technological and social & economic challenges were discussed in Section 1, including the new reality of lifelong learning and borderless mobility. As a result, coordination actions under FP7 (Euratom Fission Training Schemes) were launched, aiming at filling competence gaps, using the above ECVET instruments (Section 2 and Annex 2).

6.2 “Erasmus for all”: Knowledge Alliances and Sector Skills Alliances

“Erasmus for all” is the Commission proposal for a Euro 17 billion funding programme under Horizon-2020 for Education, Training, Youth and Sport (2014 - 2020). This programme refers to three “Europe 2020” flagship initiatives, namely: the above “Innovation Union” and “An agenda for new skills and jobs” as well as ‘Youth on the Move’ (COM(2010) 477, 15.9.2010).

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What is new?

- emphasis on innovation, productivity and growth: E&T are now more important than ever, especially in the context of the current economic and financial crisis
- emphasis on lifelong learning (requested by people of all ages) and borderless mobility (increasingly globalised labour market): E&T systems must deliver the knowledge and skills requested by the changing society.

Two proposed priorities (“key actions” no 1 and 2) of the “Erasmus for all” programme are of direct interest to Euratom R&T:

**Key Action 1 – Learning mobility of individuals**

The objective is to enhance mobility including for higher education students outside the EU (fostering joint/double degrees), building on the success of Erasmus Mundus and on the need for alternative forms of mobility. Transnational traineeships in enterprises have also a high potential to enhance employability. The aim is to facilitate the transition from education to the world of work. Opening up access for learners to methods, practices and technologies used in other countries will also help to improve their employability in a global economy.

**Key Action 2 – Cooperation for innovation and good practices**

The focus is on strengthening innovative partnerships between educational institutions and business. For higher education, the emphasis will be on capacity building, concentrating on neighbourhood countries as well as strategic partnerships with developed and emerging economies. Three networking approaches are possible:

- **Knowledge Alliances** for higher education: see ("Innovation Union" – Section 4)
- **Sector Skills Alliances (SSA)**: one of the 2013 strategic priorities consists in sectorial projects between businesses and education and training providers to create new sector-specific curricula, to develop innovative ways of vocational teaching and training and to put the EU wide recognition tools into practice, in particular:
  - EQF: European Qualifications Framework
  - ECVET: European Credit System for Vocational E&T
  - EQARF: European Quality Assurance Reference Framework for Vocational E&T.
- **IT support platforms and virtual mobility**: deliver peer learning and exchange of good practices to a greatly enlarged group of potential beneficiaries (e.g. e-courses and virtual mobility, including collaboration with neighbourhood countries).

**7 - Conclusion: Towards a new governance for Euratom research and training programmes**

The facts about energy in today's world, in particular when it comes to "Sustainable, Competitive and Secure Energy", show that energy problems cannot be taken for granted, and demand an international science-based holistic approach. This is particularly true for nuclear

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fission energy and radiation protection. The response to those challenges is at the heart of the Euratom policy measures and legislation, and of the Euratom research and training programmes.

Two general objectives are particularly important in this context, and are guiding the Euratom R&T priorities in all sectors (nuclear fission /reactor safety/, waste management /geological disposal/, radiation protection /medical applications of ionising radiations/):

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

An analysis is proposed of the question “who are the drivers and enablers for changes in Euratom Research and Training ?” The “end-user requirements” are an important driver: they are of scientific-technological type (e.g. the continuous improvement of a common nuclear safety culture world-wide, based on technical and organisational excellence) and of socio-economic type (e.g. the development of an interdisciplinary scientific approach to improve the EU nuclear decision making process). The enablers are the stakeholders providing human and financial resources (e.g. the European Technological platforms) and the Euratom programmes.

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

1. contribute to the creation and transfer not only of knowledge but also of skills and competences, taking advantage of instruments developed by three EU policies, namely: research and innovation (DG RTD), energy (DG ENE) and education (DG EAC)
2. develop a new governance for Euratom R&T based on further improvements in accountability, participation, predictability and transparency, with a view to promote a new way of “making / teaching science”, closer to the end-users (society and industry).

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

The emphasis in this lecture is on nuclear competence building through E&T actions conducted by DG RTD and DG JRC in collaboration with other DGs, referring to the IAEA definition of competence (competence means the ability to apply knowledge, skills and attitudes so as to perform a job in an effective and efficient manner and to an established standard) – Section 1.

Euratom E&T programmes make use of the instruments proposed under the Education, Youth and Culture policy, in particular: the European Credit System for Vocational Education and Training (ECVET). Those instruments are used in a number of "Euratom Fission Training Schemes" (EFTS), launched as "coordination actions" by higher education institutions (usually under the ENEN association) and by "stakeholders" (industry, research organisations, governmental bodies, etc) in areas where human resources could be at risk. The EFTS projects are contributing to the definition of requirements for recognition of certain job profiles. As a result of the implementation of ECVET, the proposed training schemes consist of portfolios of learning outcomes (made not only of knowledge, but also skills and competences /KSC/) that are needed to define the selected job profiles in view of their EU-wide recognition - Section 2.

The political and legislative background of Euratom research and training is based principally on the Europe 2020 strategy, the Lisbon Treaty and the Euratom Treaty. European and international collaboration in nuclear training (especially continuous professional development)
is well established, with emphasis on a common safety and security culture. This is also aligned with the conclusions of the "stress tests" following the 2011 triple disaster in Japan - Section 3.

A number of recent EC Communications (actually "Flagship Initiatives" under the Europe 2020 strategy) are contributing to improve the synergy within the Knowledge Triangle, i.e. between (1) research, (2) innovation, (3) education and training.

- **"Innovation Union" - Turning ideas into jobs, green growth and social progress**
  A common strategic framework is discussed with the aim to make use of not only RTD instruments (including the new ones: ERC, FET, EIT / KIC) but also of other EU policies (e.g. reformed Cohesion Policy Funds, European Investment Bank, etc). In the future, the EC will increasingly insist on public-public and public-private partnerships - Section 4.

- **“Resource efficient Europe” - Towards a resource-efficient, low-carbon economy**
  The policy priorities are set by the "Energy Policy for Europe" (sustainability; competitiveness; security of supply). A number of "European Industrial Initiatives" were launched under the "European Strategic Energy Technology Plan" (SET Plan, 2007) and SNE-TP, including the initiative on sustainable nuclear energy (ESNII) - Section 5.

- **“An agenda for new skills and jobs” - Improving employability in a global economy**
  A common language is under development between the worlds of education and of work with the aim to foster lifelong learning and borderless mobility. Portfolios of “learning outcomes” are discussed and first attempts are made to develop EU approaches for assessment/validation (related to transcripts of records and to the Europass) - Section 6.

In the future (Horizon 2020 /2014 – 2020/-, the successor of FP7 /2007-2013/), the EU policy is aiming at “externalising” a number of research and innovation actions. It is generally believed that progress would be facilitated if some initiatives are implemented by the Member States or by the industries interested in them. The emphasis is shifting from a "joint project" approach (FP7) to a "programmatic" approach where governmental bodies and stakeholders (in particular, the Technological Platforms and other authoritative expert bodies) are playing an increasing role. In the specific case of Euratom, because of the very limited available EC funding, a very strong coordination is required regarding governance and financing in order to ensure stability and clear commitments from the parties involved.

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

Under Horizon-2020, some actions in the Euratom research and training programme will be designed to better support decision making (thereby coming closer to the end-users: society and industry). This is the case, in particular, of interdisciplinarity projects related to, for example,
- basic research (e.g. low irradiation dose impact assessment /hormesis/) – MELODI
- power plant modernisation (e.g. following the "stress tests") - NUGENIA
- geological disposal facilities for ultimate waste management – IGD-TP
- breakthrough research with emphasis on safety (e.g. Generation IV systems subject to four criteria: Sustainability / including minimization of waste production /; Non-Proliferation and physical protection; Safety and reliability; Economics) – SNE-TP.

A concerted effort will be needed to describe these interdisciplinary activities in a language that is understandable to a knowledgeable non specialist or, better yet, to an average person.
Massive investments in experimental and numerical simulation tools are necessary in a range of research and innovation actions. It is clear that, whenever possible, all nuclear stakeholders should be involved and that, in particular, European publics should play a greater role in taking critical, social, environmental and economic decisions. As a consequence, a new way of "making / teaching science" is under development (focussing, in particular, on how to select the Best Available Science /BAS/) in order to contribute more effectively to robust, equitable and socially acceptable systems, while integrating public, policy, and expert knowledge.

In this context, governance means the manner in which Euratom policies, rules and decisions are made to achieve the above objectives, in synergy with the Member States and the stakeholders. Following the standard definition, good governance consists of a number of principles such as:

(i) accountability: establishing criteria to measure the performance of all parties
(ii) participation (public engagement): offering beneficiaries more opportunities
(iii) predictability: enhancing stability and autonomy of all parties involved
(iv) transparency: disseminating information (e.g. about Euratom) to the civil society.

As a consequence, wherever advisable, future Euratom research and training actions will aim at a fair balance between scientific-technological and socio-economic approaches. They will take into consideration, in particular, existing initiatives on public engagement in the nuclear sector (e.g. based on FP7 projects of the socio-economic type, national strategic guidance documents).

In conclusion of this lecture, the reader is invited to consult the "2012 interdisciplinary Study" ("Benefits and limitations of nuclear fission for a low-carbon economy - Defining priorities for Euratom fission research and training"), presented at the 2013 Symposium "Nuclear Fission Research for a low carbon economy" (EC and EESC, 26–27 February, Brussels).  

Three documents of this 2012 Study are particularly interesting in this context:
- 2012 Interdisciplinary Study - Synthesis report
- 2012 Interdisciplinary Study - Compilation of the experts' reports, Background to the synthesis report
- Ethics Opinion n°27 - 16/01/2013 - An ethical framework for assessing research, production and use of energy.

The key messages and recommendations of the above Study and Symposium are an important input in the upcoming discussions at EC and EU Council level. They will guide the orientation and priorities of the next Euratom research and training programme under Horizon-2020.

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"Some of our trading partners are competing with primary resources, which we do not have. Some compete with cheap labour, which we do not want. Some compete on the back of their environment, which we cannot accept, .......

Building the knowledge society is probably the best, and maybe only, way to sustain the European model of society, without having to make a trade-off between economic growth, social cohesion and environmental protection"

(source: ERA News, 2005-02-03)
ANNEXES

ANNEX 1

1 - SOME FACTS ABOUT NUCLEAR POWER PROGRAMMES IN THE EU AND WORLD-WIDE

1.1 - Some facts about nuclear in the EU (Eurostat data) and world-wide (IAEA database)

Today, with its 27 Member States, the EU is home to 501 million consumers (that is: 14 % of the world population) and approximately 25 million companies, and represents the world’s second-largest energy market. In 2007, dependence on imported energy in the EU amounted to 53% (with an annual bill of Euro 240 billion) - if the current trend continues, by 2030, energy dependence (primarily from fossil origin) will have grown to 67%. By the same year, CO₂ emissions are forecast to exceed the 1990 limits set by the Kyoto Protocol by 5.4%.

