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Euratom research and training programme: towards a new way of "developing / teaching science", closer to the end-users

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The European Union (EU, 28 Member States, combined population of over 500 million inhabitants) is a major player in the world of nuclear fission. In 2013, a total of 131 units (including 18 Russian-designed VVER units in 5 States) were operable in half of the EU Member States. At the end of 2013, they represented a total installed electricity capacity of 122 GWe net and a gross electricity generation of 833 TWh (i.e.: 27 % of gross electricity production in the EU). It should also be noted that 4 reactors are under construction (1 in Finland, 1 in France and 2 in Slovakia), 19 reactors are planned (6 in Poland, 4 in the UK, 2 in Hungary, 2 in the Czech Republic, 2 in Romania, 1 in France, 1 in Lithuania and 1 in Bulgaria) and 15 reactors are proposed.

Research, innovation and education are at the heart of the Euratom Treaty [1] (Rome, 1957), dedicated to peaceful applications of nuclear fission. One of the main objectives of the Euratom Treaty is to contribute to the sustainability of nuclear energy by developing and sharing appropriate knowledge, skills and competences in nuclear fission and radiation protection. Euratom programmes [2] consist in end-user driven projects in selected topics, gathering the best research organisations and structured as follows:

- research and innovation (R&I) projects which contribute to generating advanced knowledge and scientific understanding of interest to industrial applications
- education and training (E&T) projects, including continuous professional development, which contribute to developing skills and competences.

Originally, in the late 1950's, the Euratom Treaty proposed nuclear power plants (NPPs) as part of the solution to the energy crisis in Western Europe. It should be noted that, already at that time, security of energy supply was a concern (e.g. oil crisis due to the closure of the Suez Canal in 1956). Severe accidents with many casualties in the fossil

[1] Consolidated version of the *Treaty establishing the European Atomic Energy Community* (Euratom) OJ C 327, 26.10.2012: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:12012A/TXT (in general, summaries of EU Legislation: http://eur-lex.europa.eu/browse/summaries.html)
[2] EC DG Research and Innovation / Euratom: http://ec.europa.eu/research/energy/euratom/index_en.cfm

energy sector (in particular, in coal mines) were also a concern. Similar concerns today still exist in the energy sector not only in the EU but world-wide. Today's energy policies are facing even bigger challenges because of two new socio-economic requirements:
(1) decarbonisation of the global economy (connected to climate change concerns) and
(2) easy access to affordable energy for all (connected to global population growth).

Of course, in the nuclear energy sector, three severe accidents happened. Lessons however were drawn world-wide, in particular in the EU, which organised the "stress tests" in all European NPPs following the Fukushima Daiichi accident of 11 March 2011 (Great East Japan Earthquake, Tohoku's coastline, magnitude 9). These "stress tests" were defined by the European Commission (EC) as *targeted reassessments of the safety margins of nuclear power plants* and were developed by the *European Nuclear Safety Regulators' Group* (ENSREG). It should be noted that many non-EU countries also conducted comprehensive nuclear risk and safety assessments based on the EU "stress test" model. These include Switzerland and Ukraine (both of which fully participated in the EU "stress tests"), Armenia, Turkey, the Russian Federation, Taiwan, Japan, South Korea, South Africa and Brazil.

Euratom works in synergy with its own institutional laboratories (i.e.: DG Joint Research Centre /JRC/) [3] and with national programmes in the EU Member States concerned with applications of nuclear fission and ionising radiation. This is also done in association with international organisations dedicated to nuclear fission developments, such as the IAEA (*International Atomic Energy Agency*, Vienna) and the OECD/NEA (*Organisation for Economic Co-operation and Development* / *Nuclear Energy Agency*, Paris). Equally important is international collaboration with research laboratories outside the EU frontiers (industrialized countries as well as emerging nuclear energy countries).

Fission technologies can be transmitted to the next generations only within the framework of a responsible strategy regarding waste management and/or recycling of fissile and fertile materials. In this context, Euratom research and training programmes insist, in particular, on the implementation of geological disposal for spent fuel and high-level radio-active waste and/or on Generation-IV developments aiming at efficient resource utilisation and waste minimisation. Safety improvements in Generation-II (e.g. related to long-term operation) and in Generation-III (e.g. related to severe accident management) are also addressed. As regards radiation protection research, the emphasis of Euratom programmes is on better quantification of risks at low dose and how they vary between individuals (of particular interest in radio-diagnosis and radio-therapy).