In 2013, a total of 131 units are operable in 14 Member States, representing a total installed electricity capacity of 122 GWe net and a gross electricity generation of 848 TWh. They are also avoiding the emission of 700 million tonnes of CO₂ per year (this is equal to the amount of CO₂ emitted by all the cars in the EU). Having been in use for over 50 years, nuclear energy already forms part of the energy mix in those Member States that have decided to use it. The average age of the NPPs in the EU is nearly 30 years, ranging from 5 to 45 years.

It should be reminded that reliability goes together with safety (see WANO Performance Indicators 78) and that nuclear energy’s capacity factor is close to 90% in many NPPs, far exceeding all other means of electricity production. The nuclear sector employs today in the EU approximately 500 000 people, directly and indirectly (+ induced 400 000) – this is an extrapolation from the French situation analysed by PwC 79 to the whole of EU. The corresponding total “value added” for the European economy is estimated to be Euro 70 billion per year (including 28 billion only in France).

In the EU, a total of 32 reactors will be closed down by 2025 as a consequence of the phase-out policy in some Member States (BE, DE, UK for AGRs). Decommissioning is a complex process that takes years and requires also a considerable amount of interdisciplinary expertise. The staff required for decommissioning per unit is estimated to be 200 and the cost is Euro 500 million (without waste management). The remaining 100 reactors will be shut down in the period 2025 – 2050, supposing that most nuclear units will go for longer-term operation (LTO) until 50 or 60 years.

The Eurostat data 80 are an important source of information for the EU energy policy. At the end of 2010, in computing the shares in gross electricity production in the EU-27 (total of 3346 TWh, i.e. 22 % more than in 1995) by various primary sources, nuclear arrives on top (27.4 %, compared to 32.2 % in 1995), followed by solid fuels (24.7 %), gases (23.6 %), renewables (20.9 %), petroleum and products (2.6 %) and other (0.8 %) - renewable energy

includes hydraulic power (57 %), wind (21 %), biomass and renewable wastes (18 %) + solar (3 %) + geothermal (1 %). Still, that means that more than half of the EU’s electricity production (52 %) uses technologies emitting CO2. At the end of 2010, in computing the shares in primary energy consumption in the EU-27 (total of 1647 Mtep, i.e. 6 % more than in 1995) by various primary sources, oil arrives on top (37 %), followed by natural gas (24 %), coal (18 %), nuclear (14 %) and renewable energy (7 %). Still, that means that more than half of the EU’s consumed energy (56 %) comes from abroad (the respective import rates are as follows: 75 % for oil, 60 % for natural gas, 40 % for coal) – see also website of European Environment Agency (Copenhagen) /energy / nuclear / nuclear / 81.

World-wide information about nuclear policy decisions following the triple disaster in Japan in March 2011 is given in the databases of IAEA 82 and of WNA 83. World-wide, there are 437 reactors in operation in 31 countries plus Taiwan, with a total net installed capacity of 374 000 MWe (= 5.7% of the world's energy and 13.5% of the world's electricity) and there are 67 reactors under construction (most of them in Asia, notably 26 in China). Of particular interest is what happens in the "emerging nuclear energy countries" (more than 45 according to IAEA). As far as nuclear decommissioning is concerned, a total of 138 civilian nuclear power reactors are shut down in 19 countries - decommissioning has only been completed for 17 of them. Finally more than 150 naval vessels using nuclear propulsion have been constructed.

As far as research reactors are concerned, the IAEA Research Reactor Database 84 (RRDB – 2009 version) shows 248 operational research reactors (including critical assemblies), 164 shut down reactors (including 15 temporarily), 306 decommissioned reactors, 4 under construction and 6 new research reactors planned. These reactors are distributed among 58 countries. They are used for several applications, such as: Materials/Fuel Test; Isotope Production; Neutron Scattering; Neutron Radiography; Neutron Capture Therapy; Activation Analysis; Transmutation; Geochronology; Teaching (students) or training (operators).

1.2 - Total of 131 units operable in 14 EU Member States (total power=122 GWe net)

Go ahead in 12 Member States (MS) and phase-out in 2 MS / New build in 2 MS

Source: World Nuclear Power Reactors & Uranium Requirements (March 2013) 83

Go ahead in 12 MS and phase-out in 2 MS

(1) France: 58 reactors operable (63 130 MWe net in March 2013, 78 % of total electricity generation in the country in 2011), 1 in construction, 1 planned, 1 proposed
   - one EPR in construction in Flamanville-3 to operate by 2016 (and one planned in Penly) / AREVA (90 % from State) and EDF (85 % from State) / nuclear in France = 125 000 direct jobs, 300 000 indirect jobs (PwC report 79)

(2) United Kingdom: 16 reactors operable (10 038 MWe net, 18 %), 4 planned, 9 proposed
   - government wants to go "low carbon projects", including nuclear power ("Electricity Market Reform" (EMR), White Paper 2011) - utilities wishing to build new NPPs are still discussing (EDF Energy (EPR); Horizon / Hitachi (ABWR); NuGeneration / Iberdrola + GDF Suez)

82 IAEA Power Reactor Information System (PRIS) - dated October 2012 - http://www.iaea.org/pris/
(3) Sweden: 10 reactors operable (9 399 MWe net, 40 %)
- in 1979, referendum and moratorium against nuclear (phase-out planned by 2010) / in 2009, moratorium cancelled (new NPPs only to replace old ones) / plant upgrading in all utilities (up to 21 % already in place)

(4) Spain: 7 reactors operable (7 002 MWe net, 20 %)
- in 1983, moratorium / the oldest unit (at José Cabrera) was shut down at the end of 2006, 40 years after its construction / plant upgrading in many utilities (519 MWe already in place)

(5) Czech Republic: 6 reactors operable (3 766 MWe net, 33 %), 2 planned, 1 proposed
- Czech state office for nuclear safety said that the country has no immediate plans to review its nuclear expansion plans.

(6) Finland: 4 reactors operable (2 741 MWe net, 32 %), 1 in construction (TVO), 2 proposed
- EPR in construction TVO Olkiluoto-3 (to operate by 2014, AREVA and Siemens) - in July 2010, agreement from Parliament to build two more NPPs: utility TVO at Olkiluoto and utility Fennovoima at Pyhajoki (under discussion) - TVO has an interesting model of "Corporate Social, Environmental and Financial Responsibility"  

(7) Hungary: 4 reactors operable (1 880 MWe net 43 %), 2 proposed

(8) Slovak Republic: 4 reactors operable (1 816 MWe net, 54 %), 2 in construction, 1 proposed / at Mochovce 3 and 4, Italy's Enel SpA and Slovenske Elektrarne are completing the construction of Units 3 and 4, with commercial operation planned for 2013-2014

(9) Romania: 2 reactors operable (1 310 MWe net, 19 %), 2 planned, 1 proposed
- two CANDU units are planned to operate by 2016-2017 in Transylvania.

(10) Bulgaria: 2 reactors operable (1 906 MWe net, 33 %), 1 planned, namely: a Russian-designed AES-92 VVER-1000 originally in Belene (stop in March 2012) and now in Kozloduy (under discussion)

(11) Netherlands: 1 reactor operable, (485 MWe net, 4 %), 1 proposed
- new NPP by 2019 (Delta – EDF partnership)

(12) Slovenia: 1 reactor operable (696 MWe net, 42 % - see Krško NPP below), 1 proposed

(13) Germany: 9 reactors operable (12 003 MWe net, 18 %), nuclear phase-out policy since May 2011 – see below

(14) Belgium: 7 reactors operable (5 943 MWe net, 54 %)
- nuclear phase-out law since 1999 and phase-out decision in July 2012 (Doel 1 and 2 closed by 2015; Doel 3 by 2022; Tihange 2 by 2023; Doel 4, Tihange 1 and 3 by 2025) – see below

85 "TVO contributes to maintaining sustainable development and Finnish well-being by providing Finns with electricity from the Olkiluoto nuclear power plant in Eurajoki in a safe, reliable, and climate-friendly manner. At TVO, responsibility is integrated in all aspects of operations, development, and management. Responsibility is the basic foundation of operations and one of the company's values; all personnel are committed to the company's responsibility principles. Responsible business operations steer the company towards sustainable development, including the well-being of the personnel as well as society" - [http://www.tvo.fi/Responsibility](http://www.tvo.fi/Responsibility)
Nuclear phase-out in 2 EU Member States (MS)

Germany: see above (13)
- political landscape has been profoundly marked by the Fukushima events / "A decision has been taken to shut down eight plants before the end of 2011 and they definitely won’t be reactivated. The remaining nine will be shut down by the end of the decade.” (30 May 2011)

Belgium: see above (14)
- Metallurgical flaw indications in the reactor pressure vessels of Doel 3 and Tihange 2
In August 2012, it was revealed that planned inspections, carried out in June, using a new type of ultrasound technique detected many quasi-laminar flaws in the forged rings of Doel-3’s reactor vessel. These flaws were very probably generated during the casting and forging process of the vessels: these “hydrogen flakes” are present in the walls of the 20 cm thick reactor vessels. The Doel-3 and Tihange-2 reactors (which represent a third of the nuclear energy capacity in Belgium) were built using much the same technology and suppliers. Early inspection results indicate that the Tihange-2 reactor vessel is affected in a similar fashion. As a consequence, the nuclear regulator FANC (Federal Agency for Nuclear Control) has ordered to stop the operation of both reactors, pending further inspections and reports from expert panels – see Transparency website - http://transparency.gdfsuez.com/.

Slovenia and Croatia: joint ownership of the Krško NPP

Croatia is set to become the 28th member state of the European Union on 1 July 2013.

The Krško Nuclear Power Plant (2-loop Westinghouse pressurized water reactor) is located in Krško, Slovenia. It was built between 1975-1983 as a joint venture by Slovenia and Croatia, which were at the time both part of Yugoslavia. With 730 megawatts of capacity, it provided more than 25 % of Slovenia’s and 15 % of Croatia’s power. In 2001, a Treaty was signed covering: Financial settlement; Ownership 50:50; Composition of the Management Board (2 members, Slovenian has veto right in safety issues); Radwaste and Decommissioning issues.

New build: 2 MS

(1) Poland: 0 reactors operable, 6 planned - Poland had four Russian VVER-440 units under construction in the 1980's at Zarnoweic (near Danzig) but they were cancelled in 1990 and the components were sold. Development of shale gas becomes equally important as nuclear.

(2) Lithuania: 0 reactor operable - closure of last NPP in 2009 (Lithuania hosted the two largest Russian reactors of the RBMK type (1500 MWe) designed to provide power for Lithuania and for neighbouring Latvia, Belarus and the Russian exclave of Kaliningrad) - 1 planned: Visaginas NPP project with Baltic States (Latvia, Estonia) (vendor GE Hitachi, 1350 MWe Advanced Boiling Water Reactor) – under discussion after referendum in October 2012.

Other European countries with nuclear phase-out policy
- Italy: in 1987, moratorium on the construction of new NPPs; in 2009, OK for four EPRs by 2018; in 2010, law on return of nuclear; on 13 June 2011, referendum = 95% against nuclear (in Italy) and against Berlusconi

- Switzerland (not in the EU but associated to Euratom): 5 reactors operable (3252 MWe) - no construction of new NPPs (decision in May 2011, latest closure in 2034)

MS with "no-use of nuclear"

- Austria: in 1999, law for Austria without nuclear ("integrated in the Constitution")
- Greece, Ireland, Norway, Denmark: no use of nuclear in their law
- Luxembourg.

1.3 - Emerging Nuclear Energy Countries (> 45 countries according to IAEA)
(adapted from WNA source 86, September 2012)

Over 45 countries are actively considering embarking upon nuclear power programs. These range from sophisticated economies to developing nations. The front runners outside the EU are Iran, UAE, Turkey, Vietnam, Belarus, Jordan.

According to the IAEA, nuclear power is under serious consideration in over 45 countries which do not currently have it (in a few, consideration is not necessarily at government level).

In Europe: Poland (6 units planned), Lithuania (1 unit planned), Turkey (4 units planned and 4 proposed), Belarus (2 units planned and 2 proposed), Armenia (1 unit planned), Albania and Croatia, Serbia, Estonia, Latvia
In the Middle East and North Africa: Iran (2 units planned and 1 proposed), Gulf states including UAE (4 units planned and 10 proposed), Saudi Arabia (16 units proposed), Jordan (1 unit planned), Egypt (1 unit planned and 1 proposed), Qatar & Kuwait, Yemen, Syria, Tunisia, Libya, Algeria, Morocco, Sudan
In west, central and southern Africa: South Africa (6 proposed), Nigeria, Ghana, Senegal, Kenya, Uganda, Namibia
In South America: Chile, Ecuador, Venezuela
In central and southern Asia: Kazakhstan (2 units planned and 2 proposed), Bangladesh (2 units planned), Pakistan (2 proposed), Azerbaijan, Georgia, Mongolia, Sri Lanka
In SE Asia: Indonesia (2 units planned and 4 proposed), Vietnam (4 units planned and 6 proposed), Thailand (5 proposed), Malaysia (2 proposed), Singapore, Australia, New Zealand.

The IAEA published in 2007 a guidance, with a phased “milestones” approach, for emerging nuclear energy countries (“Considerations to launch a nuclear power programme”) 87.

ANNEX 2

2 - ECVET BASED "EURATOM FISSION TRAINING SCHEMES" AND NATIONAL NUCLEAR E&T NETWORKS

2.1 Nine EFTS under FP7: TRASNUSAFE, ENEN III, ENETRAP II, PETRUS II, CINCH, CORONA, EURECA!, GENTLE + post-Fukushima training action NUSHARE

Currently there are nine Euratom FP7 projects of the EFTS type and more are expected in the coming calls-for-proposals. They are examples of Euratom responses to the need of specific competences in some selected domains, using the EU tools EQF, ECTS, ECVET, etc. Whenever possible, collaboration exists with the “training” Working Groups of the EU platforms SNE-TP, IGD-TP, MELODI, ENEF and ENSREG. The current nine Euratom FP7 training projects are listed below and are described in the website of the ENEN association:

- TRASNUSAFE - Nuclear Safety Culture: addressing mainly the health physics sector (e.g., ALARA principle) (November 2010 - October 2014)
- ENEN III Training schemes - Generation III and IV engineering: addressing mainly the nuclear systems suppliers (May 2009 – April 2013)
- ENETRAP II - European Network on E&T in Radiological Protection: addressing mainly the nuclear safety authorities (March 2009 - December 2012)
- CINCH - Cooperation in education In Nuclear Chemistry: addressing mainly the sector of the nuclear fuel cycle (February 2010 - January 2013)
- CORONA - Regional Center of Competence for VVER Technology and Nuclear Applications: focus on VVER personnel (December 2011 – November 2014)
- GENTLE - Graduate and Executive Nuclear Training and Lifelong Education: focus on synergy industry – academia (January 2013 – December 2017)
- NUSHARE – Project for sharing and growing nuclear safety competence: focus on 3 target groups (policy makers; nuclear regulatory authorities; industry / 2013 – 2016).

(1) TRASNUSAFE - Nuclear Safety Culture
(Grant Agreement no 249674 / November 2010 - October 2014)

The focus in this EFTS is on competences required by the health physics sector (e.g., ALARA principle). This FP7 project aims at designing, developing and validating two training schemes on nuclear safety culture, with a common basis. One scheme is related to the nuclear industry and the other one to installations making use of ionising radiation. The target public are professionals, at the managerial level, in charge of health physics control in nuclear power plants and of radiotherapy services in hospitals.

The general objective of TRASNUSAFE includes the four following specific objectives:
- an analysis of the training needs across Europe

- a common approach with respect to the ALARA principle currently used in the radiation protection community and the safety culture of the nuclear industry
- a common generic basic module for the two training schemes, and four specialized modules
- testing and validation of the training schemes by means of pilot sessions.

The 18 Participants are: UCL (B) as coordinator, TECNATOM (E); SCK•CEN (B); ITN (P); JSI (SLO); CEPN (F); EAN from EU (SSM, ASL, BfS, GAEC, EKOTEH, ISS, ASN); UPB (RO); UNIMAN (UK); STUBA (SK); CIRTEST (I); UPM (E); ENEN association from FR (INSTN, TKK / AALTO, BME); CNCAN (RO); TRACTEBEL ENG. (B); EITA (EU); SNN (RO); SEAS (SK).

(2) **ENEN III - Training schemes in Generation III and IV engineering**
(Grant Agreement no. 232629 / May 2009 – April 2013)

Here, the focus is on competences required by nuclear system suppliers. This EFTS is organizing four training schemes:
- Basic Nuclear Topics for Non-Nuclear Engineers
- Design Challenges for Generation III NPP (2 professional profiles)
- Construction Challenges for Generation III NPPs (2 professional profiles)
- Design Challenges for Generation IV Reactor systems.

Special attention is devoted to the following competences: System and Process Engineering, Safety Analysis Evaluation, HVAC Project Implementation, digital I&C Engineering. The KSC approach for the job profile "Fluid System Construction and Commissioning Engineers" is particularly interesting. A number of internships with different stakeholders are organized in order to confront the trainees with the different policies and cultures of employers in various EU countries. The focus is on the acquisition of responsibility and autonomy under the mentorship of employers.

The 19 Participants are: ENEN Association (FR) as coordinator, SCK•CEN (BE), UCL (BE), TKK / AALTO (FI), LUT (FI), CEA / INSTN (FR), AREVA NP GmbH (DE), ISAR (DE), BME (HU), CIRTEST (POLITO, UNIPI - IT), DUT (NL), UPB (RO), UL (SLO), JSI (SLO), TECNATOM (E), UNED (E), UPM (E), UPC (E), and UCLAN (UK).

(3) **ENETRAP II - European Network on E&T in Radiological Protection**
(Grant Agreement no. 232620 / March 2009 - December 2012)

This EFTS focuses on competences required by nuclear safety authorities (e.g. Radiation Protection Expert – following the updated version of the 96/29/Euratom Directive on Basic Safety Standards).

In this FP7 project, special attention is devoted to the following issues:
- “supply” of high-quality European standards for initial education and continuous professional development for radiation protection experts (RPEs) and radiation protection officers (RPOs)
- development of the "European radiation protection training scheme" (ERPTS) for RPE training; the legal basis is the above Euratom legislation (update scheduled for 2013).
The KSC approach for the RPE is particularly interesting, based on a recent adaptation of the famous Bloom's Taxonomy (a classification of learning objectives in terms of action verbs) 89

The 12 participants are: SCK•CEN, BELGIUM as coordinator; CEA-INSTN, FRANCE; KIT-FTU, GERMANY; BfS, GERMANY; ENEA, ITALY; NRG, THE NETHERLANDS; CIEMAT, SPAIN; HPA-CRCE, UK; ENEN Association (TKK / AALTO, ISAR), FRANCE; ITN, PORTUGAL; BME-NTI, HUNGARY; UPB, ROMANIA.

(4) PETRUS II - Program for Education, Training, Research on Underground Storage
(Grant Agreement no. 232665) / 15 January 2009 - 14 January 2012

The focus here is on competences required by radwaste agencies (e.g. repository and engineered systems design). In this EFTS, a Science and Technology Passport is being developed, related to the following competences: Site Investigation Design and Management; Underground Construction; Repository and Engineered Systems Design; Above Ground Waste Handling Facility Design/Operation; Underground Systems Engineering (Waste Handling); Operational and Post-Closure Safety.

A preliminary survey of the "market" showed that a number of Training Courses do exist in the areas mentioned in the above Science and Technology Passport, spread across the EU. To complete the passport, a series of new courses are being organized in the Euratom framework.

The 15 participants are: Université de Lorraine, FR, as coordinator; ANDRA, FR; ARAO, SI; Cardiff University, UK; ENRESA, ES; ENEN Association (UPM, CTU, TKK / AALTO, BME), FR; GRS, DE; ITN, PT; ITC School of Underground Waste Storage and Disposal, CH; Microbial Analytics Sweden AB, SE; Posiva Oy, FI; RAWRA, CZ; Technische Universitaet Clausthal, DE; Ecole Mines Nantes, FR; Linne University, SE – and NDA as UK observer.

(5) CINCH - Cooperation in education In Nuclear CHeistry
(Grant Agreement no. 249690 / February 2010 - January 2013) - http://cinch-project.eu/

The envisaged consortium includes academia and "future employers", who represent all the key players in the field. EU experience is being compared with that of Russia. A set of concentrated joint modular courses (including internships) is being produced in different branches of modern nuclear chemistry. A long term sustainable strategy for the nuclear chemistry education is to be established, including a roadmap for its implementation.

Training courses are being developed in different branches of modern nuclear chemistry (e.g. chemistry of nuclear fuel cycle, separation chemistry, chemistry of actinides, radio-analytical chemistry, low-level radionuclide detection, radio-pharmaceutical chemistry, etc.). In addition to the curricula, a set of common qualification criteria and a mutual recognition system in view of a “European Passport” are being developed following the guidelines of ENEN.

An electronic tool in the form of a virtual educational platform is being developed for both education and training (designed to be applicable at the PhD and life-long learning levels).

89 Taxonomy of educational objectives: the classification of educational goals (1956) - division into three "domains": Cognitive, Affective, and Psychomotor - http://en.wikipedia.org/wiki/Bloom%27s_Taxonomy
The 8 participants are: CESKE VYSOKE UCENI TECHNICKE V PRAZE (CTU, Czech Republic); CHALMERS TEKNISKA HOEGSKOLA AB (Sweden), HELSINGIN YLIOPISTO (UH, Finland); M V Lomonosov Moscow State University (Russia); Ecole Nationale Supérieure de Chimie de Paris (France); USTAV JADERNEHO VYZKUMU REZ A.S (NRI, Czech Republic); NATIONAL NUCLEAR LABORATORY LTD (United Kingdom); UNIVERSITETET FOR MILJO OG BIOVITENSKAP (Norway).