The focus on sustainability in Euratom programmes goes together with a better governance structure in the decision making process (i.e.: more openness, participation, accountability, effectiveness and coherence). Special efforts are dedicated to a common

[3] EC DG JRC - the European Commission's in-house science service (science hub): https://ec.europa.eu/jrc/

nuclear safety and radiation protection culture, based on the highest achievable standards. Also important is public information and engagement in energy policy issues, notably in connection with nuclear decision making (*nuclear energy is the energy that generates most emotion per MWh produced !*). These soft issues are all related to lessons learned from conducting the above "stress tests" in the 131 nuclear units in the EU.

Euratom research, innovation and education programmes bring together – within so-called "European Technology Platforms" - the major stakeholder groups of nuclear fission and radiation protection, namely:

- research organisations (e.g. from public and private sectors)
- systems suppliers (e.g. nuclear vendors, engineering companies)
- energy providers (e.g. electro-nuclear utilities and industrial heat suppliers)
- *technical safety organizations* (TSO) associated to nuclear regulatory authorities
- academia and higher education and training institutions dedicated to nuclear
- civil society (e.g. policy makers and opinion leaders), interest groups and NGOs.

The above stakeholder groups are instrumental in the design of the Euratom strategy, especially under the current EU Horizon-2020 programme of research and innovation (2014 – 2020). They also foster the scientific community to participate in collaborative projects wherever appropriate (Euratom collaborative projects usually involve up to 10 organisations and have a duration of up to 4 years). It is clear that, in this collaboration, the participating TSOs strictly keep their prescribed role, powers and independence as a support to the national regulators in decision making. Non-EU research organisations are also welcome to join Euratom projects provided that their scientific contribution brings a clear added value and that they pay for their own participation.

Euratom is not isolated in the European Energy policy [4]. Nuclear fission is part of the European energy mix, together with renewable and fissile energy sources (Article 194 of Lisbon Treaty, 2007). The EU energy strategy over the current decade is defined in the "EU Energy Roadmap 2050" (issued in 2011) which proposes five scenarios towards a low-carbon economy, based on a balance between sustainable development, security of supply and industrial competitiveness. Two messages are important for the European nuclear fission community at the horizon 2050. Firstly, one of the five "decarbonisation scenarios" is based on a 20 % share of electricity generation by nuclear fission, which represents an equivalent capacity operating of 127 GWe, to be compared to today's total

[4] EC DG (Directorate General) ENER activities related to Nuclear safety; Radioactive waste and spent fuel; Radiation protection; Decommissioning of nuclear facilities; Safeguards to avoid misuse; Security (physical protection) : http://www.Euratom.org/ and http://ec.europa.eu/energy/en/topics/nuclear-energy

nuclear generation of 122 GWe. Secondly, the general conclusion for all "decarbonisation scenarios" is that electricity will play a much greater role than now (almost doubling its share in final energy demand, from 21 % today to 40% in 2050).

More recently, another important step was made in the European Energy policy, namely: the launch of the "Energy Union Package" (February 2015, EC president Jean-Claude JUNCKER, 2014-2019). One of the Objectives is "An Energy Union for Research, Innovation and Competitiveness" (Section 2.5). Here are two excerpts:

- *putting the EU at the forefront of ... all innovative energy technologies ..., including ...the world's safest nuclear generation, is central to the aim of turning the Energy Union into a motor for growth, jobs and competitiveness.*
- *The EU must ensure that ... it maintains technological leadership in the nuclear domain, including through ITER, so as not to increase energy and technology dependence.*

Not surprisingly, the above statement goes together with a number of recently revised Euratom Directives (i.e.: legally binding legislation for Member States in the EU) that all go in the same direction, specifically driven by the lessons drawn from Fukushima:

- a high-level "Nuclear Safety Objective for Nuclear Installations" avoiding radio-active releases (the most stringent safety goal in the world at the time being)
- instigation of topical peer reviews by competent regulatory authorities every six years (focussing on safety issues)
- obligation to ensure transparency of regulatory decisions and operating practices, as well as obligation to foster public participation in the decision making process
- requirement for role, powers and independence of national regulatory authorities in decision making
- establishment of a strong safety culture (a number of indicators are also provided)
- obligation to obtain, maintain and further develop expertise and skills in nuclear safety, in particular, through a special effort on education and training.

Finally, as far as future is concerned, Euratom is aiming at continuously improving the collaboration between scientific research community and policy makers. In fact, a new way of "developing / teaching science" is emerging in the EU, closer to the needs of the end-users, i.e.: society and industry. As a result, a strong scientific foundation is being established to support decision making in regulatory and/or industrial organisations, based on confirmed facts and research findings stemming from "Best Available Science".

TOWARDS MORE SCIENCE BASED POLICIES