(6) **CORONA - Regional Center of Competence for VVER Technology and Nuclear Applications**  
(Grant Agreement no. 295999 / December 2011 – November 2014)  

A special purpose structure is proposed for training and qualification of personnel for serving VVER technology. Such approach is aiming at unifying existing VVER related training schemes according to IAEA standards and commonly accepted criteria recognized in EU.

The structure is based on three general pillars:

- Training schemes for VVER nuclear professionals; for non-nuclear specialists and subcontractors, involved in nuclear sector; and for students
- VVER related knowledge management system, related to design data, operational experience, training materials, etc.
- Specialized regional training center for supporting VVER customers with theoretical and practical sessions, training materials and special assignment training facilities.

The wider objective of the project is to implement the Council Conclusions of 1 – 2 December 2008 related to skills in the nuclear field and to fulfill obligations under Article 7 of the "Nuclear Safety Directive" (EU Council, Brussels, 25 June 2009) establishing a binding Community framework for the nuclear safety of nuclear installations.

The 11 participants are: KOZLODUY NPP PLC (BG) as coordinator; MAGYAR TUDOMANYOS AKADEMIA/ KFKI (HU); Fortum Power and Heat Oy (FI); INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY - BULGARIAN ACADEMY OF SCIENCES (BG); JRC -JOINT RESEARCH CENTRE- IET; NATIONAL RESEARCH NUCLEAR UNIVERSITY "MEPhI" (RU); CENTRUM VYZKUMU REZ S.R.O. (CZ); PM Dimensions GmbH (AT); RISK ENGINEERING LTD (BG); TECNATOM S.A. (ES); INTELLECTUAL TECHNOLOGY-SLAVUTICH LLC (UA).

(7) **EURECA! - Cooperation between EU and Canada in Education, Training and Knowledge Management on Super-Critical WaterReactors**  
(Grant Agreement no. 295994 / August 2012 – July 2014)

Currently, the EU and Canada work on the Super-Critical Water-cooled Reactor (SCWR), a reactor concept selected by the Generation-IV International Forum because of the advantages regarding safety and sustainability. Although the SCWR is still a conceptual reactor, the level of knowledge and skills regarding current, water-cooled reactors will be improved and assured as well, since the concepts and technology of the SCWR are close to the ones of conventional water-cooled nuclear plants.
The EURECA! project is defining an international education & training program which
• enhances the skills of current professionals in the nuclear sector,
• attracts young graduates and professionals in other sectors to work in the nuclear field
• and enhances the mobility of professionals in the EU and Canada.

The EURECA! project consists of a European organizational branch (with EU participants),
and a mirrored, Canadian organizational branch (with Canadian participants). Although
financially separated, both branches will have a strongly symbiotic, collaborative relationship.
This project can be considered as a kind of spin-off of the “doctoral school” launched
successfully during the FP7 project HPLWR in the area of supercritical light water reactors.

The 6 participants are: TECHNISCHE UNIVERSITEIT DELFT (NL) as coordinator;
University of Stuttgart (DE); KUNGLIGA TEKNISKA HOEGSKOLAN (SE); CENTRUM
VYZKUMU REZ S.R.O. (CZ); RESEAU EUROPEEN POUR L' ENSEIGNEMENT DES
SCIENCES NUCLEAIRES (FR); UNIVERSITATEA POLITEHNICA DIN BUCURESTI
(RO); UNIVERSITA DI PISA (IT).

(8)  GENTLE - Graduate and Executive Nuclear Training and Lifelong Education
(Grant Agreement no. 323304 / January 2013 – December 2017)

Improvement of the educational efforts in Europe will be realised by effective collaboration
and coordination within the GENTLE consortium, dialogue with key stakeholders (in
particular, the "employers"), and integration of the activities with other European E&T efforts.
The focus is on Theory and Simulations; Nuclear Energy systems; Nuclear Fuel Cycle;
Economics and Operation. Specifically, the project aims at the implementation of the following
joint E&T tools:
• Student research projects to facilitate students from the participating universities to get
hands-on experience in Europe's unique and specialised laboratories and student
internships) in research and industry, increasing the value of the students' curriculum.
• Intersemester courses for graduate and post graduate students on special industry related
topics, which will be provided by academics and specialists from research and industry.
• A series of modular courses, leading to an executive European Master of Science, for
young professionals working in, among others, industry, consultancy companies or
regulatory bodies, to enhance their knowledge of nuclear reactors and fuel cycles.

The stakeholders ("employers" supporting the project) are: AREVA (France), Compania
Nationala a Uranului (Romania), Eesti Energia (Estonia), ENEN (FR - Int'l), Foratom (Int'l),
NNL (UK), NRG (Netherlands), RWE (Germany), SNE-TP (Int'l), TVO (Finland).

The 12 participants in the project (9 from academia and 3 from research) are: TUD
(Netherlands) as coordinator; BME (Hungary); CIRTEN (Italy); I2EN (France); JRC (EU);
KIT (Germany); SCK•CEN (Belgium); UPM (Spain); UMAN (UK); UT (Estonia); PSI
(Switzerland); LUT (Finland).
The NUSHARE project originated as a Euratom E&T initiative proposed by Commissioner Mrs Máire Geoghegan Quinn (Research and Innovation) and Commissioner Günther Oettinger (Energy) after the Great East Japan Earthquake and Tsunami on 11 March 2011 (Fukushima). The main objective is to develop and implement training and information activities aiming at sharing and growing across the EU the nuclear safety culture in all nuclear installations and in all applications of ionizing radiations. Some security aspects (in particular, proliferation resistance and physical protection) are also treated in a very generic way.

This initiative is interdisciplinary (e.g. requiring "hard" and "soft" sciences) and multi-sectorial (e.g. addressing policy makers and opinion leaders on one hand, and nuclear technology experts on the other hand). The European Technological Platforms (ETP) and authoritative expert bodies are being invited to participate actively. It is an EU-wide initiative, requiring the contribution of many (private and public) stakeholders in the nuclear fission and radiation protection community, who share the above ambitious objectives and are ready to share human and financial resources for this purpose.

This action requires, in particular, the collaboration of DG RTD with DG ENER: the conclusions of the "stress tests" are particularly important in this regard – see, for example, the ENSREG final report with recommendations including research and training. Moreover DG JRC, DG DEVCO and DG EAC are involved and will also share their experience in the domain. Collaboration with nuclear E&T organisations in non-EU countries is welcome (in particular, with Japan).

NUSHARE is a Euratom FP7 "support action" of 4 years, launched under the work programme 2012 through a "grant to named beneficiary". The Named Beneficiary is the ENEN association. The composition of the NUSHARE consortium is as follows:

- Coordinator = "European Nuclear Education Network" (ENEN)
- Partner no 1: "Institut National des Sciences et Techniques Nucléaires" (INSTN) / "Commissariat à l'Energie Atomique et aux Energies Alternatives" (CEA)
- Partner no 2: "Universidad Politecnica de Madrid" (UPM, Spain)
- Partner no 3: "European Nuclear Safety Training and Tutoring Institute" (ENSTTI)
- Partner no 4: Tecnatom (Spain).

Three groups of "learners" (preferably at higher education level) are targeted in the project:
- (TG1) Policy and decision makers (responsible = INSTN / CEA) => at the level of communities and governments (including EC and international organizations), emergency and crisis management teams (including the medical community)
- (TG2) Nuclear Regulatory Authorities (NRA) and Technical Safety Organisations (responsible = ENSTTI) => professional staff members of those organizations and others interested in the regulatory aspects of nuclear safety and security culture
(TG3) Industry (responsible = Tecnatom in collaboration with AREVA) => Managers and operators in the nuclear industry, in particular, systems suppliers (vendors, engineering companies, etc) and energy providers (electric utilities, etc).

The methodology for the proposed training and information programme (TG1, TG2, TG3) will contain a variety of learning paths (formal, non-formal, informal). It may include regular or virtual classroom training, seminars, workshops and discussion sessions, face-to-face or distance learning, trainee coaching, internships, webinars, cyberbooks, serious games as well as internet blogs or discussions via social networks. Special attention will be dedicated to the description of the relevant scientific and political issues in a language that is understandable to a knowledgeable non specialist. The formal training modules will have a standard duration of maximum one week, each module being thematically self-sufficient. Site visits to private and public sites with practical examples of a comprehensive safety culture and implementation of different levels of safety will also contribute to the success of the training and information actions. In TG1, special attention is dedicated to the description of the relevant scientific and political issues in a language that is understandable to a knowledgeable non specialist. In TG2 and TG3, the target public is composed principally of experts and the approach may thus be more scientific and technological, while being of course open to knowledgeable non specialists.

The synergy with the stakeholders will be ensured through regular contacts with the Technological Platforms and authoritative expert bodies concerned. A number of “associated stakeholders” are expected to implement the NUSHARE programme in their respective countries. They are high-level experts with scientific-technological and/or socio-economic expertise. Their contribution to NUSHARE will be mostly of a voluntary type. Many positive responses were received so far: from research organisations (ENEN members + 6); from systems suppliers (5); from energy providers (2); from nuclear regulatory authorities (ENSTTI members); from higher education institutions (ENEN members +1); from policy makers (9).

The "associated stakeholders" are supporting the beneficiary and project partners by:
- gathering the existing actions or re-orienting them towards meeting the above objectives (e.g. "Europeanization" of national initiatives, identification of resources and needs)
- identifying the gaps (with the help of "end users" and experts) and providing guidance to NUSHARE on how to fill them (using preferably own human / financial resources)
- contributing to the "NUSHARE training catalogue" and ensuring the correct execution of the proposed action programme in his/her country until the end of the project (2016).

The "NUSHARE training catalogue" (to be produced by the end of 2013) will be a living document (to be posted in the website of ENEN and in national dedicated websites). It will contain all proposed training and information (formal, non-formal, informal) schemes. An action programme will also be published, containing implementation roadmap and “best practice guidelines” (e.g. regarding lessons learnt from similar actions at national level; networking techniques to reach a maximum of trainers and "learners"; "learning outcomes" and related "knowledge, skills and competences" necessary to achieve the NUSHARE objectives).

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2.2 Three EFTS proposed in 2013 under FP7: CINCH II, PETRUS III, EUTEMPE RX
(under negotiation as of March 2013)

(10) CINCH-II - Cooperation in education and training In Nuclear Chemistry
(Proposal no 605173 – duration of 3 years)

CINCH-II will be a direct continuation of the CINCH-I project. The project is built around three pillars: (1) Education, (2) Vocational Education and Training (VET), and (3) Distance Learning - supported by two cross-cutting activities – Sustainability and Nuclear Awareness. The main objectives are:
- To further implement the plan for the European master's degree in nuclear and radiochemistry (NRC EuroMaster), guaranteed by the "European Chemistry Thematic Network Association"
- To develop a Training Passport in Nuclear Chemistry following the ECVET process
- To implement modern e-learning and distance learning tools developed in CINCH-I
- To lay down the foundations of a Nuclear Chemistry Education and Training Platform.

Special attention is devoted to the gathering of representatives of both the Suppliers (academia) and End-users (future employers). This will enable to design a syllabus responding not only to the current but also to the future nuclear chemical E&T needs, such as pyrochemistry for the future nuclear fuel cycles. CINCH-II takes also advantage of the well-proven five-phase (Analysis, Design, Development, Implementation, Evaluation) Systematic Approach for Training (SAT) developed by IAEA. Finally they plan to integrate the training modules developed in FP7 projects (e.g. TALISMAN, SACSESS, SKIN, ASGARD or FAIRFUELS).

The 11 participants are: Czech Technical University as coordinator; Chalmers University of Technology; University of Helsinki; National Nuclear Laboratory Ltd.; IRS (Gottfried Wilhelm Leibniz University, Hannover); Loughborough University, UK; Evalion s.r.o. CZ; CEA; University of Leeds; Norwegian University of Life Sciences (UMB); University of Oslo (UiO).

(11) PETRUS III - Implementing sustainable E&T programmes in the field of Radioactive Waste Disposal
(Proposal no 605265 – duration of 3 years)

PETRUS III is the continuation of the PETRUS initiative aiming at taking further step towards geological disposal E&T goals. The main objectives are:
- Practical implementation of PETRUS training programme following the ECVET principles. Learning outcomes will be defined in a “Competency-Based Curriculum”, using the "Designing a Curriculum” (Dacum) process, established by the British Columbia University.
- Elaboration of an interdisciplinary training framework for PhD student. The objectives are i) to fast-track the research activities in geological disposal by proposing customised training programmes, ii) organizing periodic PhD workshops and iii) favouring the emergence of interdisciplinary researches.
- Development of strategies for maintaining PETRUS over the long-term (in collaboration with the IGD-TP's Competence Maintenance Education and Training (CMET) Working Group).

In particular, senior researchers will be invited to present the most recent results obtained in FP7 projects (e.g. SKIN, FORGE, PEBS, ARCHER, CARBOWASTE…).

The 18 participants are: Université de Lorraine (FR) as coordinator; POSIVA Oy (FI); ENEN; Ecole des Mines de Nantes (FR); Cardiff University (UK); Linnaeus University (Sweden); Microbial Analytics Sweden AB (Sweden); Radioactive Waste Repository Authority (RAWRA in CZ); Agencija za radioaktivne odpadke (ARAO, Slovenia); Empresa Nacional de Residuos Radiactivos, S.A (ENRESA, Spain); Aalto University (Aalto, Finland); Universidad Politecnica de Madrid; Czech Technical University; Universitatea Politehnica Din Bucuresti; CEA; Instituto Superior Técnico (Portugal); Delft University of Technology (TU Delft); Studiecentrum voor Kernenergie (SCK-CEN in Belgium)

(12) EUTEMPE-RX
EUropean Training and Education for Medical Physics Experts in Radiology
(Proposal no 605298 - duration of 3 years)

Council Directive 97/43/Euratom (Medical Exposures Directive, MED) defines the Medical Physics Expert (MPE). The relevant articles of MED require Member States to ensure that MPEs have adequate theoretical and practical training for the purpose of radiological practices, as well as relevant competence in radiation protection. A guidance document was issued in April 2012 (“European Guidelines on Medical Physics Expert", RP 174) with recommendations on harmonising MPE education, training and recognition requirements in the EU. One accompanying document is particularly interesting in the context of ECVET: "MPE Guideline Annex 2 (Inventory of Learning Outcomes for the MPE in Europe)" - see EFOMP 90.

The newly recognized professions require, however, an educational platform that is not generally available in the Member States. Moreover there is lack of academic staff specialized in all aspects mentioned above. The EUTEMPE-RX project has been initiated to provide the best possible training opportunities to the European medical physics professionals to become MPEs working in Diagnostic and Interventional Radiology and aiming for EQF level 8.

The 13 participants are: Katholieke Universiteit Leuven (BE) as coordinator; European Federation of Organisations for Medical Physics (EFOMP - UK); Complutense University and San Carlos Hospital (SERMAS - ES); Universita degli studi di Pavia (IT); Universitat Politècnica de Catalunya (ES); Università di Ferrara (IT); Technical University of Varna (BG); National Co-ordinating Centre for the Physics of Mammography (RSCH - UK); Hospices Cantonaux CHUV (CH); Landelijk ReferentieCentrum voor Bevolkingsonderzoek (RCB –NL); University of Crete (GR); Azienda Ospedaliero Universitaria S. Maria della Misericordia (AOUD –IT); Klinikum Braunschweig (KLIN-BR - DE).

90 EFOMP - http://222.efomp.org/professional-issues/committees/professional-matters/113.html
2.3 - Other nuclear E&T initiatives supported by Euratom

- "European Nuclear Safety and Security School" 91 (EN3S network of DG JRC, launched in December 2011) with emphasis on Actinide Properties and Safety of the Nuclear Fuel Cycle. The centre of this JRC networking School is hosted in Karlsruhe (ITU) and builds on a long-standing synergy with other Commission’s global security initiatives. JRC’s objective is to make its nuclear research facilities more accessible for graduate and post-graduate training and education programmes in Europe. The following tracks are under consideration: 1. Nuclear Security, Safeguards and Forensics; 2. Nuclear Fuels; 3. Nuclear Fuel Reprocessing; 4. Nuclear Waste and Decommissioning; 5. Physics and Chemistry of the Actinides; 6. Nuclear Data. This initiative will enable students to get hands-on experience in JRC’s unique nuclear laboratories and participate to cutting-edge research (including handling of nuclear materials in practical quantities), increasing the value of their curriculum significantly.

- ENSTTI – European Nuclear Safety Training and Tutoring Institute 92: the ENSTTI was created in 2010 following a joint initiative by four European Technical Safety Organisations (TSOs): IRSN in France, GRS in Germany, BelV in Belgium and LEI in Lithuania (and supported by ETSON, the European TSO Network). The goal is, in association with the European Union and the IAEA, to drive the vocational training of the present and coming generations of professionals in nuclear safety, nuclear security and radiation protection (with emphasis on the European TSOs’ technical staff).

NB: European fusion education activities (Fusenet Association)

The Fusenet Association is an independent legal entity that was founded in December 2010. The aim is to provide a platform for the coordination of European fusion education activities and the initiation, development and implementation of new EU-wide actions. The secretariat is located at the Eindhoven University of Technology (NL). The association counts 42 members from universities and research organisations. It is open to all European organizations that are active in the field of fusion education and research. On their website 93, information and teaching materials are available about fusion in general, and also about master study opportunities, PhD and postdoc positions, etc.

2.4 - National education and training networks (14 in total):

INSTN, BNEN, NTEC, Kompetenzverbund Kerntechnik, CIRFEN, FINNEN and SKC, EPFL and ETHZ, ROREN, PNPN (Poland), CENEN, KINT and CNEN

Main sources = European Nuclear Education Network databank in the ENEN website 20 + EC Communication 2011 45 + EHRO-N summary report about higher education in the EU 25: "Mapping of nuclear education possibilities and nuclear stakeholders in the EU-27" (2012).

93 Fusenet Association - http://www.fusenet.eu/ - see also Goal Oriented Training (GOT) programme under EFDA
(1) INSN / Institut National des Sciences et Techniques Nucléaires in France (created in 1956, total of 114 permanent staff members and 1 400 specialised instructors)

As a part of the CEA (French Atomic Energy and Alternative Energies Commission), the National Institute for Nuclear Science and Technology (INSTN) is a higher education institution under the joint supervision of the Ministries in charge of higher Education and Economics. The INSTN’s mission is to disseminate the knowledge and know-how developed at the CEA. The headquarters are located at the Saclay CEA Centre. Four branches are set up in the CEA’s centres at Grenoble, Cadarache and Marcoule, and on the campus of Cherbourg-Octeville - http://www-instn.cea.fr/Page-Home.html

(2) BNEN / Belgian Nuclear Education Network (created in 2001), hosted at SCK-CEN Mol

It is a master-after-master academic programme in nuclear engineering, organised through a consortium of six Belgian universities (Université Catholique de Louvain, Katholieke Universiteit Leuven, Universiteit Gent, Vrije Universiteit Brussel, Université de Liège, Université Libre de Bruxelles) and the Belgian Nuclear Research Centre SCK•CEN - http://bnen.sckcen.be/. Also worth mentioning is the CHERNE, an European academic network for Cooperation in Higher Education on Radiological and Nuclear Engineering (created in 2005 by two Belgian institutions + 4 institutions in the EU) - http://www.upv.es/cherne/

(3) NTEC / Nuclear Technology Education Consortium in the UK - http://www.ntec.ac.uk/

A new concept in postgraduate-level training for the nuclear sector has been developed by a strong consortium of UK universities and HE institutions. The Nuclear Technology Education Consortium (NTEC) comprises the Universities of Birmingham, Central Lancashire, Lancaster, Leeds, Liverpool, Manchester and Sheffield, City University, London, Defence Academy - College of Management and Technology, Imperial College London and UHI Millennium Institute. Together these institutions represent more than 90% of the nuclear postgraduate teaching expertise residing in the UK's universities and research institutes.

(4) Kompetenzverbund Kerntechnik / Alliance for Nuclear Competence, lead by BMWi in Germany (Bundesministerium für Wirtschaft und Technologie). The Alliance is composed of four branches (http://nuklear-server.ka.fzk.de/kompetenzverbund/start.htm):

- Kompetenzzentrum West = Forschungszentrum Jülich: RWTH Aachen, FH Aachen / Jülich + Bundesanstalt für Geowissenschaften und Rohstoffe (Hannover) + EnBW
- Kompetenzzentrum Südwest: Karlsruhe Institute of Technology (KIT) Campus Nord: Campus Süd, JRC ITU, Uni Heidelberg, Uni Stuttgart, MPA Stuttgart => RWE + AREVA + Westinghouse
- Kompetenzzentrum Ost = Forschungszentrum Dresden Rossendorf (FZR): TU Dresden, FH Zittau / Görlitz + AREVA
- Kompetenzzentrum Süd = Gesellschaft für Anlagen und Reaktorsicherheit (GRS, München): TU München + E.ON.

(5) CIRTEN / Consorzio Interuniversitario per la Ricerca Tecnologica sull’ Energia nucleare in Italy (created in 1994). It is composed of seven universities: Politecnico di Milano, Politecnico
di Torino, Università di Bologna, Università di Padova, Università di Palermo, Università di Pisa, Università di Roma “La Sapienza” (CIRTEN secretariat at Pisa) - http://www.cirten.it/.

(6) FINNEN / Finnish Nuclear Education Network / "Aalto University School of Science and Technology (AALTO)" in Finland - http://www.aalto.fi/en/. Also of interest is the SKC (Swedish Centre for Nuclear Technology). Using the funding provided by the industry and the regulator, and funding from the universities themselves, KTH, Chalmers and Uppsala university join forces in R&T - http://www.kth.se/en/sci/centra/skc. Finally, the NKS (Nordic Nuclear Safety Research) is an informal forum for Nordic cooperation and competence in nuclear safety including radiation protection and emergency preparedness. The Nordic region comprises Denmark (including the Faroe Islands and Greenland), Finland, Iceland, Norway and Sweden. - http://www.nks.org/en/welcome.htm.

(7) EPFL Lausanne and ETHZ Zurich + Paul Scherrer Institute: joint program by for Master of Science in Nuclear Engineering Application deadline - http://www.master-nuclear.ch/ The overall objectives of the Master of Science in Nuclear Engineering program are to: (1) Provide in-depth knowledge on the fundamentals and technology of harnessing nuclear fission for energy supply; (2) Provide complementary knowledge on nuclear fusion; (3) Provide knowledge on nuclear techniques in medicine, research and industry; (4) Provide a view on the complete nuclear energy conversion system and the entire fuel cycle from uranium mining to the back-end; (5) Integrate nuclear energy into energy systems as a whole.

(8) REFIN / Retea Educationala in Fizica si Ingineria Nucleara in Romania RONEN (ROmanian Nuclear Higher Education and Training Network) is a joint initiative of the important Romanian Universities and Nuclear Research Institutes (IFIN-HH, UPB, UoBFoPh, Babes-Bolyai University, University of Pitesti, INR, Dozimed, ASCENDIA, AREN, CNCAN and SCK-CEN), SMEs, NGOs and Regulatory Body to coordinate their efforts in nuclear education and training, aligned with ENEN - http://www.ronen.ro/.

(9) Polish Nuclear Physics Network (PNPN) - http://www.slcj.uw.edu.pl/pnpp/en/0.html Thirteen Polish research and educational institutions have signed an agreement, namely: (1) AGH University of Science and Technology; (2) Polish Academy of Sciences - Nicolaus Copernicus Astronomical Center; (3) Marian Smoluchowski Institute of Physics - Jagiellonian University; (4) August Chelkowski Institute of Physics - University of Silesia; (5) Institute of Experimental Physics - Nuclear Physics Division - Warsaw University; (6) Institute of Experimental Physics - Division of Nuclear Spectroscopy - Warsaw University; (7) Henryk Niewodniczański Institute of Nuclear Physics - Polish Academy of Sciences – Cracow; (8) Institute of Theoretical Physics - Warsaw University; (9) Andrzej Soltan Institute for Nuclear Studies - Świerk/Warsaw; (10) Heavy Ion Laboratory - Warsaw University; (11) University of Łódź - Division of Nuclear Physics – Łódź; (12) Department of Theoretical Physics - Institute of Physics - M. Curie Skłodowska University – Lublin; (13) Faculty of Physics - Warsaw University of Technology – Warsaw.

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2.5 - Industrial initiatives aiming at E&T collaboration with universities (non-exhaustive)

(1) KIC InnoEnergy

InnoEnergy is actually one of the three KICs (together with EIT "Information and Communication Technologies (ICT) labs" and "Climate-KIC") created under the leadership of the EIT. It is a commercial company, incorporated as Societas Europea, with 29 shareholders, all of them key players in the energy field, with top rank industries, research centres and universities, including nuclear fission research and training. It is profit oriented, but has a “not for dividend” financial strategy since they will reinvest their profits in their activities.

As far as education and training towards the needs of industry is concerned, the KIC InnoEnergy launched a European Master in Nuclear Energy (MSc EMINE) as a partnership between universities (UPC, KTH, Grenoble INP and Paristech), major companies and research institutes (Vattenfall, AREVA, EDF, ENDESA, CEA) which are hosting EMINE students for in-hands sessions at their experimental reactors (EDF and CEA). Dealing with training, another project “Innovative Nuclear Experimental Platform & Training” (INEPT) is aiming as a recognized EU platform to maintain and increase the excellence of the nuclear community by proposing access and training on facilities which allows knowledge of nuclear operations.

(2) Tecnatom in Spain, an engineering services company (750 staff) founded in 1957.

They have a website dedicated to master courses with Madrid university (UPM), supported by ENDESA and IBERDROLA (http://www.tecnatom.es/master/index.html). They are also moving towards ICT based learning environments (e-learning programmes) through their Virtual Campus (http://www.tcampusvirtual.com/). The CEIDEN platform ("Plataforma Tecnológica de Energía Nuclear de Fisión") is also an interesting initiative, launched in 2007 (http://ceiden.com/wp-content/uploads/2012/07/ceiden_en.pdf). They are composed of a mix of stakeholders interested in nuclear R&T: Tecnatom and CIEMAT (Coordinators), CSN, MINETUR, ENUSA, Thunder España, Foro Nuclear, UPM, UAB, U País Vasco, Indra and Endesa. They launched a capacity building programme in 2011 (http://ceiden.com/formacion/).
ANNEX 3

3 - VISION REPORTS OF THE TECHNOLOGICAL PLATFORMS SNE-TP, IGD-TP AND OF MELODI


Excerpt:
"This vision report .... proposes a vision for the short-, 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
- a continuous improvement of safety levels as well as resistance to proliferation.

In particular, this document proposes ...... actions to harmonise Europe’s training and education, whilst renewing its research infrastructures."

3.2 - IGD-TP: A Vision Report (November 2007) 95

Excerpt:
"Our vision is that by 2025,
the first geological disposal facilities for spent fuel, high-level waste,
and other long-lived radioactive waste will be operating safely in Europe".

Our commitment is to:
- build confidence in the safety of geological disposal solutions ......;
- encourage the establishment of waste management programmes that integrate geological disposal as the accepted option for the safe long-term management of long-lived and/or high-level waste;
- facilitate access to expertise and technology ......“

3.3 - MELODI: A vision document (High Level Group report, November 2008) 96

Excerpt:
"Better quantification of risks at low dose and how they vary between individuals will impact policy in many areas, for example:
- the management of spent fuel or high level waste where the concern is potential exposure of populations to very small doses over extremely long time periods;
- decisions on screening programmes (e.g., mammography) where a balance must be sought between the benefits and the potential harm;
- the identification of those who are more "radiosensitive", through genetic screening."

96 MELODI - http://www.melodi-online.eu/ (originated from “High Level Group” - http://www.hleg.de/)
ANNEX 4

4 - SYMPOSIUM "NUCLEAR FISSION RESEARCH FOR A LOW CARBON ECONOMY" (BXL, 26-27/02/2013)

The "2012 Interdisciplinary Study - Benefits and limitations of nuclear fission for a low carbon economy: Defining priorities for Euratom fission research & training (Horizon 2020)" was presented at the subject Symposium (350 participants including high level representatives from the Council, the Member States, the EC and the scientific community). The proceedings contain the two parts of the 2012 Study (scientific-technological part and socio-economic part).

4.1 - Scientific-technological part of the “2012 Interdisciplinary Study”

The Terms of Reference identified a number of Topics for the scientific-technological part, pertaining to three main domains: (1) EU Energy Policy; (2) Euratom Treaty and other EU policies; (3) principles of good governance.

A total of 9 scientific-technological experts were selected by EC DG Research and Innovation, in collaboration with DG JRC and DG ENER. The names are listed hereafter (they are representatives of the stakeholders from industry and public bodies – see Section 2.3):

1) Topic 1: EU energy policy - William D’haeseleer, Faculty of engineering science, University of Leuven (KU Leuven), Belgium
2) Topic 2: SET-Plan - Maria Teresa Dominguez, Empresarios Agrupados, Spain
3) Topic 3: Research and development - Gustaf Lowenhielm, CGL Consulting, Sweden
4) Topic 4: Education and training and skills - Francois Weiss, Grenoble Institute of Technology, France and KIC InnoEnergy
5) Topic 5: EU nuclear safety and security - Victor Teschendorff, Private consultant, Germany
6) Topic 6: People, quality of life and the environment - William Nuttall, The Open University, UK
7) Topic 7: Safety and security culture beyond EU borders - Olivia Comsa, Centre of Technology and Engineering for Nuclear Projects (CITON), Romania
8) Topic 8: Science-based policies and legislation - Jozef Misak, UJV Řež, Czech Republic
9) Topic 9: Ethics – treated separately by BEPA, Bureau of European Policy Advisers

The above experts looked at the "Benefits and limitations of nuclear fission for a low carbon economy" from a variety of perspectives. Here are some of their main recommendations regarding Euratom research and training, that are treated in detail in the "2013 Symposium":

(Domain 1) EU Energy Policy:

- from a security of supply perspective, RTD may further improve the characteristics of stable but dispatchable electricity production facilities capable of load-following and of large turbo-generators providing inertia to the system, permitting reactive power control (voltage stability)
- from the peer reviewed “stress tests” (see ENSREG meeting of 26 April 2012).
the subject study has identified RTD opportunities to improve the safety margins - the costs of additional safety improvements are estimated to be in the range of €30 million to €200 million per reactor unit (total cost of upgrade approximately euro 25 billion).

(Domain 2) Euratom Treaty and other EU policies:
- from a EU harmonization perspective,
  joint public – private RTD actions may contribute to the convergence of nuclear and industrial codes and standards (including the “European Utility Requirements” /EUR/), thereby facilitating a common licensing certification of Standard Plant Designs
- from a competitiveness point of view,
  RTD may improve the methodologies for evaluating the external costs of nuclear, including risk analysis and accidents, fuel-cycle and waste, routine operation, life-cycle analysis - all this is to be summarized in rigorous cost-benefit analyses.

(Domain 3) principles of good governance
- from a public involvement point of view,
  public acceptance of any nuclear installations relies on trust that they are operated safely – RTD and training may contribute e.g. to the implementation of the Aarhus Convention (Access to Information, Public Participation in Decision-making)
- from a Euratom policy management point of view,
  RTD and training might serve to support specific legislation harmonized across the EU - a sound mechanism should be established to collect the scientific evidence at national and international level and deliver them to the policy makers in a manner that allows their effective translation in policies and regulations (Best Available Science /BAS/)

4.2 - Socio-economic part of the “2012 Interdisciplinary Study”

For the socio-economic part, a total of 6 Questions were asked, pertaining to three main domains, namely: (1) decision making, (2) risk governance, (3) Euratom research, namely:

(1) DM = Decision Making
- DM1 / Who are the end-users of EU energy research (especially in the nuclear domain)? Should this research be driven principally by public concerns or by industrial needs? Who are then the best representatives of the "civil society"?
- DM2 / What is specific to EU nuclear fission research? To what extent is it distinct from energy research in general? Should it be driven by EU legislation? (e.g. similarly to the "Bataille law" which underpinned a long-term research programme in France)

(2) RG = Risk Governance
- RG1 / What is an acceptable level of (nuclear) risk for the public at large? Your opinion about “low cost” nuclear? What kind of EU research is needed to improve the risk governance? (technological risk minimisation versus public fear minimisation)
- RG2 / How to deal with and how to communicate about uncertainties? How about strategic questions in nuclear? e.g. is plutonium an asset or a liability? What is the impact of low-dose ionising radiation (linear no-threshold model versus hormesis)?

97 The 1991 Bataille Law on the management of high level long lived waste committed France to a 15-year research programme focussed on three “axes”. Axis 1 is partitioning and transmutation (CEA). Axis 2 includes both retrievable and non-retrievable geological repositories (ANDRA). And Axis 3 covers conditioning and long term storage (CEA) – see 2005 political debate http://www.senat.fr/opecst/rapport/rapport_dechets_anglais.pdf
(3) ER = Euratom Research

- ER1 / What is the public perception of EURATOM research programmes? What could be improved to better "serve" the end-users? More generally, how is the role of the technical (especially nuclear) experts perceived in the public at large?
- ER2 / What is the impact of the Fukushima event on the public debate and on policy making in the EU Member States? Should Euratom research focus more on socio-political issues? (thereby improving public understanding, involvement, and acceptance).

A total of 16 social scientists, representing the civil society, provided responses, namely:

1) Evandro Agazzi, International Academy of Philosophy of Science, Belgium
2) Anne Bergmans, Faculty of political and social sciences, Uni. of Antwerp, Belgium
3) Simon Burall, Involve, UK and Democratic Audit, UK
4) Francis Chateauraynaud, Group for Pragmatic and Reflexive Sociology, Ecole des Hautes Etudes en Sciences Sociales, France + Soraya Boudia, Laboratoire Techniques, Territoires et Societes, Universite Paris-Est Marne-la-Vallee, France + Markku Lehtonen, Sussex Energy Group, University of Sussex, UK and Institute for Research and Innovation in Society, Universite Paris-Est Marne-la-Vallee, France
5) Paul Dorfman, Warwick Business School, UK
6) Eberhard Falck, Centre international de Recherches en Economie ecologique, Eco-innovation et ingenierie du Developpement Soutenable, Universite de Versailles Saint-Quentin-en-Yvelines, France
7) Romain Garcier, Department of social sciences, Ecole normale superieure, University of Lyon, France
8) Phil Macnaghten, Department of geography, Durham Uni., UK and Unicamp, Brazil
9) Gaston Meskens, Nuclear science and technology studies unit, SCK-CEN, Belgium
10) Jacques Percebois, Centre de Recherche en Economie et Droit de l’Energie, University of Montpellier I, France
11) Marc Poumadere, Institut Symlog, France
12) Ortwin Renn and Piet Sellke, Institute of Social Sciences, Uni. of Stuttgart, Germany and Dialogik Institute for Communication and Cooperation Research, Germany
13) Judith Simon and Armin Grunwald, Institute for Technology Assessment and Systems Analysis, Karlsruhe Institute of Technology, Germany
14) Heli Talja and Pia Oedewald, VTT Technical Research Centre, Finland
15) Eugenijus Ušpuras, Lithuanian Energy Institute, Lithuania
16) Vivianne Visschers, Institute for Environmental Decisions, ETH Zurich, Switzerland.

Some of the above experts have worked closely with the European Economic and Social Committee (EESC) who played a key role in the subject "2012 interdisciplinary study" (see for example EESC publication 98). They looked at the "Benefits and limitations of nuclear fission for a low carbon economy" from a variety of perspectives and came to interesting conclusions and recommendations that are treated in detail in the "2013 Symposium", for example:

(Question 1) Decision Making (DM)

DM1 - Who are the end-users of EU energy research (especially in nuclear)?
Both industry and public are the end users of research, and research can sometimes act as a mediator between them by providing neutral knowledge of the safety related technical, human, and organisational phenomena.

DM2 - What is specific to EU nuclear fission research? (e.g. Bataille law in France)
An EU legislation to propose a long-term research strategy may be productive if it settles for an integrated research program on energy options and their mutual interconnections, including natural sciences and social sciences - it also needs to promote active outreach to stakeholders.

(Question 2) Risk Governance (RG)

RG1 - What is an acceptable level of risk for the public at large?
The EU policy and the economic research must develop analyses on three fields:
a) impacts of the nuclear choice on the health of the various populations; b) transparent and objective information about the fair cost of nuclear energy (including social cost); c) comparative analysis of the risk management in the main industrial sectors (chemistry, nuclear, oil and gas)

RG2 - How to deal with and how to communicate about uncertainties?
The issues around the so-called 'uncertainties' are not matter of communication but of: a) the transparency of decision making concerning nuclear activities and the confidence in nuclear institutions regarding their relationships with the public in the past; b) the different interpretations of the precautionary principle, a key principle for risk governance in Europe.

(Question 3) Euratom Research (ER)

ER1 - What could be improved to better "serve" the end-users?
End-users could feel better served if they got involved, directly or indirectly. Action-research could be developed to have scientists share work on the field with the local population whenever possible.

ER2 - Should Euratom research focus more on socio-political issues?
Euratom should as a matter of urgency undertake work on socio-political issues across Europe. Such work needs to involve an appropriate balance of disciplines and should be set within an appropriate socio-political framing. This should involve, inter alia, sociologists and political scientists.

Worth mentioning is the important role played by the European Technological Platforms and other authoritative expert bodies 22. For example, the SWOT report (2010) of ENEF was particularly appreciated: this is a “Strengths, Weaknesses, Opportunities, Threats” strategic analysis of nuclear energy today and at 2020 based on economic as well as environmental and social performance indicators (ENEF / WG "Opportunities" / Task "Competitiveness").

4.3 - "Topic 9: Ethics".

On January 16, 2013, the European Group on Ethics (EGE) adopted an "Ethical framework for assessing research, production, and use of Energy" (Ethics Opinion n°27) 13. The EGE recommends achieving a fair balance between four criteria - access rights, security of supply, safety, and sustainability - in light of social, environmental and economic concerns.
The 10 Recommendations of the "2012 Interdisciplinary Study" 13
(Rapporteur: John Wood, Association of Commonwealth Universities, UK)

(1) Europe faces today major societal challenges including climate change and energy dependency. In the energy field, notably – as identified by the EGE -availability, security of supply, sustainability or safety issues, all require continuing specific research effort, within the energy supply context as a whole, ranging from renewables to nuclear fission and fusion, and aiming at a responsible response to the EU energy policy.

(2) Following Fukushima, nuclear fission for energy has become a sensitive political issue in some Member States and the public at large which expects that their concerns are properly addressed. Future research activities on fission therefore need to respond to those including new ways of engaging the public in its research actions. This is the only way for European industry in the nuclear field to maintain its worldwide leading position.

(3) For this reason, all aspects of safety, risk-mitigation, safeguards and security, in addition to waste management should be the first priority of the Euratom programme; furthermore, participation of social scientists and others from the non-nuclear science and engineering community is required to ensure a holistic approach to the fission Euratom programme.

(4) To allow all citizens in Europe to profit from transparent, publically financed independent knowledge in nuclear fission, Europe needs to keep its capacity building competence at the highest level. Therefore European skills need to stay up to date, and support for continuous professional development is essential. In addition qualifications should be standardised across MS to allow freedom of knowledge and expertise to become a reality as well as to facilitate links to other disciplines.

(5) Respect for European values, solidarity among Member States, and a prudent equilibrium between a common policy, competition between different energy plans and national diversification regarding energy sources are all necessary elements of an EU energy and research framework. The link between scientists/engineers and policy makers needs therefore to become stronger. Ways of doing this at EC level and in Member States (e.g. through research and educational institutions) should be analysed, optimized and implemented as soon as possible.

(6) Existing nuclear related research associations and technology platforms should do more to interact with the general public, and to develop stronger links with the European Energy Fora, including the ENEF, the Nuclear Energy Forum.

(7) New and emerging technologies need to be supported not only to support the safety and security aspects but also to develop innovative areas such as nuclear medicine.

(8) In line with the changing research and innovation scene world-wide, EURATOM should take a full part in international discussions forming partnerships where there is advantage in working with other regions of the world.

(9) Considering the evolution of all these challenges, the governance of Euratom research, including STC, should be reformed; research efforts should be integrated, whenever appropriate, with other support and policy streams in the EC, ensuring transparency and cost effectiveness; the role of the European Economic and Social Committee (EESC) in monitoring the Euratom activities should also be reviewed.

(10) Finally, the role of the JRC as a EU Centre for nuclear safety, safeguards and security science should be reinforced; in this respect consideration shall be given to the possibility for the JRC to play a proactive role in maintaining and disseminating the Euratom research results.
ANNEX 5

5 - DRAWING THE LESSONS FROM FUKUSHIMA (INTERNATIONAL EVENTS AND "STRESS TESTS")

5.1 - First lessons from Fukushima – dedicated events in EU and world-wide in 2011

  Main actors = European Council; European Commission; and ENSREG
  The European Council of 24/25 March 2011 requested for all EU nuclear plants that the safety and its governance should be reviewed on the basis of a comprehensive and transparent risk and safety assessment ("stress tests") 99. These “stress tests” were defined as targeted reassessments of the safety margins of nuclear power plants, developed by the European Nuclear Safety Regulators’ Group (ENSREG), including the European Commission. All 14 EU Member States that operate nuclear power plants (Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, the Netherlands, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom – see Annex 1.2) and Lithuania, which is decommissioning its nuclear power units, agreed to participate in these voluntary stress tests – Section 5.2 below.

- Event (2): 2011 EU-Japan Summit of 28 May 2011, Brussels
  Main actors = European Council (Mr Herman Van Rompuy, President); EC (Mr Jose Manuel Barroso, President); Japan (Mr Naoto Kan, Prime Minister)
  Of particular interest in this context is Article 4 of the joint Press Statement 100 which insists on "seeking synergies between respective programmes dealing with nuclear safety, severe accidents, radiation protection, radioecology, emergency management, radiological and nuclear risks, and environmental impact monitoring".

- Event (3): G8-G20 meeting co-organised by the OECD/NEA (7-8 June 2011, Paris)
  Main actors = Mr Angel Gurría, OECD Secretary-General; Mr Yukiya Amano, IAEA Director General; Mr Luis Echávarri, OECD/NEA Director-General
  “There are a number of lessons to be drawn from the accident in Fukushima, that apply to the design, construction, operation and maintenance of existing and future nuclear plants, but also apply to waste management or the backlash against nuclear power. .... We have an opportunity to learn from this tragic event and take it into account as we go forward.”

- Event (4): the IAEA Ministerial Conf. on Nuclear Safety of 20-24 June 2011, Vienna
  Main actors = IAEA; Nuclear Emergency Response Headquarters Government of Japan
  This high-level Japanese report contains a total of 28 lessons "learned from the accident thus far", belonging to 5 categories (e.g. "thoroughly instil a safety culture").


The “stress tests” (decided in March 2011) have been carried out along two convergent tracks:

- The Safety Track focused on assessing how nuclear installations can withstand the consequences of various unexpected events beyond design basis.
- The Security Track focused on analysing security threats and the prevention and response to incidents due to malevolent or terrorist acts. This assessment ran under a separate framework in the Council of the European Union.

This is the first time that a comprehensive assessment of all EU nuclear power plants is carried out simultaneously and based on a common methodology that had been developed and agreed by all the EU regulators and the European Commission.

The first step (in 2011) required the operators of all nuclear power plants in the EU and in two other participating countries – Switzerland and Ukraine – to perform a thorough assessment and make proposals for safety improvements, following the ENSREG specifications. In 2011, operators thoroughly assessed their installations.

The second step (in 2012) was for the national regulators to perform an independent review of the operators’ self-assessments and compile national reports with requirements, whenever appropriate. These national reports were subject to international peer reviews, which took place in the first half of 2012. Each country subjected to the peer review was visited by a team of eight peer reviewers for three or four days. A plant selected by the review team was also visited in each country. These reviews represent the most important added value of the whole process. ENSREG published their final report on 26 April 2012, with a number of recommendations including research and training (see NB below).

In July 2012, in agreement with the national regulators and the EC, the ENSREG set up an action plan, which provides a framework for implementing recommended safety improvements.

On 4 October 2012, the European Commission released the Communication on the results of the stress tests: "Communication on nuclear stress test by Energy Commissioner Günther Oettinger". This document highlights that European nuclear power plants (145 tested) have generally high safety standards but further improvements are needed in almost all of them.

Here is an excerpt: "The stress tests have revealed where we are good at and where we need to improve. The tests were serious, and they were a success. Generally, the situation is satisfactory but there is no room for complacency.

Although the tests did not show that any European nuclear power plant should be shut down for safety reasons, they identified a number of plant-specific technical improvements. Areas highlighted for attention at a number of reactors include tightening the application of standards for earthquake and flooding risk calculations, the installation or improvement of on-site seismic instruments, the installation of containment filtered venting systems at those reactors that do not already have them, the storage of (mobile) equipment needed in the event of severe accident in "places protected even in the event of general devastation" and the availability of a backup emergency control room should an accident render the main control room unusable.

The European Commission published on 9 October its communication to the Council and Parliament on the results of the stress tests. It contains the main findings of the stress tests with the Commission's views on the overall process, recommendations and follow-up actions. The Commission has also reviewed the existing European legal framework for nuclear safety and will present a revision of the current nuclear safety directive in 2013. The proposed amendments will focus on safety requirements, the role and powers of nuclear regulatory authorities, transparency, as well as monitoring.

In conclusion, the stress tests have demonstrated that nuclear safety is an area where cross-border cooperation and action at EU level bring tangible benefits. Significant safety improvements have been identified in all participating countries. Concrete follow-up measures will represent an important contribution to nuclear safety in the EU. The stress test process, and particularly its peer-review component, could also serve as a benchmark or a model for other countries and the international community.

NB - Research and training recommendations - Excerpt of the “Post-Fukushima accident Peer review report (Stress tests)”, 26 April 2012, by ENSREG, Stress Test Peer Review Board.

(1) Executive summary

Main results of the peer review

.......... As a result of the stress tests, significant measures to increase robustness of plants have already been decided or are considered. Such measures include ... the improvement of severe accident management, together with appropriate staff training measures ......

(2) Section 7 EUROPEAN PLANTS ASSESSMENT RELATIVE TO SEVERE ACCIDENT MANAGEMENT

7.1 Description of present situation of plants at the European level

...............  
7.1.2 Main requirements applied to this specific area

The main requirements for AM are currently internationally defined in the WENRA "reference levels" (RLs) and in IAEA safety standards. Most operators’ strategies are defined in their EOPs and SAMGs (or equivalent)..........

...............  
7.2 Assessment of plant robustness beyond the design basis

......  
7.2.4 Measures already decided on or implemented by operators and/or required for follow-up by regulators

Immediately after the Fukushima accident, regulators and operators started evaluating the events and possible improvements to the organisation of SAM, related procedures, needed hardware provisions and further studies or research and development needed. In the text below, examples of such improvements are provided. Nevertheless the level of implementation varies among countries.

With regard to the organisation of SAM, many countries have decided that the WENRA SAM-related RLs should be reflected in the national regulations. The harmonisation of SAMGs and related training across units, sites, utilities and even across borders is envisaged. ............
Regular and realistic SAM training exercises, including the use of the necessary equipment, with consideration of multi-unit accidents, long-duration events, etc. are part of the measures expected in almost all countries to improve SAM preparedness. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios.

5.3 - Response to the Fukushima Accident - Identification of relevant research areas

Excerpts of "Report of the SNETP Fukushima Task Group" 22, January 2013

Section 2. What are the main challenges revealed by the Fukushima accident?

The Fukushima accident was triggered by the combination of two main initiating events:
- An exceptional magnitude earthquake which caused the sudden total loss of almost all the off-site power supply. The reactors 1-2-3 which were in operation have been automatically shut-down. The residual heat removal systems were started immediately after, relying on electricity supplied by emergency power sources (diesel generators and batteries).
- The associated tsunami has caused the flooding of the site under a wave about twice the size considered previously in the risk evaluation. It led to both the loss of all the emergency power supply systems and of the heat sink.

Section 3. Identification of relevant research areas

The Fukushima event reveals the importance of human and organizational factors under high stress and harmful conditions in order to identify operational way to improve the emergency preparedness and the response to a severe nuclear accident. Following a review of the available information on the Fukushima accident, the Task Group has identified 13 main areas of research, focused on siting, design and operation of nuclear power plants.

These areas are briefly described below:

a. Systematic assessment of vulnerabilities to defence-in-depth and safety margins for beyond design basis loads
b. Human and organizational factors under high stress and harmful conditions
c. Improved methods for external event hazard evaluation
d. Use of the probabilistic methods to assess plant safety in relation to extreme events
e. Advanced deterministic methods to assess plant safety in relation to extreme events
f. Advanced safety systems
g. Advanced materials for nuclear power
h. Advanced methods for the analysis of severe accidents
i. Improved procedures for management of severe accidents
j. Assessment of the radiological effects of the severe accidents
k. Improved modelling of fuel degradation in spent fuel pool
l. Methods for minimization of contamination in the NPP surroundings and for treatment of large volume of radioactive waste
m. Accident management in the framework of the integrated rescue system.

A special attention shall be made on how the research outcomes will be implemented and so transferred into normal industrial practice.
ANNEX 6

6 - HORIZON-2020 - EC CALLS FOR PARTNERSHIPS (PUBLIC-PUBLIC AND PUBLIC-PRIVATE)

What is partnering? Partnering brings together the public sector at European, national and regional levels in public-public partnerships ("P2Ps") as well as the public and private sectors in public-private partnerships ("PPPs"). Partnering can help to maximise the contribution of Research and Innovation to achieving smart and sustainable growth in the EU, by making the research and innovation ("R&I") cycle more efficient and shorten the time from research to market. This is essential to achieve the European Research Area (ERA) by 2014 and to deliver on the Innovation Union, the Resource Efficient Europe and the Agenda for new Skills and Jobs, and other EU 2020 Flagship initiatives.


Public-public partnerships (P2Ps) align national strategies, helping to overcome fragmentation of the public research effort. They also offer the potential of more efficient interaction with strategic international partners. Here are 3 types of P2P instruments and some concrete applications (examples):

- ERA-NET (100 projects since 2002): coordinate national research programmes in a selected area (without EU financial contribution)
  - Example of P2P ERA-NET: Rare Diseases (E-Rare): three joint calls of € 10 million (up to 40% of public research in this area is now coordinated) - http://www.e-rare.eu/

- Article 185 Initiatives (5 initiatives since 2003): integrate national and European research programmes in a selected area
  - Example of Article 185 Initiative: European Metrology Research Programme (EMRP): value of over euro 400 million (pooling 44% of overall metrology resources in one initiative) - http://www.emrponline.eu/

- Joint Programming Initiative (JPI) (10 initiatives since 2008): coordinate / integrate national research programmes to address a societal challenge

Public-private partnerships (PPPs) at EU level are undertaken jointly by the EU and other public entities together with private partners to achieve shared objectives. PPPs in R&I aim at strengthening European industrial leadership and are used to leverage R&I investments in a specific area. Here are 2 types of PPP instruments and some concrete applications (examples):

- Joint Technology Initiative (JTI) (5 initiatives since 2007): strengthen European industrial leadership in well-defined areas
  - Examples of Joint Technology Initiative: Fuel cells and Hydrogen (FCH JU – see details in NB below); ARTEMIS (embedded computing systems) and ENIAC (nano-

103 An invitation to public and private actors to join forces at EU level to apply research and innovation solutions http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/11/623&format=HTML&aged=0&language=EN&guiLanguage=en
electronics) aim to implement a research agenda defined by industry and academic/research organisations – [http://www.artemis-ju.eu/] and [http://www.eniac.eu]

- European Industrial Initiatives (EII) under the SET Plan (6 EIIs since 2010): address the demonstration/market rollout bottleneck in the innovation chain of low carbon energy technologies – see Section 5.2.1

☞ Example of European Industrial Initiative under the SET Plan: the above SNETP has set up a Task Force comprising research organisations and interested industrial partners to set the basis of the European Sustainable Nuclear Industrial Initiative (ESNII) (with emphasis on fast neutron spectrum breeder reactors).

**NB:** Joint Technology Initiative on Fuel cells and Hydrogen (FCH JU / 2014-2020/)

The Fuel Cells and Hydrogen (FCH) Joint Technology Initiative (JTI) was established for the period 2008-2013. It is a public private partnership with joint funding from the EU and from industry with industry in the lead under article 187 of the TFEU. The Fuel Cells and Hydrogen JTI was established as a Joint Undertaking by Council Regulation (EC) 521/2008. It was officially launched at the First Stakeholders General Assembly in Brussels in October 2008. The Commission planned to fund Euro 470 m from the FP7 programme over six years and at least the same amount would come from private industry (total investment needed over the period 2014-2020 was originally estimated at Euro 5 bn). The main objective of the Fuel Cells and Hydrogen Joint Undertaking ("FCH JU") is to significantly accelerate the market introduction of fuel cell and hydrogen technologies, realizing their potential as an instrument in achieving a carbon-clean energy system.

The FCH JU members are a number of fuel cell and hydrogen industries (grouped together in the New Energy World Industry Grouping /NEW-IG/), as well as the research community (grouped together in the N.ERGHY), and the EC. The budget in grants allocated up to date to more than 100 projects have contributed to bring some applications to the edge of market introduction (e.g. passenger cars, material handling vehicles, back-up power systems).

It is worth mentioning the Technology Roadmap 2010 – 2020, developed by the NEW-IG in the Strategic Research Agenda. The public (EU + national) and private financial effort required for the period 2014-2020 are estimated as Euro 6.4 bn (Euro 3.3 bn for R&D actions and Euro 3.1 bn for demonstration programmes) and do not include the dedicated financial effort that will be needed for market introduction activities (around Euro 11.5 bn). As of February 2013, a total of 28 proposals of the 2012 call are currently under negotiation (EC contribution ~ euro 80 M).

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104 **FCH** has 3 members: EU; NEW Industry Grouping; N.ERGHY Research Grouping - [http://www.fch-ju.eu/](http://www.fch-ju.eu/)
Towards a new governance for Euratom research and training programmes in nuclear fission and radiation protection

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